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Prevalence and Predictors of U.S. Medical Graduates' Federal F32, Mentored-K, and R01 Awards: A National Cohort Study

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Abstract

The size and diversity of the physician-scientist workforce are issues of national concern. In this retrospective, national cohort study of U.S. medical-school matriculants who graduated in 1997–2004, we describe the prevalence and predictors of federal F32, mentored-K, and R01 awards among physicians. In multivariable logistic regression models, we identified demographic, educational, and professional-development variables independently associated with each award through August 2014, reporting adjusted odds ratios and 95% confidence intervals (AOR [95% CI]). Among 117 119 graduates with complete data (97.7% of 119 906 graduates in 1997–2004), 509 (0.4%) received F32, 1740 (1.5%) received mentored-K, and 597 (0.5%) received R01 awards. Adjusting for all variables except U.S. Medical Licensing Examination Step 1 scores, Black (vs. white) graduates were less likely to receive F32 (0.48 [0.28–0.82]), mentored-K (0.56 [0.43–0.72]), and R01 (0.48 [0.28–0.82]) awards; Hispanic graduates were less likely to receive mentored-K awards (0.68 [0.52–0.88]), and women less likely to receive F32 (0.81 [0.67–0.98]) and R01 (0.59 [0.49–0.71]) awards. After adding Step 1 scores, these race/ethnicity effects were not significant, but women (0.62 [0.51–0.75]) were still less likely to receive R01 awards. Graduates reporting both (vs. neither) medical-school research elective and authorship were more

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likely to receive F32 (1.89 [1.45–2.48]), mentored-K (2.48 [2.13–2.88]), and R01 (2.00 [1.54–2.60]) awards. Prior F32 (2.17 [1.46–3.21]) and mentored-K (28.08 [22.94–34.38]) awardees more likely received R01 awards. Findings highlight the need for research-experiential interventions along the medical-education continuum to promote greater participation and diversity of U.S. medical graduates in the federally funded, biomedical-research workforce.

Keywords

Medical Education; Biomedical Research; Students; Schools; Ethnic Groups

INTRODUCTION

There are growing concerns about the size and composition of the physician-scientist workforce.(1–3) Physician-scientists (MD-PhDs and other MDs) make important contributions to the biomedical-research workforce, frequently focusing on patient-oriented clinical research.(2, 3) Although the number of U.S. physicians has increased substantially since 1980, the number of physicians whose primary activity is research has declined.(2, 3) Moreover, compared to the diversity of graduates from U.S. Liaison Committee for Medical Education (LCME)-accredited medical schools,(4) there is a lack of gender and racial/ethnic diversity in the National Institutes of Health (NIH)-funded physician-scientist workforce.(1)

From 1990–2015, internal medicine (IM) was among the specialties comprising the largest proportion of American Board of Medical Specialties (ABMS)-member-board-certified physicians with NIH funding;(5) about half of physician recipients of K08 and K23 awards were affiliated with departments of medicine and related specialties.(6, 7) However, there has been a shift away from IM specialty choice among U.S. medical-school graduates.(8–10) The extent to which this shift may have contributed to the decline in physicians' participation in the biomedical-research workforce remains unknown. Thus, we sought to identify factors contributing to the size and diversity of the physician-scientist biomedical-research workforce, examining demographic, educational, and professional-development variables, including specialty, as potential predictors of receiving federal F32 postdoctoral-research-training awards, early-career mentored-K (K01/K08/K23) awards, and independent-investigator R01 awards.

METHODS

After Institutional Review Board approval as non-human-subjects research, the Association of American Medical Colleges (AAMC) provided us with individually linked, de-identified data for the national cohort of 129 867 U.S. LCME-accredited medical-school matriculants from 1993–1994 through 2000–2001.

Gender, race/ethnicity, and graduation year data were obtained from the AAMC Student Records System (SRS). Race/ethnicity was categorized as Black, Hispanic, American Indian/Alaska Native (groups underrepresented in medicine), Asian/Pacific Islander (PI), other/unknown (including multiple races and missing race/ethnicity data), or white. The AAMC also provided data for matriculation at a top-40 NIH-funded (“research-intensive”)

medical school(11) and first-attempt United States Medical Licensing Examination (USMLE) Step 1 scores as a measure of medical-school academic performance. We included Step 1 scores because consideration of an applicant's academic record is among review criteria for F32 and mentored-K awards.(12–15)

From the AAMC Graduation Questionnaire (GQ), completed voluntarily and confidentially by graduating students,(16) we created a 5-category variable for medical-school research activities (medical-school research elective, authorship on a research paper submitted for publication during medical school, both research elective and authorship, neither, or missing), a 4-category variable for career intention (research-related careers [full-time university faculty and non-academic researchers], non-academic clinical practice, other/undecided, or missing), and a 4-category variable for degree program at graduation (MD-PhD, MD-other-advanced-degree, MD-only [including BA/BS-MD degree], or missing). Using two GQ items regarding specialty-board-certification plans (yes, no, or undecided) and specialty choice, we created an 8-category specialty variable (IM, family medicine, pediatrics, obstetrics/gynecology, surgery, all other non-generalist/non-surgical specialties, no/undecided to planning specialty-board certification, or missing). To address the potential source of bias from missing GQ data, we included a missing-data category in the analyses.

Study Outcomes

Binary outcomes included data for federal F32, mentored-K (K01/K08/K23), and R01 awards received after medical-school graduation. To minimize false positives in the record match for data in the NIH Information for Management, Planning, Analysis, and Coordination (IMPAC II) database, multiple identifiers shared between the AAMC and the NIH (e.g., first/middle/last name, gender, medical school, graduation year, and 2–3 unique identifiers) were used.(17) The NIH and AAMC contracted with Net ESolutions Corporation in Bethesda, Maryland to conduct the record match on our behalf. The AAMC provided us with the de-identified, linked data in August 2014.

