Sex Differences Among Career Development Awardees in the Attainment of Independent Research Funding in a Department of Medicine

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Abstract

Background: National data suggest that women are overall less likely than men to attain independent research funding. However, it remains unclear whether such sex differences are also observed in academic institutions that have integrated diversity in the workplace as a priority.

Methods: During 1999–2008, all National Institutes of Health (NIH) Career Development (K01, K08, or K23) awardees in the Department of Medicine at Johns Hopkins University School of Medicine were identified to investigate differences in the attainment of independent funding by sex, including NIH Research Project Grant (R01) or equivalent awards, (U01, P01, P50), and any R award (also R03, R21, R34) through 2012.

Results: A similar number of men ($n=49$) and women ($n=43$) received a K award. There were no significant sex differences in attaining an R01/equivalent award or any R award. The median time to attaining the first R01/equivalent award was similar for men and women (5.6 vs. 5.3 years, $p=0.93$). The actuarial rate of R01/equivalent award attainment at 10 years was 64% overall (56% among men vs. 74% among women; log-rank $p=0.41$). For any R award, the rate was 72% overall (70% among men vs. 76% among women; log-rank $p=0.63$). In Cox proportional hazards models, adjusting for race/ethnicity, age, Doctor of Medicine (MD) degree, and funding period, sex was not an independent predictor of R01/equivalent or any R award attainment. Interestingly, black race and/or Hispanic ethnicity significantly predicted any R award attainment (adjusted hazard ratio [HR]=2.34, 95% confidence interval [CI] 1.02–5.37).

Conclusions: No sex differences were found in the attainment of independent funding by K awardees in our study. Future studies to investigate the impact of specific diversity initiatives on subsequent success in attaining independent research funding are needed.

Introduction

WOMEN REPRESENTED APPROXIMATELY one-third of the active physician workforce in the United States in 2013, and although the proportion has increased over time,¹ they remain in the minority in academic medicine.² The American Association of Medical Colleges (AAMC) reported that in 2013–2014, women constituted 38% of full-time medical school faculty but only 21% of full professors, 15% of department chairs, and 16% of deans, without much change compared to the previous 5 years.³ There may be multiple reasons for the low proportion of women in the senior ranks of academic medicine.⁴ Persons in these senior positions may have attended medical school at a time when

women were underrepresented.⁵ Only 27% of all Doctor of Medicine (MD) degrees in 1982–1983 were awarded to women, compared to a rise of 48% in 2010–2011.³ Further, past studies had reported a decline in the research intentions of graduating medical students, particularly among women.⁶ As a result, it has been unclear whether women with a demonstrated commitment to research succeed at the same rate as their male counterparts.

Clinician-scientist recipients of Career Development (K) awards from the National Institutes of Health (NIH) may be a particularly informative group for understanding the career trajectory of female research faculty. These K01, K08, and K23 awards, which are intended to support the career development of researchers who hold medical degrees or

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doctorates, are highly competitive grants given to young physicians or doctoral graduates and provide protected time for awardees to participate in research and career development under the guidance of an experienced mentor. It is anticipated that recipients of these awards will eventually advance and establish independent research careers. Arguably, a key indicator of such independence is subsequent success in obtaining an NIH Research Project Grant (R01) award.

A study from 2009 examined the subsequent transition to R01 funding among K awardees from the United States.⁷ That study reported a lower rate of independent funding attainment among women at 5 years (18.8% in women vs. 24.8% in men, $p < 0.001$) and similar differences at 10 years. The study also found sex to be a significant independent predictor of R01 award attainment, with women being 21% less likely to attain an R01.⁷ In addition, K award recipients at higher-tier NIH funding institutions were significantly less likely to have women represented. However, at academic institutions with several long-standing efforts to promote diversity in the workplace, it remains unclear whether the attainment of independent funding also differs by sex.

We sought to examine the rates at which men and women with mentored K awards attained independent funding in the Department of Medicine (DOM) at our institution, the Johns Hopkins University School of Medicine, Baltimore, MD. The hypotheses of our study were that no sex differences exist: (1) in the rate of R01 (or equivalent) attainment among K awardees, (2) in the rate of any R grant award attainment among K awardees, and (3) in the attainment of independent funding by race/ethnicity categories among K awardees.

