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Physics Contribution

# Diversity and Professional Advancement in Medical Physics

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**Purpose:** While disparities in the inclusion and advancement of women and minorities in science, technology, engineering, mathematics, and medical fields have been well documented, less work has focused on medical physics specifically. In this study, we evaluate historical and current diversity within the medical physics workforce, in cohorts representative of professional advancement (PA) in the field, and within National Institutes of Health (NIH)−funded medical physics research activities.

**Methods and Materials:** The 2020 American Association of Physicists in Medicine (AAPM) membership was queried as surrogate for the medical physics workforce. Select subsets of the AAPM membership were queried as surrogate for PA and early career professional advancement (ECPA) in medical physics. Self-reported AAPM-member demographics data representative of study analysis groups were identified and analyzed. Demographic characteristics of the 2020 AAPM membership were compared with those of the PA and ECPA cohorts and United States (US) population. The AAPM-NIH Research Database was appended with principal investigator (PI) demographics data and analyzed to evaluate trends in grant allocation by PI demographic characteristics.

**Results:** Women, Hispanic/Latinx/Spanish individuals, and individuals reporting a race other than White or Asian alone comprised 50.8%, 18.7%, and 32.4% of the US population, respectively, but only 23.9%, 9.1%, and 7.9% of the 2020 AAPM membership, respectively. In general, representation of women and minorities was further decreased in the PA cohort; however, significantly higher

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Data sharing statement: Data underlying this study include American Association of Physicists in Medicine (AAPM) membership records, AAPM committee rosters, AAPM awards rosters, AAPM member demographics data, AAPM Education and Research Fund Recipient records, the AAPM −National Institutes of Health Research Database, and United States population demographics data. AAPM membership records, AAPM committee rosters, AAPM awards rosters, and AAPM member demographics data were provided to the authors by AAPM; however, the authors do not own these data and are therefore unable to share them. AAPM Education and Research Fund Recipient records were made publicly available by AAPM and are available at https://gaf.aapm.org/education/edfund.php. The AAPM−National Institutes of Health Research Database is available to AAPM members upon request. United States population demographics data are publicly available at https://data.census.gov/cedsci/.

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proportions of women ($P < .001$) and Hispanic/Latinx/Spanish members ($P < .05$) were observed in the ECPA cohort than the 2020 AAPM membership. Analysis of historical data revealed modest increases in diversity within the AAPM membership since 2002. Across NIH grants awarded to AAPM members between 1985 and 2020, only 9.4%, 5.3%, and 1.7% were awarded to women, Hispanic/Latinx/Spanish, and non-White, non-Asian PIs, respectively.

**Conclusions:** Diversity within medical physics is limited. Proactive policy should be implemented to ensure diverse, equitable, and inclusive representation within research activities, roles representative of PA, and the profession at large.



## Introduction

Limited diversity in science, technology, engineering, mathematics, and medicine (STEMM) is a long-standing issue.[1,2] Despite improvements in the inclusion of women and underrepresented minorities[i] at the undergraduate level,[3] disparities persist in higher educational attainment[3,4] and in activities classically representative of professional advancement (PA), including scientific authorship[5] and among award and grant recipients.[6-8] Within academia, diversity tends to be more limited at the faculty level than among students, a trend that is exacerbated with increasing academic rank.[3,4,9] Collectively, these findings reveal a progressive decline in the representation of women and minorities in roles associated with increased seniority, specialization, or qualification—a leaky pipeline through which there is a disproportionate loss of diversity along academic and career trajectories (eg, Pell,[10] Buckles,[11] and Liu et al[12]). Rather than representing a lack of talent, ability, or motivation among those exiting the pipeline, pipeline leaks have been attributed to a number of interrelated, systemic factors, including limited networking and mentorship opportunities, social isolation within the workplace, disproportionate service and administrative burdens, work-life integration challenges, implicit bias, and experiences of harassment and discrimination, among others.[10-13] Fortunately, improved understanding of these issues has led to development of ameliorating interventions and avenues for support within various fields (eg, Buckles,[11] Liu et al,[12] and Allen-Ramdial and Campbell[14]).