Statistical Analysis

We report results of chi-square tests for associations between each categorical variable and type of award receipt and analysis of variance for differences in Step 1 scores by award receipt, showing descriptive statistics (frequencies [%] or mean [SD]) for these comparisons. Among award recipients, we computed number of years from graduation to award receipt and from medical-school matriculation to award receipt. We used analysis of variance to test between-groups differences in years from graduation to each award and in years from matriculation to each award. Using multivariable logistic regression models, we identified variables independently associated with F32 (Model 1), mentored-K (Model 2), and R01 awards (Model 3). We ran each model without Step 1 scores, and then ran each model adjusting for Step 1 score deciles, based on the sample frequency distribution of Step 1 scores. We report adjusted odds ratios and 95% confidence intervals; two-tailed $P < .05$ was considered significant. All tests were performed using IBM SPSS Statistics (Version 24, IBM Corp).

RESULTS

All 119 906 graduates in 1997–2004 (92.3% of our matriculant cohort) were eligible for study inclusion (allowing for 10 years of post-graduation follow-up). We excluded 208 graduates missing gender data, then 807 American Indians/Alaska Natives (none of whom had received F32 or R01 awards), 1654 graduates of other/unknown race/ethnicity, and 118 missing USMLE Step 1 scores. Our final sample of 117 119 graduates with complete data (97.7% of 119 906 eligible) included 509 F32, 1740 mentored-K (49 K01, 840 K08, and 855 K23), and 597 R01 awardees.

Table 1 shows descriptive statistics by award receipt. IM graduates accounted for 15.3% of all graduates in the sample and 35.4% of F32, 37.6% of mentored-K, and 32.0% of R01 awardees. Figure 1 shows proportions of F32, mentored-K, and R01 recipients among graduates within each graduation year. The proportion of graduates who were K awardees increased from 1997 to 2001 and subsequently declined. Among graduates choosing a specialty, the proportions choosing IM declined from 23.2% in 1997 to 17.0% in 2004, and proportions choosing all other non-generalist/non-surgical specialties increased from 21.6% in 1997 to 39.8% in 2004 (Figure 2). Mean Step 1 scores were significantly higher among awardees than non-awardees for each type of award (Table 1) and differed (each $P < .001$) by gender (women, mean [standard deviation] = 211.8 [21.2]; men, 217.5 [21.1]) and by race/ethnicity (white, 218.0 [19.8]; Black, 195.5 [21.2], Hispanic, 203.0 [23.4]; Asian/PI, 215.7 [20.5]).

Table 2 shows the mean number of years from graduation to F32, mentored-K, and R01 award. Gender differences in time to mentored-K and R01 awards were relatively small but significant. Time to each type of award was shorter for MD-PhD-program (vs. MD-degree-program) graduates, and time to F32 award was shorter for surgery (vs. IM) graduates. Time to R01 award was longer for graduates with (vs. without) F32 and mentored-K awards. We also examined the number of years from matriculation to award receipt by degree program (Table 3). Number of years from matriculation to award receipt was significantly longer for MD-PhD compared with MD-program graduates for each of F32, mentored-K and R01 awards.

Table 4 models included all variables in Table 1 except Step 1 scores. Across all models, more-recent graduates, and graduates who were Black, indicated clinical practice or other/undecided career intentions, and chose surgery were less likely to receive awards; graduates who attended research-intensive medical schools, reported both medical-school research elective and authorship, and were MD-PhD-program graduates were more likely to receive awards.

Associations between award receipt and other variables differed across Models 1–3. Women were as likely as men to be mentored-K awardees but less likely to be F32 and R01 awardees. Asian/PI graduates were more likely to be F32 awardees, and Hispanic graduates were less likely to be mentored-K awardees. Graduates who reported research elective only were more likely to be F32 and mentored-K awardees, and graduates who reported authorship only were more likely to be mentored-K awardees. Graduates in other specialties

(vs. IM) were less likely to receive F32 awards and, except for pediatrics, were less likely to receive mentored-K awards. Graduates who reported no/undecided to specialty-board-certification plans were less likely to receive F32 and mentored-K awards and more likely to receive R01 awards. MD-other-advanced-degree program graduates were more likely to be F32 and mentored-K awardees. F32 awardees were more likely to be mentored-K awardees, and F32 and mentored-K awardees were each more likely to be R01 awardees.

In Table 5, we added Step 1 score deciles to each model. Graduates in increasingly higher Step 1 deciles were more likely to receive each award. In these models, women were now as likely as men to receive F32 awards, but still less likely to receive R01 awards; furthermore, Black graduates were as likely as white graduates to receive each award, and Hispanic graduates were as likely as white graduates to receive mentored-K awards. Adding Step 1 scores did not alter the significance of any other associations observed in models shown in Table 4.

DISCUSSION

We described the prevalence of F32, mentored-K, and R01 awardees in a national cohort of U.S. LCME-accredited medical-school graduates with 10–17 years of follow-up and identified independent predictors of award receipt. We discuss implications of our findings in the context of the size and diversity of the federally funded, physician-scientist workforce.