Materials and Methods

Study population

We identified recipients of new K01, K08, and K23 awards in the Johns Hopkins University School of Medicine DOM, based on institutional grants reports and databases from the institution's Office of Research Administration. K awardees were identified between the years 1999–2008 for the three types of K awards most widely used.⁸ Funding start and end dates, type of award, and funding institute of K awards were then verified by a grants specialist (author TC) in the DOM-sponsored projects office, using institutional access to the NIH Electronic Research Administration (eRA) Commons database. For our study, 92 faculty members (49 men, 43 women) met the criteria, and all eligible faculty members were included in our analyses. Attainment of independent funding was determined by searching the NIH eRA Commons database, using institutional access for each individual K awardee to identify the subsequent attainment of independent funding, including R01, R01 equivalents (Opportunities for Collaborative Research at the NIH [U01], NIH Research Program Projects and Centers [P01, P50]), and any R award (also includes R03, R21, R34), based on annual grant updates in the database through 2012. Independent grant-award details were then verified by our grants specialist, using institutional grant reports generated for these same time intervals to confirm that the awards were accepted by the institution.

We extracted demographic information provided by faculty members on appointment (or departure) to the DOM credentialing office. Race/ethnicity was categorized as fol-

lows: white, black or Hispanic, and Asian. Possible female surname change was accounted for in our tracking database.

Statistical analyses

We performed descriptive analyses using chi-squared tests (or Fisher's exact test) for proportions and Student's *t*-test for continuous variables (mean $\pm$ standard deviation [SD]) to compare differences in demographic and award characteristics among men vs. women. The median time to attainment of a K awardee's first R01 or equivalent award was defined as the month and year of K award receipt subtracted from the month and year of R01 award receipt. We used Kaplan-Meier curves to construct estimates of the probability of the receipt of an R01 or equivalent (or any R) after K award receipt through the 2012 award cycle, by sex. We censored recipients from analyses if they departed the institution; no recipients had other competing events (i.e., death) during this period. For K awardees who received multiple R01 awards, the date of first R01 award (in month and year) was considered the event for analysis. We used the log-rank test to assess differences in attainment of R01 awards between male and female K award recipients. We constructed a multivariable Cox proportional hazards model to determine whether sex was an independent predictor of an R01 or equivalent award, or any R award, as follows: Model 1: adjusted for demographic characteristics (sex, age at K award, race/ethnicity); Model 2: adjusted for all variables in Model 1 plus funding period (early [1999–2003] vs. late [2004–2008]) and the presence of MD degree. A *p*-value < 0.05 was considered to be statistically significant. Data were analyzed using Stata/SE Version 12.0 (StataCorp., College Station, TX).

Results

We identified 49 men and 43 women who received a K01, K08, or K23 award from 1999–2008 in the DOM. Men constituted 53% and women constituted 47% of K awardees during this time. Table 1 shows the demographic characteristics of these K awardees by sex. The mean age at receipt of K award was significantly higher in men than in women (37.2 ± 0.53 years vs. 35.6 ± 0.41 years, $p = 0.03$). The median duration of K awards was approximately 5 years and similar by sex ($p > 0.05$). Race/ethnicity significantly differed by sex, with a higher proportion of whites in men (73%) vs. women (58%), $p = 0.03$. Most K award recipients had an MD degree (92%), and a notable proportion had a Doctor of Philosophy (PhD) degree (29%), without differences by sex. A total of 20 faculty members ($n = 22\%$) had both an MD and a PhD. Faculty award recipients spanned various subspecialties, with the greatest representation, not surprisingly, mostly from larger divisions, including pulmonary ($n = 23$), infectious diseases ($n = 17$), general internal medicine ($n = 9$), and rheumatology ($n = 9$).