While work regarding diversity and PA in medical physics is limited, existing scholarship suggests similar issues within the field. Recent analysis of the historical and current American Association of Physicists in Medicine (AAPM) membership revealed that women have remained underrepresented for over 5 decades, at maximum comprising 23.3% of AAPM members in 2019.[15] Additionally, women were found to be underrepresented in a variety of clinical and AAPM leadership positions, including as Commission on Accreditation of Medical Physics Education Programs (CAMPEP) program directors and AAPM council chairs, within AAPM executive committee roles, and as award recipients. Development and analysis of the AAPM–National Institutes of Health (NIH) Research Database has also revealed gender disparities in the allocation of research funding.[16] Amongst AAPM members, men are more than twice as likely to hold NIH funding than are women,[16] and, relative to representation in the AAPM membership, a consistently lower proportion of women held NIH funding than did men for all years 2002 to 2019.[17] Collectively, this literature reveals that women are not only underrepresented in medical physics in general, but they are even less likely to hold roles or distinctions classically representative of PA in the field.

Improvements in the recruitment, retention and career advancement of women and minority medical physicists would benefit the entire medical physics workforce, as a diverse and inclusive climate begets enhancements in innovation, productivity, and morale.[18,19] Furthermore, increased workforce diversity may yield improvements in both public health and individual patient experiences. As medical providers, minority physicians disproportionately care for patients of medically underserved populations, including low income, minority, and Medicaid patients.[20] Additionally, racial concordance between patients and medical providers may be associated with increased patient satisfaction and cultural competence, longer encounters, and adherence to treatment plans.[21-23] Recent work has called attention to the particularly important role of a diverse oncology workforce in addressing racial disparities in cancer outcomes.[24] Given that, in 2019, 78% of PhD, board-certified medical physicists reported their role to be “primarily clinical,”[25] efforts to increase diversity in medical physics stand to produce meaningful improvements in patient care and outcomes.

To our knowledge, there has not been a comprehensive, quantitative study of historical and current diversity in the medical physics workforce, leadership pools, and research activities that includes analysis of race and ethnicity in addition to gender, nor which evaluates diversity in roles associated with early career professional advancement (ECPA). In this study, we therefore seek to analyze gender, racial, and ethnic diversity within the medical

[i] In the context of STEMM higher education and workforce, ‘underrepresented minorities’ refers to individuals reporting Black or African American race, American Indian or Alaska Native race, or Hispanic or Latino ethnicity.

**Table 1 Inclusion criteria for study analysis groups and subgroups**

| Study analysis group | Subgroup | Inclusion criteria |
|---|---|---|
| 2020 AAPM membership | | Active member of AAPM in 2020 |
| Professional advancement cohort | CAMPEP program directors | Director of CAMPEP-accredited medical physics residency, graduate, certificate, or professional doctorate program as of 2021<br>Current or former member of AAPM |
| | NIH grant recipients | Principal investigator awarded NIH grant between 1985 and 2020<br>Active member of AAPM in 2020 |
| | AAPM award recipients | Ever recipient of AAPM award<br>Active member of AAPM in 2020 |
| | AAPM committee members | Ever AAPM committee member<br>Active member of AAPM in 2020 |
| | AAPM committee chairs | Ever AAPM committee chair or vice chair<br>Active member of AAPM in 2020 |
| Early career professional advancement cohort | Early career leadership | Member of any professional advancement cohort subgroup<br>Age <40 y as of January 1, 2020 |
| | Early career research leadership | Received NIH K- or F-grant funding, an AAPM Research Seed Grant, or an AAPM early career or junior investigator award between 2016 and 2020 |

*Abbreviations:* AAPM = American Association of Physicists in Medicine; CAMPEP = Commission on Accreditation of Medical Physics Education Programs; NIH = National Institutes of Health.

physics workforce and in cohorts representative of PA in the field, including those representative of ECPA. Additionally, we use the AAPM-NIH Research Database[16] to examine trends in medical physics grant funding by principal investigator (PI) demographic characteristics. This work will provide meaningful context to support the development of actionable policy that ensures diversity and equitable opportunity for PA within medical physics.

## Methods and Materials

The 2020 AAPM membership was queried as surrogate for the current medical physics workforce, while select subsets of the AAPM membership representing career advancement and leadership were queried as surrogates for PA and ECPA in the field. The PA cohort included CAMPEP program directors, NIH grant recipients, and AAPM committee members, committee chairs, and award recipients. The ECPA cohort was comprised of 2 subgroups, early career leadership and early career research leadership. Inclusion criteria for study analysis groups and subgroups are summarized in Table 1. Active AAPM membership in 2020 was added to the inclusion criteria for subgroups without criteria that otherwise ensured recent involvement in medical physics-related professional activities. Awards associated with the AAPM award recipients subgroup are available in Appendix E1.

Historical membership, committee, and awards records provided by AAPM were used to identify AAPM members, committee members and chairs, and award recipients, respectively. NIH grant recipients, CAMPEP program directors, and AAPM Research Seed Grant recipients were identified through the AAPM-NIH Research Database,[16] the CAMPEP website,[26] and publicly available AAPM Education and Research Fund Recipients data,[27] respectively.