In all models, more-recent graduates were less likely to receive awards. An increase in F32 awards is unlikely, as all graduates in our sample have advanced beyond this early-career stage. In our cohort, the proportion of graduates who received mentored-K awards peaked among graduates in 2001. Mentored-K applications typically are submitted 3–5 years after graduation with a terminal degree for K01 and 7–9 years for K08 and K23 awards; small numbers of applications (particularly K23) are submitted 15 or more years after graduation. (18) Thus, mentored-K awardees in our cohort might increase slightly with longer follow-up. The average time from medical-school graduation to first Research Project Grant ([RPG], including R01 and other grant mechanisms) was reportedly 17 years for MD-program and 13 years for MD-PhD-program graduates.(1) Therefore, we expect the number of R01 recipients in our cohort to increase, particularly among mentored-K awardees based on our own and others' work,(19) although declining success rates for first-time R01 applicants may limit the extent of further accrual.(20)

Graduates with higher Step 1 scores were more likely to receive each award. Although not part of the grant-review process, this standardized test score correlates with other pre-clinical and clinical medical-school academic-performance measures.(21–23) Our findings for Step 1 in association with F32 and mentored-K award receipt are consistent with review criteria for these awards, which include consideration of an applicant's academic record.(12–15) Step 1 also was independently associated with R01-award receipt. In our analysis, we included Step 1 scores as a standardized measure of medical-school academic performance because, in addition to being a measure of academic performance, Step 1 scores are associated with other factors that may be considered in grant-application reviews, such as the quality of one's academic record (e.g., Alpha Omega Alpha [AOA] election) and quality of one's

clinical record (e.g., GME program for residency and program for fellowship training). AOA is a national honor medical society that recognizes excellence in scholarship in medical school.(24) Some medical schools use Step 1 scores in the AOA selection process.

Step 1 scores also are extensively used by program directors in the graduate medical education (GME) resident-selection process(25–27) and were cited by 94% of program directors surveyed as the most frequently used of 33 factors in selecting applicants to interview for their programs.(25) Many program directors reported using a target Step 1 score to select applicants for interviews,(25) a practice reported to negatively impact Black applicants.(28) Higher Step 1 scores also independently predict success in matching into preferred residency-training positions.(29) Step 1 scores also are used by most advanced-specialty/fellowship program directors of programs who participate in the NRMP Specialties Matching Service; 74% of these advanced-specialty/fellowship program directors reported using Step 1 in selecting applicants to interview for their training programs.(30) Therefore, our Step 1 findings might reflect, in part, differences in residency and fellowship program characteristics (e.g., availability and quality of research opportunities and mentoring for residents/fellows interested in research) as well as differences in applicant pools (if lower-scoring graduates opted not to apply for these research awards or were discouraged from doing so) and/or differences in applicant success (if lower-scoring applicants were less likely to receive these awards). Further research with applicant-level data is warranted.

Women were as likely as men to receive F32 awards in the model that included Step 1 and were as likely as men to receive mentored-K awards in models both with and without Step 1; but women were about 40% less likely to be R01 awardees, and the duration from graduation to R01 award was nearly a year longer for women than for men. Consistent with an earlier report,(31) we observed that women in our cohort scored, on average, six points lower on Step 1 than men, which might have contributed to the observed gender difference in F32-award receipt; but adding Step 1 to the model did not eliminate the gender difference in R01-award receipt. Even among a highly selected, motivated group of physician-scientists with mentored-K awards, gender differences exist in R01 receipt—a gap found to persist even 10 years after a mentored-K award.(19) Our national study provides additional evidence of gender disparities in physician-scientists' career trajectories, particularly transitioning from mentored-K to R01 funding, the hallmark of research independence.

We observed that Black and Hispanic graduates were disproportionately underrepresented, and Asian/PI graduates were overrepresented, among F32, mentored-K, and R01 awardees. In models without Step 1, but not in models with Step 1, Black graduates were less likely than white graduates to receive F32, mentored-K and R01 awards, and Hispanic graduates were less likely than white graduates to receive mentored-K awards. Previous studies of R01 physician applicants and awardees, which reported that Black applicants were less likely to be funded, did not adjust for academic performance.(32, 33) Racial/ethnic differences in Step 1 scores also were previously reported, with a 24-point gap in mean scores between Black and white graduates and a 13-point gap between Hispanic and white graduates.(31) Using mediation analysis,(34) Step 1 scores alone explained 80% of the effect of race/ethnicity on K-award receipt among medical-school graduates planning research-related careers.(35) Thus, racial/ethnic differences in medical-school academic performance may

contribute to persistent racial/ethnic disparities in physicians' participation in the federally funded biomedical-research workforce at multiple stages of their post-graduation professional development.

Graduates of research-intensive medical schools were more likely to receive F32, mentored-K and R01 awards. We speculate that access to highly accomplished and effective research mentors at these institutions might substantially contribute to students' research accomplishments during and after medical school, but there is a paucity of empirical research supporting the effects of mentored-research programs on research accomplishments.(36–38) That graduates who both completed research electives and authored manuscripts during medical school were more likely to receive F32, mentored-K, and R01 awards aligns with grant-review criteria to consider a candidate's research publication record.(12–15, 39) The critical role of medical-school research productivity for aspiring physician-scientists cannot be overemphasized. Moreover, efforts to promote students' interest in research careers during and even prior to medical school(1, 3, 40, 41) are warranted as a means to increase U.S. medical-school graduates' participation in the biomedical-research workforce, as medical graduates with non-research-related career intentions in our cohort were less likely to receive research awards.