As shown in Table 1, there were higher numbers of K award recipients in the late (2004–2008) vs. early (1999–2003) funding period for women and similar numbers between the time periods for men, though differences were not statistically significant. Among all recipients, K23 awards were the most common (52%), followed by K08 (37%) and K01 awards (11%), without differences by sex. The awarding institutes with the greatest number of recipients included the National Heart, Lung, and Blood Institute (NHLBI), $n = 30$;

TABLE 1. CHARACTERISTICS OF CAREER DEVELOPMENT AWARDEES BY SEX, 1999–2008

	Total n = 92	Men n = 49	Women n = 43	p-value
Age at K award (years) ^a	36.4 (0.35)	37.2 (0.53)	35.4 (0.41)	0.03
Median duration of K award (years) ^b	5 (4.9–5.9)	5 (4.9–5.9)	5 (4.9–6.0)	0.98
Race/ethnicity				0.03
White	61 (66%)	36 (73%)	25 (58%)	
Black/Hispanic	9 (10%)	1 (2%)	8 (19%)	
Asian	22 (24%)	12 (24%)	10 (23%)	
MD degree	85 (92%)	45 (92%)	40 (93%)	0.83
PhD degree	27 (29%)	16 (33%)	11 (26%)	0.46
K award year start date				0.51
Early (1999–2003)	44 (48%)	25 (51%)	19 (44%)	
Late (2004–2008)	48 (52%)	24 (49%)	24 (56%)	
Type of K award				0.72
K08	34 (37%)	20 (41%)	14 (33%)	
K23	48 (52%)	24 (49%)	24 (56%)	
K01	10 (11%)	5 (10%)	5 (12%)	
Division/Specialty				0.76
Allergy and clinical immunology	3 (3%)	2 (4%)	1 (2%)	
Cardiology	8 (9%)	4 (9%)	4 (8%)	
Endocrinology, diabetes, & metabolism	5 (5%)	1 (2%)	4 (9%)	
Gastroenterology and hepatology	6 (7%)	4 (8%)	2 (5%)	
General internal medicine	9 (10%)	3 (6%)	6 (14%)	
Geriatric medicine and gerontology	6 (7%)	3 (6%)	3 (7%)	
Hematology	2 (2%)	1 (2%)	1 (2%)	
Infectious diseases	17 (18%)	8 (16%)	9 (20%)	
Nephrology	4 (4%)	3 (6%)	1 (2%)	
Pulmonary and critical care	23 (25%)	14 (28%)	9 (21%)	
Rheumatology	9 (10%)	6 (12%)	3 (7%)	
Institute of K award				0.43
AHRQ	1 (1%)	0	1 (2%)	
Fogarty	1 (1%)	0	1 (2%)	
HRSA	5 (5%)	2 (4%)	3 (7%)	
NCCAM	1 (1%)	1 (2%)	0	
NCI	1 (1%)	1 (2%)	0	
NCRR	1 (1%)	1 (2%)	0	
NHLBI	30 (33%)	17 (35%)	13 (30%)	
NIA	2 (2%)	2 (4%)	0	
NIAAA	3 (3%)	0	3 (7%)	
NIAID	14 (15%)	9 (18%)	5 (12%)	
NIAMS	8 (9%)	5 (10%)	3 (7%)	
NICHD	2 (2%)	1 (2%)	1 (2%)	
NIDA	5 (5%)	2 (4%)	3 (7%)	
NIDDK	13 (14%)	7 (14%)	6 (14%)	
NIEHS	2 (2%)	0	2 (5%)	
NIGMS	1 (1%)	1 (2%)	0	
NIMH	1 (1%)	0	1 (2%)	
NINDS	1 (1%)	0	1 (2%)	
Received an R01 award or equivalent ^c	34 (37%)	16 (33%)	18 (42%)	0.36
Received any R grant ^d	44 (48%)	22 (45%)	22 (51%)	0.54
Departed from institution	33 (36%)	22 (45%)	11 (26%)	0.05

^amean (SD).^bmedian (IQR).^cIncludes R01 or equivalent (P01, P50, U01) as a PI.^dIncludes R01 award or equivalent, R03, R21, R34 as a PI.