Voluntary, self-reported demographics data for current and former AAPM members were provided by AAPM. Demographics data were recoded for clarity and, for race data, consistency with United States (US) Census data.[28] A detailed data recoding schema is available in Appendix E2, Figure E1. US population race and ethnicity demographics data were obtained from the 2020 US Decennial Census.[29,30] US population sex demographics data were obtained from the 2019 American Community Survey.[31]

AAPM-member demographics data representative of the 2020 AAPM membership, PA cohort, and ECPA cohort were identified through a series of data processing steps (Fig. 1). Number and percentage of members by demographic characteristic were calculated for each study analysis group. Not reported or unavailable demographics data were excluded from calculations of percentages. To evaluate historical trends in membership demographics, the process was repeated for all years of available AAPM membership data, 2002 to 2020.

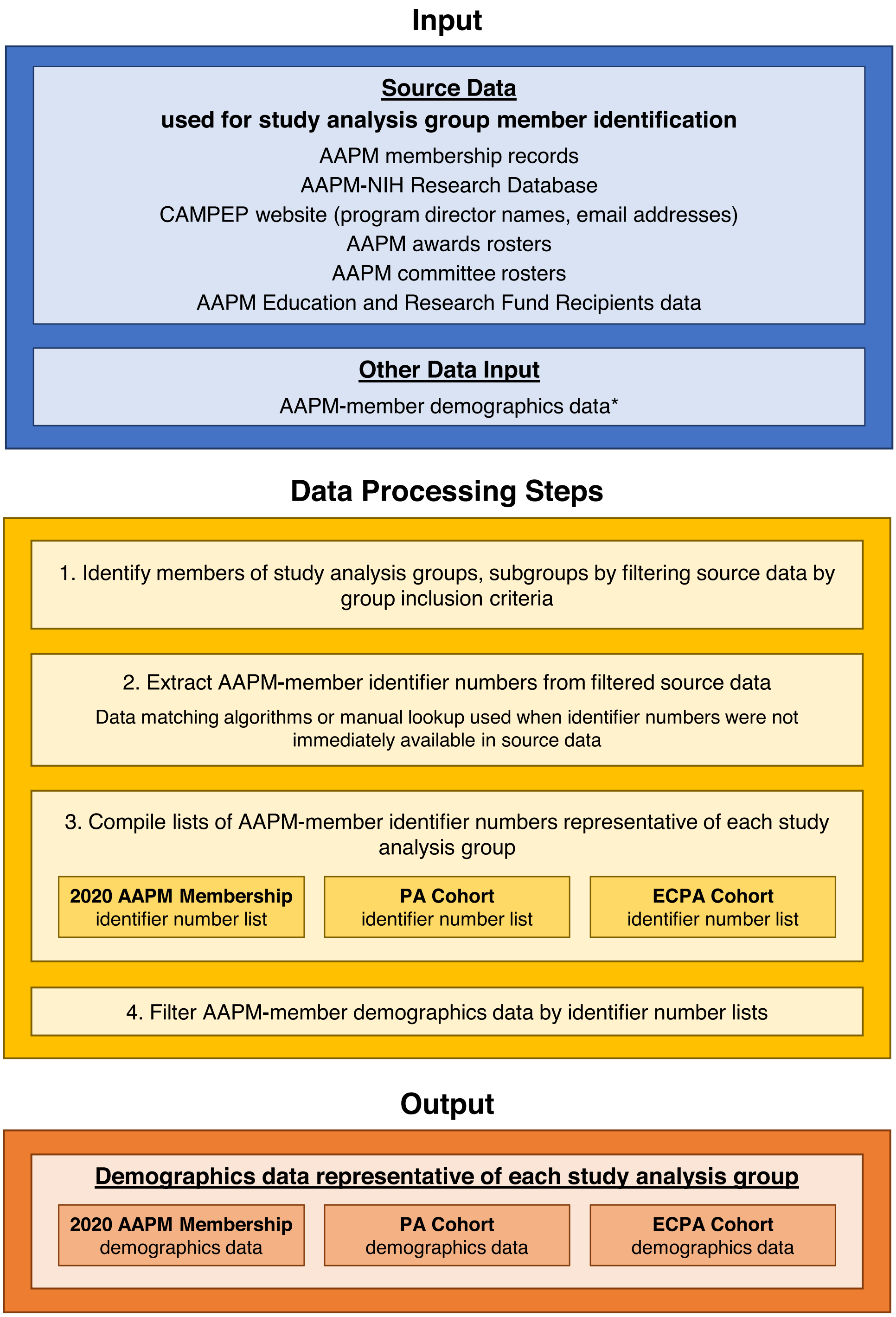


**Figure 1** Process used to identify demographics data representative of study analysis groups. Demographics data representative of study analysis groups were identified by filtering American Association of Physicists in Medicine (AAPM) −member demographics data with lists of AAPM-member identifier numbers representative of each study analysis group. *Abbreviations:* CAMPEP = Commission on Accreditation of Medical Physics Education Programs; ECPA = early career professional advancement; NIH = National Institutes of Health; PA = professional advancement. *Self-reported AAPM-member demographics data was not available for all members.