We controlled for both F32 and mentored-K award receipt in the R01 award model based on well-recognized associations between prior awards and future funding success.(18, 32, 42, 43) Since 2003, about half of all RPG awardees had received or had been supported by at least one prior F, T, or K award (a proportion that has remained stable over time), whereas the proportion of unfunded RPG applicants with these prior awards declined from about 51% to just over 40%.(44) Extending the evidence that mentored-K awards promote retention of physicians in the federally funded biomedical-research workforce,(1) half of all R01 recipients in our cohort had received mentored-K awards, and mentored-K awardees were *28 times* more likely to receive R01 awards. Targeted efforts to increase physicians' participation in mentored-K programs might be a particularly effective strategy to retain physician-scientists in the research workforce.

Our findings about degree program at graduation fill a gap in the literature about physician-scientists. Generally, studies that examined physicians' federal-award receipt considered all MD and PhD dual-degree holders as a single group, whether or not they obtained both degrees from MD-PhD joint-degree programs.(1, 18, 20, 32, 45, 46) In our study, although the overall time from matriculation to grant award was longer for MD-PhD joint-degree-program graduates, they were more likely to have received F32, mentored-K, and R01 awards and to have received these awards sooner after graduation, on average, than graduates with MD and MD-other-advanced degrees. These observations provide new evidence of the success of MD-PhD joint-degree programs in selecting and training a cadre of medical students who will be particularly successful as federally funded independent investigators.(1, 40, 47, 48) As MD-other-advanced-degree program (vs. MD-program) graduates in our study were more likely to be F32 and mentored-K awardees, and higher mentored-K success rates have been observed among MD applicants with Master's degrees, (49) the growing participation of medical students in MD-other-advanced-degree

programs(50) may contribute to increasing physicians' participation in the biomedical-research workforce.(1)

IM graduates were markedly over-represented among F32, mentored-K, and R01 awardees. That surgery graduates were less likely to be mentored-K and R01 awardees might reflect in part, specialty-specific differences in years of GME for ABMS member-board-certification eligibility.(51) Notably, graduates who reported no/undecided to board-certification plans were more likely to be R01 awardees, which also could reflect differences in duration of GME, as graduates not planning specialty-board certification might not have completed GME requirements for any specialty-board-certification eligibility. However, GME duration would not explain the lower likelihood of F32 and mentored-K awards among graduates choosing family medicine and of F32 awards among graduates choosing pediatrics--specialties requiring the same 3-year minimum GME duration for ABMS-member-board general certification as IM has.(51)

In this national cohort, there was a steady decline in choice of IM by graduation year (1997–2004), consistent with the historical decline from 30% in 1975 to 19% in 2004 in the proportions of U.S. medical students matching in categorical IM.(52) This national trend in the match may have contributed to declines in physicians' participation in the federally funded research workforce. High retention in the biomedical-research workforce has been reported among graduates of residency programs offering the long-standing American Board of Internal Medicine (ABIM) integrated research pathway.(49, 53) More-recently developed integrated research pathways are now offered or are being developed by several other ABMS-member boards,(5) which may lead to greater numbers of graduates training in these specialties to pursue biomedical-research careers.

Limitations

Our study had several strengths. To our knowledge, this is the first study to describe the prevalence of F32, mentored-K and R01 awardees in a national cohort of U.S. LCME-accredited medical-school graduates. We also had gender and race/ethnicity data for 98% of the entire cohort and 10 years of follow-up after graduation for the entire sample. The data-matching process for individual awards in the IMPAC II database was conducted using multiple identifiers, and at least one unique identifier, shared between the AAMC and NIH. Moreover, our study included numerous variables not previously examined in association with physicians' federal research awards (e.g., Step 1 score and career intention, degree program, and specialty choice at graduation).

As an observational study, however, causality cannot be inferred from observed relationships. The somewhat lower proportions of MD-other-advanced-degree- and MD-PhD-degree-program graduates in our sample compared to their representation among all medical-school graduates was a limitation, although not unexpected due to the lengthier medical-school duration for graduates of these programs.(54, 55) Unmeasured variables reflecting institutional and/or departmental support (e.g., research intensity of the institution where residents completed GME and departmental provision of protected time for research, mentoring, and other resources) for trainees and faculty members to pursue research also might have contributed to our observations about associations between specialty and award

receipt. In addition to the differences we observed in award receipt across specialties, there may be differences in award receipt among graduates *within* a particular specialty that are associated with subspecialty training. In IM, for example, subspecialty training may provide additional opportunities for extended periods of research time, which can vary considerably across subspecialty fellowships.(56) An earlier study of Accreditation Council for Graduate Medical Education (ACGME)-accredited GME programs reported that the proportion of U.S. medical-school graduates who continued in GME after completing requisite training for initial board certification differed substantially by specialty. In that study, across all specialties examined, 31.6% of U.S. medical graduates overall continued in GME after completing initial specialty training; but there were striking differences between specialties—only 7.5% of trainees who completed initial specialty training in family medicine continued in GME, whereas 60.9% of those who completed initial specialty training in IM did so.(57) Further research is warranted to examine the relationship between subspecialty training and receipt of federal research grants.

We also were limited by the provision of awards data in the public domain under the Freedom of Information Act.(58) Thus, our findings may reflect differences in application rates, success rates among applicants, or both. Finally, our observations may not be generalizable to graduates of non-LCME-accredited U.S. medical schools or of non-U.S. medical schools.

CONCLUSION

Despite these limitations, results from this national population cohort support a multifaceted approach of the Association of Professors of Medicine to identify, develop and implement strategies to promote the growth and diversity of the physician-scientist workforce(3) and provide evidence in support of the recommendations of the NIH Physician-Scientist Workforce Working Group.(1) In particular, our results indicate that educational strategies that foster medical students' interest in research-related careers and provide opportunities for and promote students' participation in productive research experiences during and after medical school can serve to increase the numbers and the diversity of U.S. medical-school graduates' participation and retention in the biomedical-research workforce.