AHRQ, Agency for Healthcare Research & Quality; HRSA, Health Resources and Services Administration; IQR, interquartile range; K, NIH Career Development award; MD, Doctor of Medicine; NCCAM, National Center for Complementary and Alternative Medicine; NCI, National Cancer Institute; NCRR, National Center for Research Resources; NHLBI, National Heart, Lung, and Blood Institute; NIA, National Institute on Aging; NIAAA, National Institute on Alcohol Abuse and Alcoholism; NIAID, National Institute of Allergy and Infectious Diseases; NIAMS, National Institute of Arthritis and Musculoskeletal and Skin Diseases; NICHD, National Institute of Child Health and Human Development; NIDA, National Institute on Drug Abuse; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NIEHS, National Institute of Environmental Health Sciences; NIGMS, National Institute of General Medical Sciences; NIH, National Institutes of Health; NIMH, National Institute of Mental Health; NINDS, National Institute of Neurological Disorders and Stroke; P, NIH Research Program Projects and Centers; PhD, Doctor of Philosophy; PI, principal investigator; R, NIH Research Project Grant; SD, standard deviation; U01, Opportunities for Collaborative Research at the NIH.

National Institute of Allergy and Infectious Diseases (NIAID), $n=14$; and National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), $n=13$.

From the year of K award receipt through 2012, 37% of the K awardees received an R01 or equivalent (U01, P01, P50) award, without significant differences between men and women (33% vs. 42%, $p=0.36$ [Table 1]). Similarly, 48% of K awardees received any R grant as principal investigator (PI) (i.e., R03, R21, R34), with no significant differences between men and women (45% vs. 51%, $p=0.54$).

Over the 14-year period, a higher proportion of men ($n=22$, 45%) vs. women ($n=11$, 26%) left the institution ($p=0.05$). The majority of departing faculty members were still funded by their K award on leaving the institution ($n=20$ out of 33, 60%), followed by those who had completed their K award but not yet attained any R grant ($n=8$, 24%) and those who had completed their K award and had successfully attained an R grant ($n=5$, 15%).

Figure 1 shows the actuarial rates of R01 or equivalent award attainment among K awardees by sex. The median time to attainment of a K awardee's first R01 or equivalent award was 5.6 years for men and 5.3 years for women, without significant differences by sex (p -value=0.93). The actuarial rate of R01 or equivalent award attainment at 5 years was 15% overall: 12% among men and 19% among women. At 10 years, the rate was 64% overall: 56% among men and 74% among women for R01 or equivalent award attainment. There was no difference of R01 or equivalent award attainment by sex during follow-up (log-rank p -value=0.41). For any R award (Fig. 2), the actuarial rate of

FIG. 1. Kaplan-Meier curves demonstrate the probability of National Institutes of Health Research Project Grant (R01) or equivalent award attainment among Career Development (K) awardees for men and women, in years from the start date of the K award. The number of awardees who have not yet attained independent funding during follow-up (those still “at risk”) is also shown for men and women at every year. The actuarial rate of R01 or equivalent award attainment at 5 years was 15% overall: 12% among men and 19% among women. At 10 years, the rate was 64% overall: 56% among men and 74% among women for R01 or equivalent award attainment. There was no difference of R01 or equivalent award attainment by sex during follow-up (log-rank p -value=0.41).

FIG. 2. Kaplan-Meier curves demonstrate the probability of any R award attainment among K awardees for men and women, in years from the start date of the K award. The number of awardees who have not yet attained independent funding during follow-up (those still “at risk”) is also shown for men and women at every year. For any R award, the actuarial rate of attainment at 5 years among K awardees was 28% overall: 23% among men and 32% among women. At 10 years, the rate was 72% overall: 70% among men and 76% among women for any R award attainment. There was no difference of any R award attainment by sex during follow-up (log-rank p -value=0.63).

attainment at 5 years among K awardees was 28% overall: 23% among men and 32% among women. At 10 years, the rate was 72% overall: 70% among men and 76% among women for any R award attainment. There was no difference of any R award attainment by sex during follow-up (log rank p -value=0.63). Of note, one male faculty member had an R03 award prior to attainment of a K award and thus was not included in the Kaplan-Meier curves.