The AAPM-NIH Research Database was appended with AAPM demographics data by merging data sets on PI AAPM-member identifier number. PI race and ethnicity were identified using appended AAPM demographics data while PI gender identity was identified using a preexisting gender data field from the AAPM-NIH Research Database. Number and percentage of grants awarded by PI demographic characteristic were calculated, once

**Table 2 Demographic characteristics of the US population, 2020 American Association of Physicists in Medicine membership, and medical physics professional advancement and early career professional advancement cohorts**

| Characteristic | US population* | 2020 AAPM membership (N = 9450) | Professional advancement cohort (n = 2894) | Early career professional advancement cohort (n = 703) |
|---|---|---|---|---|
| **Gender identity, n (%†)** | | | | |
| Man | 161,588,973 (49.2) | 6844 (76.1) | 2189 (76.4) | 430 (61.7) |
| Woman | 166,650,550 (50.8) | 2149 (23.9) | 674 (23.5) | 266 (38.2) |
| Gender identity minority | | 3 (<0.1) | 1 (<0.1) | 1 (0.1) |
| Not reported or unavailable | | 454 | 30 | 6 |
| **Race, n (%†)** | | | | |
| White alone | 204,277,273 (61.6) | 2611 (64.6) | 935 (69.3) | 268 (68.5) |
| Asian alone | 19,886,049 (6.0) | 1112 (27.5) | 321 (23.8) | 99 (25.3) |
| Black or African American alone | 41,104,200 (12.4) | 107 (2.6) | 29 (2.1) | 7 (1.8) |
| Native Hawaiian or Pacific Islander alone | 689,966 (0.2) | 6 (0.1) | 3 (0.2) | 0 (0.0) |
| American Indian or Alaska Native alone | 3,727,135 (1.1) | 7 (0.2) | 2 (0.1) | 2 (0.5) |
| Some other race alone | 27,915,715 (8.4) | 89 (2.2) | 26 (1.9) | 5 (1.3) |
| 2 or more races | 33,848,943 (10.2) | 110 (2.7) | 34 (2.5) | 10 (2.6) |
| Not reported or unavailable | | 5408 | 1544 | 312 |
| **Ethnicity, n (%†)** | | | | |
| Hispanic, Latinx, or Spanish | 62,080,044 (18.7) | 289 (9.1) | 90 (8.7) | 41 (12.2) |
| Not Hispanic, Latinx, or Spanish | 269,369,237 (81.3) | 2875 (90.9) | 944 (91.3) | 294 (87.8) |
| Not reported or unavailable | | 6286 | 1860 | 368 |

*Abbreviations:* AAPM = American Association of Physicists in Medicine; US = United States.
* US population data by race and ethnicity obtained from the 2020 US Decennial Census.[28,29] US population data by sex obtained from the 2019 American Community Survey.[30]
† Counts for 'Not reported or unavailable' groups were excluded from calculation of percentages.

across all grant activity types and once for the subset of K- and F-grants only. For both calculations, grants awarded in all years represented in the data set, 1985 to 2020, were pooled. Data were filtered to ensure that grants were counted only once regardless of years of funding. To investigate historical trends, calculations were repeated with grants stratified by first year of funding. Grants with not reported or unavailable demographics data were excluded from calculations of percentages.

Data processing and analysis were performed using Python version 3.7.4 (Python Software Foundation, https://www.python.org/) and Microsoft Excel.

## Statistical analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc). Demographic characteristics of the 2020 AAPM membership were compared with those of the PA cohort, ECPA cohort, and US population. The 1-sample test for proportions was used to determine whether differences in percentages of members reporting a given demographic identity were statistically significant at the $P < .05$ level of significance. The exact 1-sample test for proportions was used when 1-sample test assumptions were not met. Statistical analysis was not performed in cases where one or both comparison group(s) contained no members reporting a given demographic identity.