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Significance of this study

What is already known about this subject?

- The size and diversity of the physician-scientist workforce are issues of national concern.
- Underrepresented groups in the biomedical-research workforce include women and Black/African American, Hispanic, and American Indian/Alaska Native racial/ethnic groups.

What are the new findings?

- Medical-school research experiences and authorship, MD-PhD dual-degree program graduation, research-intensive medical-school attendance, and higher medical-school academic achievement (measured by USMLE Step 1 scores) were independently, positively associated with each of F32, mentored-K, and R01 award receipt.
- In models unadjusted for Step 1 scores, we observed a lower likelihood of Black (vs. white) physicians to receive each type of award, of Hispanic (vs. white) physicians to receive K awards, and of women (vs. men) to receive F32 awards; after adjusting for Step 1, these findings were no longer significant, suggesting that these disparities in research awards could be attributed to observed racial/ethnic and gender differences in medical-school academic achievement.
- U.S. medical graduates choosing other specialties (vs. internal medicine) were disproportionately underrepresented among federal research-grant awardees.
- Prior F32 and mentored-K awardees also were more likely to receive R01 awards.

How might these results change the focus of research or clinical practice?

- Early academic and research-experiential interventions along the medical-education continuum are needed to promote greater participation and retention of U.S. medical graduates, particularly those from historically underrepresented groups, in the biomedical-research workforce.
- Targeted efforts to increase physicians' participation in mentored-K programs might be a particularly effective strategy to retain physician-scientists in the research workforce.

Figure 1. Percentage of U.S. medical graduates in each graduation year (1997–2004), by F32, mentored-K, and R01 award receipt (N=117 119).

Figure 2. Percentage of U.S. medical graduates in each graduation year (1997–2004) who planned to become specialty-board certified, by specialty category (n=90 643).

Table 1

Characteristics of the Sample, by Receipt of F32, Mentored-K, and R01 Awards^a

Characteristics	Total N = 117 119	F32 award n = 509	No F32 n = 116 610	K award n = 1740	No K n = 115 379	R01 award n = 597	No R01 n = 116 522
Gender, <i>n</i> (%) ^b							
Women	51 137 (43.7)	179 (35.2)	50 958 (43.7)	747 (42.9)	50 390 (43.7)	182 (30.5)	50 955 (43.7)
Men	65 982 (56.3)	330 (64.8)	65 652 (56.3)	993 (57.1)	64 989 (56.3)	415 (69.5)	65 567 (56.3)
Race/ethnicity, <i>n</i> (%)							
White	78 718 (67.2)	301 (59.1)	78 417 (67.2)	1166 (67.0)	77 552 (67.2)	409 (68.5)	78 309 (67.2)
Black	8351 (7.1)	14 (2.8)	8337 (7.1)	62 (3.6)	8289 (7.2)	15 (2.5)	8336 (7.2)
Hispanic	7497 (6.4)	18 (3.5)	7479 (6.4)	64 (3.7)	7433 (6.4)	22 (3.7)	7475 (6.4)
Asian/Pacific Islander	22 553 (19.3)	176 (34.6)	22 377 (19.2)	448 (25.7)	22 105 (19.2)	151 (25.3)	22 402 (19.2)
Graduation year, <i>n</i> (%) ^c							
1997	12 757 (10.9)	67 (13.2)	12 690 (10.9)	171 (9.8)	12 586 (10.9)	89 (14.9)	12 668 (10.9)
1998	14 005 (12.0)	59 (11.6)	13 946 (12.0)	196 (11.3)	13 809 (12.0)	103 (17.3)	13 902 (11.9)
1999	14 959 (12.8)	66 (13.0)	14 893 (12.8)	239 (13.7)	14 720 (12.8)	118 (19.8)	14 841 (12.7)
2000	14 530 (12.4)	68 (13.4)	14 462 (12.4)	231 (13.3)	14 299 (12.4)	91 (15.2)	14 439 (12.4)
2001	15 263 (13.0)	69 (13.6)	15 194 (13.0)	276 (15.9)	14 987 (13.0)	69 (11.6)	15 194 (13.0)
2002	15 178 (13.0)	57 (11.2)	15 121 (13.0)	226 (13.0)	14 952 (13.0)	56 (9.4)	15 122 (13.0)
2003	15 029 (12.8)	74 (14.5)	14 955 (12.8)	207 (11.9)	14 822 (12.8)	30 (5.0)	14 999 (12.9)
2004	15 398 (13.1)	49 (9.6)	15 349 (13.2)	194 (11.1)	15 204 (13.2)	41 (6.9)	15 357 (13.2)
Research-intensive medical school, <i>n</i> (%)							
No	77 031 (65.8)	189 (37.1)	76 842 (65.9)	576 (33.1)	76 455 (66.3)	198 (33.2)	76 833 (65.9)
Yes	40 088 (34.2)	320 (62.9)	39 768 (34.1)	1164 (66.9)	38 924 (33.7)	399 (66.8)	39 689 (34.1)
Medical-school research activities, <i>n</i> (%)							
No research activities	43 493 (37.1)	85 (16.7)	43 408 (37.2)	268 (15.4)	43 225 (37.5)	92 (15.4)	43 401 (37.2)
Research elective only	22 931 (19.6)	100 (19.6)	22 831 (19.6)	302 (17.4)	22 629 (19.6)	80 (13.4)	22 851 (19.6)
Authorship only	3204 (2.7)	13 (2.6)	3191 (2.7)	54 (3.1)	3150 (2.7)	17 (2.8)	3187 (2.7)
Both activities	31 056 (26.5)	237 (46.6)	30 819 (26.4)	874 (50.2)	30 182 (26.2)	332 (55.6)	30 724 (26.4)
Missing	16 435 (14.0)	74 (14.5)	16 361 (14.0)	242 (13.9)	16 193 (14.0)	76 (12.7)	16 359 (14.0)
Career intention at graduation, <i>n</i> (%)							