In Cox proportional hazards model, adjusting for sex, race/ethnicity, and age at K award, sex was not a predictor of either an R01 or equivalent award or any R award (Model 1, Table 2). Interestingly, however, black/Hispanic race/ethnicity compared to white race was a nonsignificant predictor of R01 or equivalent award (adjusted hazard ratio [HR]=1.86, 95% confidence interval [CI] 0.72–4.77) and a significant predictor of any R award attainment (adjusted HR=2.57, 95% CI 1.14–5.80). After accounting for the presence of an MD degree and award funding period, black/Hispanic race/ethnicity remained a significant predictor of any R award attainment (adjusted HR=2.34, 95% CI 1.02–5.37, Model 2). Faculty members with an MD degree were 72% less likely to obtain an R01 or equivalent award (adjusted HR=0.28, 95% CI 0.10–0.79) and 76% less likely to obtain any R award (adjusted HR=0.24, 95% CI 0.10–0.56).

Discussion

In our study of K award recipients through 2012, fewer than one-fifth of K award recipients received R01 funding or equivalent by 5 years, but three-fifths of those had done so by 10 years. These results are somewhat higher than previously reported for attainment of R01 awards alone⁷ but remain

TABLE 2. HAZARDS MODEL OF R01 OR EQUIVALENT AND ANY R AWARD ATTAINMENT

	<i>R01 or equivalent award^a</i>		<i>Any R award^b</i>	
	<i>Model 1 HR (95% CI)</i>	<i>Model 2 HR (95% CI)</i>	<i>Model 1 HR (95% CI)</i>	<i>Model 2 HR (95% CI)</i>
Sex				
Women	1.00	1.00	1.00	1.00
Men	0.87 (0.43–1.79)	0.79 (0.38–1.64)	0.98 (0.52–1.82)	0.97 (0.52–1.82)
Race/ethnicity				
White	1.00	1.00	1.00	1.00
Black/Hispanic	1.86 (0.72–4.77)	1.75 (0.68–4.50)	2.57 (1.14–5.80) ^c	2.34 (1.02–5.37) ^c
Asian	0.69 (0.26–1.84)	0.57 (0.21–1.58)	0.74 (0.30–1.78)	0.74 (0.30–1.79)
Age at K award	0.97 (0.86–1.09)	0.95 (0.84–1.08)	1.00 (0.90–1.10)	0.98 (0.88–1.09)
MD degree				
No		1.00		1.00
Yes		0.28 (0.10–0.79) ^c		0.24 (0.10–0.56) ^d
Funding period				
Early		1.00		1.00
Late		0.71 (0.35–1.46)		0.90 (0.48–1.71)

^aR equivalent includes R01, U01, P01, P50 as a PI.^bAny grant includes R01 equivalent or R03, R21, R34.^c $p < 0.05$.^d $p \leq 0.001$.

CI, confidence interval; HR, hazard ratio.

concerning because significant funding gaps persist. In comparison to national data that report sex differences in attainment of independent funding,⁷ we found no sex differences in attainment of independent funding among K award recipients in the DOM at our institution. As noted, efforts to increase diversity within the DOM were a priority, resulting in the implementation of many long-standing programs to promote research success. Further, ethnic minorities (blacks or Hispanics) were approximately twofold more likely to obtain any R award compared to white faculty members in our study, a notable finding in comparison to older studies suggesting that minority faculty members are otherwise promoted at lower rates compared to whites.⁹ However, this finding may more broadly reflect recent national trends and warrants further investigation.

In 2012, 209 faculty members were in the DOM at the assistant professor level, including 95 females (45%) and 17 blacks or Hispanics (8%). Overall, there was a relatively similar representation of junior faculty men and women. The Task Force on Women's Academic Careers in Medicine, formed in the DOM at our institution in 1990 to investigate gender-specific obstacles to advancement and implement solutions, was recognized by the AAMC with a 2013 Women in Medicine Leadership Development Award for an Organization. Task Force initiatives have included salary-equity analyses, surveys of meeting times outside of usual work hours, reviews of representation in leadership, an annual keynote address by a distinguished female visiting professor, and a program to mentor trainees. About a decade later, in 2002, the Diversity Council in the DOM was formed, with multiple initiatives to increase the pipeline of underrepresented minorities and those from disadvantaged backgrounds, including a visiting minority medical student clerkship program. Around the same time, awards for faculty mentoring were introduced at the DOM's annual retreat. Mentoring has been recognized as an important mechanism

by which to combat disparities in the professions and to substantively advance academic careers for women faculty members, in particular.^{10–14} Further, at annual divisional reviews with the chairman of the DOM, representatives from both the Women's Task Force and the Diversity Council attended, with the explicit goal of reviewing diversity of faculty, particularly in leadership positions. Although the DOM had several long-standing efforts to promote diversity over the past few decades, our study was not designed to explicitly investigate the impact of these programs but instead to characterize whether sex differences currently exist in the attainment of independent funding. Further intervention studies that examine the effects of specific diversity initiatives on research success are required in the future.