## Results

Demographic characteristics of the 2020 AAPM membership, PA cohort, ECPA cohort, and US population are summarized in Table 2. Granular demographic characteristics of PA and ECPA cohort subgroups are available in Appendix E3, Tables E1 and E2, respectively. Notably, AAPM-member demographics data was limited, with gender identity, race, and ethnicity reported by 90.2%, 38.6%, and 28.2%, respectively, of members represented in the data set overall.

In general, diversity within medical physics study analysis groups was limited (Fig. 2A), and women and minority groups were frequently underrepresented. Women were

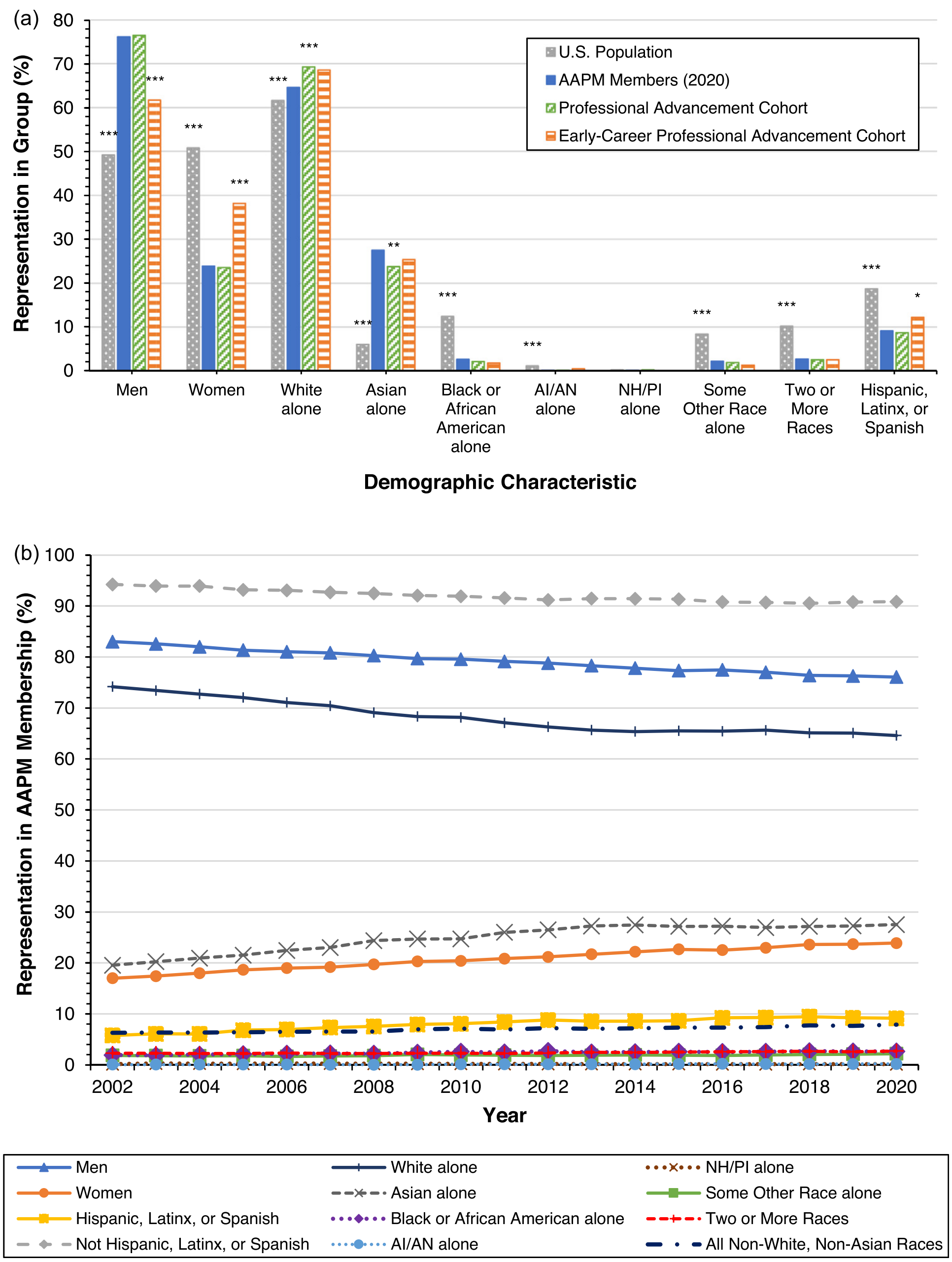


**Figure 2** Diversity in the current and historical medical physics workforce. A, Representation of various demographic groups in the 2020 American Association of Physicists in Medicine (AAPM) membership were calculated and compared with those in the US population, professional advancement cohort, and early-career professional advancement cohort. Stars denote a statistically significant difference between the percentage of the 2020 AAPM membership reporting a given demographic characteristic and the percentage of individuals in the respective comparison group reporting the same characteristic. *$P < .05$. **$P < .01$. ***$P < .001$. B, Historical trends in AAPM membership demographics. Percentages of members reporting various demographic characteristics were calculated for each year in available membership records 2002 to 2020. *Abbreviations:* AI/AN = American Indian or Alaska Native; NH/PI = Native Hawaiian or Pacific Islander.