Characteristics	Total N = 117 119	F32 award n = 509	No F32 n = 116 610	K award n = 1740	No K n = 115 379	R01 award n = 597	No R01 n = 116 522
Research-related	28 036 (23.9)	317 (62.3)	27 719 (23.8)	1175 (67.5)	26 861 (23.3)	393 (65.8)	27 643 (23.7)
Full-time clinical practice	48 950 (41.8)	63 (12.4)	48 887 (41.9)	144 (8.3)	48 806 (42.3)	56 (9.4)	48 894 (42.0)
Other/undecided	21 969 (18.8)	48 (9.4)	21 921 (18.8)	167 (9.6)	21 802 (18.9)	62 (10.4)	21 907 (18.8)
Missing	18 164 (15.5)	81 (15.9)	18 083 (15.5)	254 (14.6)	17 910 (15.5)	86 (14.4)	18 078 (15.5)
Degree program, n (%)							
MD	98 286 (83.9)	391 (76.8)	97 895 (84.0)	1252 (72.0)	97 034 (84.1)	429 (71.9)	97 857 (84.0)
MD-other-advanced	1164 (1.0)	16 (3.1)	1148 (1.0)	47 (2.7)	1117 (1.0)	10 (1.7)	1154 (1.0)
MD-PhD	1261 (1.1)	29 (5.7)	1232 (1.1)	195 (11.2)	1066 (0.9)	81 (13.6)	1180 (1.0)
Missing	16 408 (14.0)	73 (14.3)	16 335 (14.0)	246 (14.1)	16162 (14.0)	77 (12.9)	16 331 (14.0)
Specialty for board certification at graduation, n (%)							
Internal medicine	17 909 (15.3)	180 (35.4)	17 729 (15.2)	655 (37.6)	17 254 (15.0)	191 (32.0)	17 718 (15.2)
Family medicine	10 824 (9.2)	4 (0.8)	10 820 (9.3)	12 (0.7)	10 812 (9.4)	14 (2.3)	10 810 (9.3)
Pediatrics	10 606 (9.1)	50 (9.8)	10 556 (9.1)	284 (16.3)	10 322 (8.9)	60 (10.1)	10 546 (9.1)
Obstetrics/gynecology	6189 (5.3)	4 (0.8)	6185 (5.3)	29 (1.7)	6160 (5.3)	17 (2.8)	6172 (5.3)
Surgery	15 222 (13.0)	116 (22.8)	15 106 (13.0)	87 (5.0)	15 135 (13.1)	34 (5.7)	15 188 (13.0)
All other specialties	29 893 (25.5)	43 (8.4)	29 850 (25.6)	312 (17.9)	29 581 (25.6)	153 (25.6)	29 740 (25.5)
No/undecided	8708 (7.4)	33 (6.5)	8675 (7.4)	103 (5.9)	8605 (7.5)	45 (7.5)	8663 (7.4)
Missing	17 768 (15.2)	79 (15.5)	17 689 (15.2)	258 (14.8)	17 510 (15.2)	83 (13.9)	17 685 (15.2)
F32 award, n (%)							
No	116 610 (99.6)	----	----	1607 (92.4)	115 003 (99.7)	553 (92.6)	116 057 (99.6)
Yes	509 (0.4)	----	----	133 (7.6)	376 (0.3)	44 (7.4)	465 (0.4)
Mentored-K award, n (%)							
No	115 379 (98.5)	----	----	----	----	299 (50.1)	115 080 (98.8)
Yes	1740 (1.5)	----	----	----	----	298 (49.9)	1442 (1.2)
USMLE Step 1 score, mean (SD), y	215.0 (21.3)	227.4 (19.2)	215.0 (21.3)	228.0 (18.5)	214.8 (21.3)	227.4 (18.8)	215.0 (21.3)

USMLE = United States Medical Licensing Examination; SD = standard deviation.

^aValues are frequencies (percentages) or means (SD), as noted. Percentages may not total 100 due to rounding. All associations were significant at $P < .005$ except as noted.

^bAssociation between gender and mentored-K award was not statistically significant, $P = .54$.

^cAssociation between graduation year and F32 award was not statistically significant, $P = .18$.

Table 2
Frequencies of Awards and Mean (SD) Years from Graduation to Each Award for Selected Variables of Interest