Perhaps not surprisingly, we found that having an MD degree was associated with a lower likelihood of attaining independent funding. During times of gap funding, faculty members with MDs can typically increase clinical practice time, whereas a similar option is not present for faculty members with PhDs after completion of training.¹⁵ Indeed, K23 awards were first established in 1999 by the NIH in response to reports that medical school students' aspirations to pursue a research career had declined, continued downward trends in the number of MDs with NIH training and fellowships, and concerns that the future of the physician-scientist career path was at risk.^{6,16–19} Reasons for the continued reported lower success rate of MDs reported in our study should be further explored.

Among K awardee recipients in our study, we found that women were significantly younger than men. Age differences by sex were not reported in previous studies of K awardees.^{8,20} The reasons for this finding are not clear and should be investigated in the future.

The limitations of our study are that we focused on K awardee recipients from a single institution, which may limit generalizability of our findings. Comparative studies from

similar institutions are needed. Nonetheless, our findings challenge national data by suggesting that sex differences in attainment of independent funding are not apparent at all institutions. It is also possible that the reduced sex differences observed in our study reflect a more general national trend toward reduced sex differences in the attainment of independent funding rather than specific efforts within the DOM at our institution. Future studies are needed to compare the results of our study with national data over more recent years and with findings from other institutions that have implemented diversity programs. Given that efforts to promote diversity in the DOM have been integrated as a priority over decades, we did not have baseline data to examine whether the lack of sex differences observed was owing to departmental diversity efforts or could be explained by other factors. Further rigorous studies to investigate potential explanatory factors are needed.

By focusing on K awardees, we also could not examine sex differences among recipients of career development awards from professional scientific societies or KL2 awardees, who may have directly transitioned to R01 awards. We did not have data on the number of grant applications submitted or whether both sexes were equally likely to succeed in the review process. Previous studies have found that success and funding rates were generally similar by sex, although application rates may be higher for men.^{8,20–22} Our study also does not give insight into potential sex differences in other equally rewarding non-R01 award career trajectories, such as grants from private foundations or industry or leadership positions in their institution. However, since the R01 award is the most common grant award given by the NIH, receipt of such an award is considered an important milestone. Our study also did not investigate whether funding amounts were similar by sex, as this information was not readily available in the institutional database we used, though previous studies have suggested that women's awards are smaller.⁷ Ongoing NIH budgetary restraints may also render such data difficult to interpret. Nonetheless, sex differences in funding award amounts should be explored in future studies.

The strengths of our study included the ability to examine demographic and award characteristics of individual K awardees and relationship to attainment of independent funding, since our study was conducted within a single institution and we had availability of this individual-level information. We also had a relatively longer duration of follow-up compared to previous studies⁷ and were able to analyze both attainment of R01 or equivalent awards or any R awards in our analyses.

In conclusion, we found no sex differences in the attainment of independent funding by men and women in the DOM at our institution. The results of our study do not detract from the importance of previously recognized barriers to research success that may be unique for women, such as less high-quality mentoring, inadequate protected research time, subconscious sex biases, biological constraints of fertility, and challenging societal expectations regarding distribution of domestic responsibilities. In fact, in 2007, the Association of Professor of Medicine's Physician-Scientist Initiative recommended that institutions should actively promote the advancement and minimize attrition of women in physician-scientist careers.²² Instead, our study suggests that disparities may be eliminated and that research success in these tradi-

tionally less successful groups may be possible in a department of medicine. Initiatives to eliminate sex differences should be explored at other institutions and can inform efforts to promote diversity at the workplace in the future.

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