significantly underrepresented in the 2020 AAPM membership relative to the US population ($P < .001$) and comprised a minority (23.5%) of PA cohort members. Similarly, Hispanic/Latinx/Spanish members were underrepresented in the 2020 AAPM membership relative to the US population ($P < .001$) and comprised only 8.7% of PA cohort members. Interestingly, the ECPA cohort was more diverse by gender and ethnicity, comprised of significantly higher percentages of women ($P < .001$) and Hispanic/Latinx/Spanish members ($P < .05$) relative to the 2020 AAPM membership.

Racial diversity within all medical physics groups was highly limited. Despite comprising 32.4% of the US population, racial groups other than White or Asian alone collectively comprised only 7.9%, 7.0%, and 6.1% of the 2020

**Table 3 National Institutes of Health grants awarded to American Association of Physicists in Medicine members by grant activity type and principal investigator demographic characteristics, 1985-2020 pooled**

| Characteristic | Total grants: Any activity type | Total grants: K- and F-grants only |
|---|---|---|
| **Gender identity, n (%*)** | | |
| Man | 1537 (90.6) | 35 (71.4) |
| Woman | 159 (9.4) | 14 (28.6) |
| Gender identity minority | 0 (0.0) | 0 (0.0) |
| Not reported or unavailable | 36 | 1 |
| **Race, n (%*)** | | |
| White alone | 300 (62.2) | 13 (76.5) |
| Asian alone | 174 (36.1) | 3 (17.6) |
| Black or African American alone | 1 (0.2) | 0 (0.0) |
| Native Hawaiian or Pacific Islander alone | 1 (0.2) | 0 (0.0) |
| American Indian or Alaska Native alone | 0 (0.0) | 0 (0.0) |
| Some other race alone | 2 (0.4) | 1 (5.9) |
| 2 or more races | 4 (0.8) | 0 (0.0) |
| Not reported or unavailable | 1250 | 33 |
| **Ethnicity, n (%*)** | | |
| Hispanic, Latinx, or Spanish | 21 (5.3) | 6 (37.5) |
| Not Hispanic, Latinx, or Spanish | 373 (94.7) | 10 (62.5) |
| Not reported or unavailable | 1338 | 34 |

* Counts for not reported or unavailable groups were excluded from calculation of percentages.

AAPM membership, PA cohort, and ECPA cohort, respectively. Black/African American members were significantly underrepresented in the 2020 AAPM membership relative to the US population, as were American Indian/Alaska Native members and members reporting some other race or 2 or more races. While Asian members were overrepresented in the 2020 AAPM membership relative to the US population ($P < .001$), they were underrepresented in the PA cohort relative to the 2020 AAPM membership ($P < .01$); however, there was no significant difference between the proportion of Asian members in the ECPA cohort and the 2020 AAPM membership. Two-sided $P$ values for all statistical tests are available in Appendix E3, Table E3.

The proportions of women, Hispanic/Latinx/Spanish, and Asian members in the AAPM membership generally increased between 2002 and 2020 while proportions of men, non-Hispanic/Latinx/Spanish, and White members decreased accordingly (Fig. 2B). Individually, racial groups other than White or Asian have consistently comprised very low (<3%) percentages of the AAPM membership.

Of NIH grants listed in the AAPM-NIH Research Database, 97.9%, 27.8%, and 22.7% were matched to PI gender identity, race, and ethnicity, respectively (Table 3). By percentage of grants, funding has primarily been awarded to men (90.6%), White and Asian PIs (98.3%), and non-Hispanic/Latinx/Spanish PIs (94.7%). Notably, no grants have been awarded to American Indian/Alaska Native PIs. By gender, the distribution of K- and F-grants appears more equitable than the distribution of grants overall (28.6% vs 9.4% of grants awarded to women, respectively); however, interpretation is limited by low sample size.