	F32, n	F32 Mean (SD), y	P value	Mentored-K, n	Mentored-K Mean (SD), y	P value	R01, n	R01 Mean (SD), y	P value
Awardees	509	5.0 (2.0)		1740	8.6 (2.1)		597	10.9 (3.2)	
Gender			.093			<.001			.004
Women	179	5.2 (1.6)		747	8.9 (2.1)		182	11.5 (3.0)	
Men	330	4.9 (2.2)		993	8.4 (2.1)		415	10.7 (3.3)	
Degree program			.007			<.001			<.001
MD	391	5.2 (2.1)		1252	8.9 (2.1)		429	11.4 (3.2)	
MD-other-advanced	16	5.4 (1.4)		47	8.5 (1.9)		10	11.5 (2.3)	
MD-PhD	29	4.0 (1.3)		195	7.3 (1.8)		81	9.6 (2.3)	
Missing	73	4.7 (1.9)		246	8.4 (2.2)		77	9.9 (3.7)	
Specialty for board certification at graduation			<.001			<.001			<.001
Internal medicine	180	5.7 (1.4)		655	8.5 (1.9)		191	11.9 (2.5)	
Family medicine	4	10.0 (4.2)		12	7.7 (2.4)		14	9.5 (4.2)	
Pediatrics	50	5.7 (2.1)		284	9.1 (1.9)		60	12.0 (2.5)	
Obstetrics/gynecology	4	5.5 (4.5)		29	9.7 (2.4)		17	11.2 (3.9)	
Surgery	116	3.7 (1.7)		87	10.7 (2.2)		34	11.6 (3.8)	
All other specialties	43	5.4 (2.5)		312	8.0 (2.2)		153	10.0 (3.2)	
No/undecided	33	5.2 (1.7)		103	8.6 (1.8)		45	10.2 (3.8)	
Missing	79	4.7 (1.9)		258	8.5 (2.2)		83	10.0 (3.7)	
F32 award						.70			.017
No	---	---		1607	8.6 (2.1)		553	10.8 (3.3)	
Yes	---	---		133	8.7 (1.6)		44	12.1 (2.4)	
Mentored-K award									<.001
No	---	---		---	---		299	10.0 (3.8)	
Yes	---	---		---	---		298	11.9 (2.3)	

SD = standard deviation.

Table 3

Frequencies of Awards and Mean (SD) Years from Matriculation to Award Receipt, by Degree Program

Degree program	F32 <i>n</i>	F32 Mean (SD) ^a	Mentored-K <i>n</i>	Mentored-K Mean (SD) ^b	R01 <i>n</i>	R01 Mean (SD) ^c
MD	391	9.4 (2.1)	1252	13.2 (2.1)	429	15.7 (3.3)
MD-other advanced	16	10.2 (1.5)	47	13.8 (2.0)	10	16.6 (2.2)
MD-PhD	29	11.4 (1.8)	195	14.8 (1.9)	81	17.0 (2.3)
Missing	73	9.3 (2.0)	246	13.6 (2.3)	77	14.8 (3.6)
Total	509	9.6 (2.1)	1740	13.5 (2.1)	597	15.8 (3.3)

SD = standard deviation.

^aMain effect $P < .001$; post-hoc tests significant at $P < .001$ for MD-PhD vs. MD and MD-PhD vs. missing.

^bMain effect $P < .001$; post-hoc tests significant at $P < .001$ for MD-PhD vs. MD and MD-PhD vs. missing, and significant at $P = .041$ for MD-PhD vs. MD-other advanced degree.

^cMain effect $P < .001$; post-hoc tests significant at $P = 0.018$ for MD-PhD vs. MD, and at $P = 0.001$ MD-PhD vs. missing.

Table 4

Multivariable logistic regression models identifying variables independently associated with each award type, unadjusted for USMLE Step 1 score deciles (N=117 119)^a

Predictor Variables	Model 1: F32 AOR (95% CI)	Model 2: Mentored-K AOR (95% CI)	Model 3: R01 AOR (95% CI)
Graduation year ^b	0.94 (0.91–0.98)	0.95 (0.92–0.97)	0.76 (0.73–0.79)
Gender			
Men	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Women	0.81 (0.67–0.98)	0.99 (0.90–1.10)	0.59 (0.49–0.71)
Race/ethnicity			
White	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Black	0.48 (0.28–0.82)	0.56 (0.43–0.72)	0.48 (0.28–0.82)
Hispanic	0.70 (0.43–1.13)	0.68 (0.52–0.88)	0.76 (0.49–1.20)
Asian/Pacific Islander	1.58 (1.30–1.90)	0.98 (0.87–1.10)	1.02 (0.83–1.25)
Research-intensive medical school			
No	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Yes	2.24 (1.86–2.70)	2.50 (2.25–2.78)	1.91 (1.58–2.30)
Medical-school research activities			
No research activities	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Research elective only	1.52 (1.13–2.05)	1.51 (1.27–1.79)	1.02 (0.74–1.41)
Authorship only	1.38 (0.76–2.49)	1.73 (1.27–2.35)	1.35 (0.78–2.36)
Both activities	1.92 (1.47–2.51)	2.51 (2.16–2.92)	2.00 (1.54–2.61)
Missing	2.56 (0.57–11.56)	1.54 (0.61–3.88)	1.28 (0.26–6.38)
Career intention at graduation			
Research-related	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Full-time clinical practice	0.21 (0.16–0.28)	0.13 (0.11–0.16)	0.24 (0.18–0.32)
Other/undecided	0.32 (0.23–0.43)	0.29 (0.25–0.34)	0.50 (0.37–0.67)
Missing	0.54 (0.23–1.26)	0.24 (0.13–0.45)	0.80 (0.38–1.66)
Degree program			
MD	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
MD-other-advanced	2.44 (1.46–4.07)	1.99 (1.45–2.73)	1.06 (0.54–2.09)
MD-PhD	2.32 (1.55–3.48)	4.52 (3.74–5.44)	3.10 (2.26–4.25)
Missing	0.62 (0.18–2.20)	1.97 (0.96–4.02)	1.04 (0.26–4.06)
Specialty for board certification at graduation			
Internal medicine	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Family medicine	0.11 (0.04–0.29)	0.11 (0.06–0.20)	0.71 (0.40–1.26)
Pediatrics	0.64 (0.46–0.88)	1.00 (0.86–1.16)	0.75 (0.54–1.03)
Obstetrics/gynecology	0.11 (0.04–0.29)	0.21 (0.14–0.31)	0.94 (0.55–1.58)
Surgery	0.68 (0.54–0.87)	0.12 (0.10–0.15)	0.34 (0.23–0.50)
All other specialties	0.17 (0.12–0.24)	0.33 (0.28–0.38)	0.99 (0.78–1.26)
No/undecided	0.62 (0.42–0.90)	0.54 (0.44–0.68)	1.57 (1.10–2.25)
Missing	0.52 (0.19–1.40)	0.60 (0.34–1.06)	0.84 (0.33–2.10)