The percentage of NIH grants awarded to women generally increased between 1985 and 2020 but, as of 2020, remained disproportionately low relative to the proportion of women within AAPM (Fig. 3). By race, notable trends in the allocation of funding included an increase in the percentage of grants awarded to Asian PIs mirrored by a decrease in the percentage awarded to White PIs. Percentages of grants awarded to PIs identifying as Black/African American, Native Hawaiian/Pacific Islander, some other race, 2 or more races, or Hispanic/Latinx/Spanish have generally remained low (<10%) and disproportionate relative to representation within the AAPM membership.

## Discussion

This study revealed important insights regarding diversity and equity in medical physics. Limited diversity in the 2020 AAPM membership relative to the US population suggests a costly disproportionality in recruitment of individuals to the profession. Additionally, limited diversity in the PA cohort and within grant-funded research activities may be indicative of bias, discrimination and/or exclusion in the advancement to leadership positions. Notably,

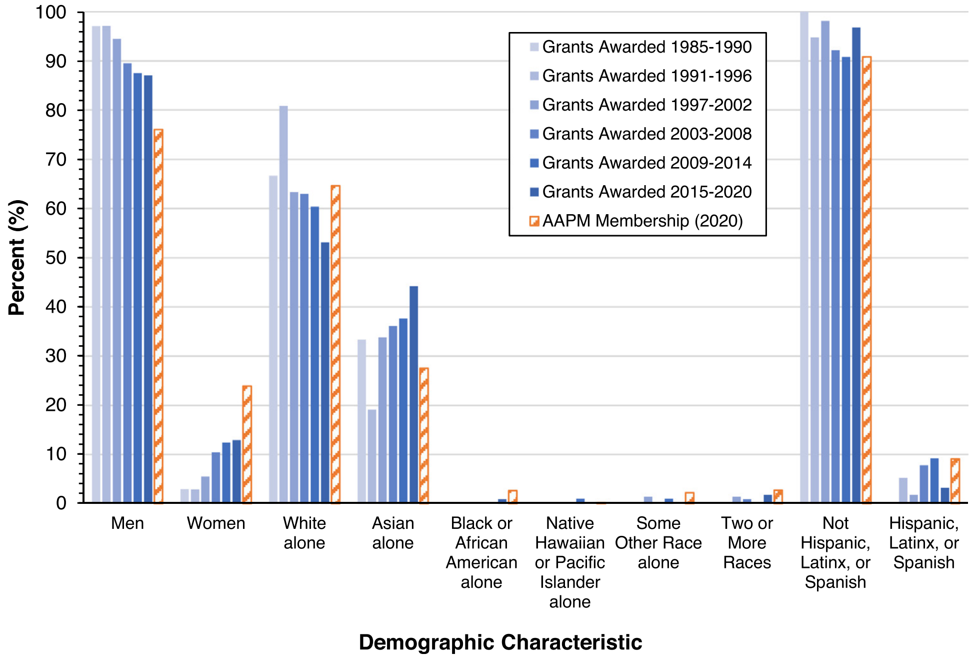


**Figure 3** Trends in the allocation of National Institutes of Health grants to American Association of Physicists in Medicine (AAPM) members by principal investigator demographic characteristics. Grants listed in the AAPM−National Institutes of Health Research Database were stratified by first year of funding. Percentages of grants awarded by principal investigator demographic characteristic were calculated for each period (blue bars). Percentages of the 2020 AAPM membership by demographic group are provided for context (striped orange bars).

underrepresentation of Asian members in the PA cohort relative to AAPM demonstrates, in the case where sufficient data exists, that barriers to PA may exist even for minority groups with relatively high representation in the workforce. In comparisons to related fields, representation of women and minorities[ii] in AAPM was similar to that observed in physical science fields and science and engineering fields overall,[32] was generally in line with physician workforce demographics,[4] and was very similar to radiation oncology workforce demographics.[33]

Prior work has linked a number of factors to the exclusion of women and minorities from leadership roles and participation in research activities in STEMM.[9-13,34,35] While work specific to medical physics has been limited, existing literature, focused primarily on gender, offers important insight. A study of work-life integration among medical physicists revealed that, more so than men, women report that their academic productivity and ability to "keep up" in their career advancement are limited by childcare needs and other domestic responsibilities.[36] Indeed, recent analysis of research productivity among radiation therapy physicists revealed gendered differences in h-index, number of publications and representation as senior faculty.[37] Such reports may also explain the existence of large, persistent disparities in NIH grant funding by gender despite similar award success rates among men and women.[7,16,17] Beyond research, inequitable leadership promotion practices, including selection processes reliant on networking with male colleagues and a lack of transparency regarding opportunity for promotion, may also contribute to limited representation of women within leadership roles.[15,38] Further study of these issues is needed, especially in the context of other excluded groups in addition to gender (eg, racial/ethnic minoritized populations, sexual and gender minorities, disabled populations, and others), which have been investigated to a lesser extent in existing literature. Additionally, future analysis of PA subgroup demographics may reveal potential areas for targeted intervention, as limited diversity within certain leadership cohorts may be indicative of unique barriers to PA.

It is unclear whether increased diversity in the ECPA cohort and K- and F-grant funding pools[iii] represents a broader trend toward improved workforce diversity or early, yet-unaffected stages of a leaky pipeline. In the context of prior work implicating the early career and postdoctoral stages as particularly critical breakpoints for

[ii] Including individuals reporting race as Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, 'Some other race', or two or more races, or reporting a Hispanic, Latinx, or Spanish ethnicity.

[iii] Although data for T-grant subaward recipients would similarly inform this area of analysis, information pertaining to T-grant institutional subawards was not available.

career attrition and trajectory,[10,39,40] our findings may be suggestive of critical losses in medical physics workforce diversity at graduate-to-early-career and/or early-to-mid-career transitions. Additional work is required to further evaluate demographic trends in the medical physics pipeline and assess the extent to which such trends explain disparities in leadership and research representation. In any case, given an increasingly diverse pool of STEMM bachelor's degree holders,[3] efforts to recruit and support a diverse body of early career medical physicists will be paramount in ensuring future improvements in diversity. Interventions may include improvement of mentorship and networking opportunities; fostering a sense of belonging and identity; provision of social, financial, faculty, departmental and institutional support; bias training; and the development of interinstitutional relationships between primarily majority- and minority-serving institutions.[11-14,41-44]

The role of current leadership in achieving these ends cannot be overstated. While a lack of representation in leadership reinforces experiences of marginalization and devaluation that contribute to career attrition, the converse improves access to key resources for overcoming barriers to PA.[45-47] However, given limited diversity in existing medical physics leadership roles, women and minority medical physicists may not have access to leaders and/or mentors with similar backgrounds and experiences. Despite this limitation, underrepresented medical physicists may benefit from support systems including individuals not exclusively from their own demographic group.[48] Although non-White, non-Asian racial groups individually comprise low percentages of the AAPM membership, they collectively comprise nearly the same share as do Hispanic/Latinx/Spanish members (Fig. 2B). Given that improvements in inclusion and leadership promotion may be fueled by the development of a "critical mass" of nonmajority group members,[49] as may be the case for women and Hispanic/Latinx/Spanish medical physicists, support networks promoting connections across demographic lines may be beneficial for members of other underrepresented groups. In the context of research, funded women and Asian investigators may be a source of support as they are similarly nonmajority but have received funding to a relatively broad extent. In any case, allocation of resources to the development of avenues of support will be critical in improving the retention and advancement of talented minority medical physicists, in turn driving improvements in workforce and leadership diversity.

### Limitations and future directions

There are several limitations of this study. Low reporting rates of AAPM-member demographic characteristics, especially race and ethnicity, preclude a complete understanding of workforce diversity, limit evaluation of associations between demographic factors and PA, and restrict statistical analysis. While improved demographics data are critical to our understanding and may improve data interpretation, there are well-established concerns with self-reporting of such metrics by underrepresented and often vulnerable individuals.[50,51] Efforts to increase diversity within AAPM will help yield more meaningful results.

AAPM is not necessarily representative of the entire medical physics workforce, as there are many specialty fields that are not prominently represented in the activities of the AAPM membership but which can be considered subfields of medical physics.[17] The generalizability of this work is dependent on whether or how the demographic characteristics of these fields differ from those that are more predominant in AAPM. Future work may pursue a broader definition of the medical physics workforce by including investigation of non-AAPM medical physicists, although limited availability of quality demographics data may hinder this approach.

The data presented in this report does not speak to the unique experiences of the individuals it represents, nor does it directly address climate. In 2021, AAPM conducted its first climate survey of its membership, focused on equity, diversity, and inclusion within medical physics.[52] The findings of this survey provide important insight into personal experiences of individuals and groups within the specialty.

## Conclusion

Women and most racial and ethnic minority groups are underrepresented in the medical physics workforce and in roles and activities classically representative of PA in the field. Given an increasingly diverse pool of STEMM graduates, actionable policy and targeted efforts at recruitment and retention should be developed and implemented to ensure future improvements in workforce diversity and inclusivity, as well as equitable opportunity for PA and leadership promotion. Given limited coverage in the existing literature, future work should pursue understanding of the unique experiences of minority medical physicists.

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## Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2022.101057.

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