Predictor Variables	Model 1: F32 AOR (95% CI)	Model 2: Mentored-K AOR (95% CI)	Model 3: R01 AOR (95% CI)
F32 award			
No	----	1.00 [Reference]	1.00 [Reference]
Yes	----	10.27 (8.12–12.98)	2.21 (1.49–3.28)
K award			
No	----	----	1.00 [Reference]
Yes	----	----	30.09 (24.60–36.81)

USMLE = United States Medical Licensing Examination; AOR = adjusted odds ratio; CI = confidence interval.

^a All 95% CIs that do not include 1.00 are statistically significant at $P < .05$.

^b AOR < 1.00 indicates lower likelihood of award receipt with each more-recent graduation year.

Table 5

Multivariable logistic regression models identifying variables independently associated with each award type, adjusted for USMLE Step 1 score deciles (N=117 119)^a

Predictor Variables	Model 1: F32 AOR (95% CI)	Model 2: Mentored-K AOR (95% CI)	Model 3: R01 AOR (95% CI)
USMLE Step 1 score ^b	1.12 (1.08–1.17)	1.16 (1.13–1.18)	1.10 (1.06–1.14)
Graduation year ^c	0.92 (0.89–0.96)	0.92 (0.90–0.94)	0.74 (0.71–0.78)
Gender			
Men	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Women	0.87 (0.72–1.05)	1.08 (0.97–1.19)	0.62 (0.51–0.75)
Race/ethnicity			
White	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Black	0.65 (0.38–1.13)	0.82 (0.62–1.07)	0.62 (0.36–1.08)
Hispanic	0.84 (0.52–1.36)	0.86 (0.66–1.11)	0.87 (0.55–1.37)
Asian/Pacific Islander	1.66 (1.37–2.00)	1.04 (0.93–1.17)	1.06 (0.86–1.30)
Research-intensive medical school			
No	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Yes	2.00 (1.66–2.42)	2.17 (1.95–2.42)	1.74 (1.43–2.10)
Medical-school research activities			
No research activities	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Research elective only	1.50 (1.11–2.01)	1.49 (1.26–1.77)	1.03 (0.75–1.41)
Authorship only	1.38 (0.77–2.50)	1.75 (1.29–2.39)	1.35 (0.78–2.36)
Both activities	1.89 (1.45–2.48)	2.48 (2.13–2.88)	2.00 (1.54–2.60)
Missing	2.62 (0.58–11.73)	1.64 (0.65–4.12)	1.29 (0.26–6.30)
Career intention at graduation			
Research-related	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Full-time clinical practice	0.23 (0.18–0.31)	0.15 (0.13–0.18)	0.26 (0.19–0.35)
Other/undecided	0.34 (0.25–0.46)	0.32 (0.27–0.38)	0.53 (0.39–0.70)
Missing	0.57 (0.24–1.35)	0.26 (0.14–0.49)	0.83 (0.39–1.75)
Degree program			
MD	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
MD-other-advanced	2.49 (1.49–4.16)	2.06 (1.50–2.84)	1.10 (0.56–2.17)
MD-PhD	2.37 (1.58–3.55)	4.64 (3.84–5.60)	3.25 (2.36–4.46)
Missing	0.62 (0.18–2.15)	1.88 (0.92–3.83)	1.05 (0.27–4.03)
Specialty for board certification at graduation			
Internal medicine	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Family medicine	0.12 (0.05–0.33)	0.13 (0.07–0.23)	0.78 (0.44–1.39)
Pediatrics	0.68 (0.49–0.94)	1.08 (0.93–1.26)	0.79 (0.57–1.08)
Obstetrics/gynecology	0.11 (0.04–0.31)	0.22 (0.15–0.33)	0.98 (0.58–1.66)
Surgery	0.67 (0.52–0.85)	0.12 (0.09–0.15)	0.33 (0.22–0.49)
All other specialties	0.17 (0.12–0.24)	0.34 (0.29–0.39)	1.02 (0.80–1.30)
No/undecided	0.66 (0.45–0.97)	0.59 (0.48–0.74)	1.65 (1.15–2.36)

Predictor Variables	Model 1: F32 AOR (95% CI)	Model 2: Mentored-K AOR (95% CI)	Model 3: R01 AOR (95% CI)
Missing	0.54 (0.20–1.47)	0.64 (0.36–1.14)	0.86 (0.34–2.19)
F32 award			
No	----	1.00 [Reference]	1.00 [Reference]
Yes	----	9.53 (7.53–12.07)	2.17 (1.46–3.21)
K award			
No	----	----	1.00 [Reference]
Yes	----	----	28.08 (22.94–34.38)

USMLE = United States Medical Licensing Examination; AOR = adjusted odds ratio; CI = confidence interval.

^a All 95% CIs that do not include 1.00 are statistically significant at $P < .05$.

^b AOR > 1.00 indicates greater likelihood of award receipt with each decile increase in Step 1 scores.

^c AOR < 1.00 indicates lower likelihood of award receipt with each more-recent graduation year.