Factors Associated With Success of Clinician–Researchers Receiving Career Development Awards From the National Institutes of Health: A Longitudinal Cohort Study

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Abstract

Purpose
Understanding the careers of recent career development awardees is essential to guide interventions to ensure gender equity and success in academic medicine.

Method
In 2010–2011 (T1) and 2014 (T2), 1,719 clinician–researchers who received new K08 and K23 awards in 2006–2009 were longitudinally surveyed. Multivariable analyses evaluated the influence of factors on success, including demographics, job characteristics, work environment, priorities, and domestic responsibilities.

Results
Of 1,275 respondents at T1, 1,066 (493 women; 573 men) responded at T2. Men and women differed in job characteristics, work environment, priorities, and domestic responsibilities. By T2, women had less funding (mean $780,000 vs. $1,120,000, $P = .002$) and published fewer papers (mean 33 vs. 45). Using a composite measure that considered funding, publications, or leadership to define success, 53.5% (264/493) of women and 67.0% (384/573) of men were successful. Gender differences in success persisted after accounting for other significant predictors—K award type, specialty, award year, work hours, funding institute tier, feeling responsible for participating in department/division administration, importance of publishing prolifically, feeling responsible for contributing to clinical care, importance of publishing high-quality research, collegiality of the mentoring relationship, adequacy of research equipment, and departmental climate. A significant interaction existed between K award type and gender; the gender difference in success was most pronounced among K23 researchers (among whom the odds ratio for females = 0.32).

Conclusions
Men and women continue to have different experiences and career outcomes, with important implications for the design of interventions to promote equity and success.

Concerns abound regarding the physician–scientist pipeline in the United States,[1] particularly given the increasingly competitive funding environment.[2,3] Prior research has demonstrated that fewer than half of the recipients of prestigious K series career development awards from the National Institutes of Health (NIH) from 1997 to 2003 went on to achieve independent R01 awards, and women fared worse than men.[4] A prior survey study from our group demonstrated that gender differences in outcomes persisted in that older cohort even when considering a broader definition of success that included other grant funding, publication track record, or administrative leadership, but the cross-sectional nature of that evaluation precluded ascertainment of what other factors influenced success and whether they might have mediated the relationship between gender and success.[5]

Research and commentary have identified a number of factors that may influence the success of clinicians who pursue research careers in academic medicine and that might mediate gender differences in outcomes that cannot be explained by differences in basic job characteristics. These include mentorship,[6–14] access to resources,[15,16] time allocation, and other aspects of the work environment.[17–20] They also include competing demands in the domestic sphere,[21–26] along with the priorities of the individuals themselves.[27]

To investigate the outcomes of a recent cohort of clinician–researchers whose careers have evolved after the economic downturn and the restriction of funding for biomedical research, we surveyed a cohort of clinician–researchers who received new K08 and K23 career development awards in 2006 through 2009. We employed a longitudinal design to allow for the evaluation of the influence of various factors on success, including demographics, basic job characteristics, the work environment, priorities, and domestic responsibilities. We have previously reported findings regarding the baseline characteristics of this sample[6,15,25]; this report constitutes the analysis of the primary objective of the longitudinal study, which was funded by the NIH through an R01 research grant.

Method

Survey sampling and administration

Using the NIH RePORTER database, we identified 1,719 clinician–researchers who received new K08 and K23 awards in 2006–2009. After gaining approval from the University of Michigan institutional review board, we conducted Internet searches and made telephone calls to obtain background information and current U.S. mailing addresses for these recipients.

In 2010–2011 (hereinafter called T1), we conducted a baseline survey of 1,708 clinician–researchers who received NIH

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K08 and K23 awards in 2006–2009, and for whom we were able to obtain valid U.S. mailing addresses. We mailed a paper survey along with a $50 incentive. We used a modified Dillman approach[28] to remind nonrespondents and maximize response rates. We received 1,275 responses (75% response rate).

Approximately four years later (in 2014, hereinafter called T2), we conducted a follow-up survey, administered exclusively to the 1,275 respondents to the initial questionnaire, such that all individuals with T2 data also had T1 data available for analysis. Prior to distributing this follow-up survey, we once again conducted Internet searches and made telephone calls to obtain current contact information. We were able to verify current U.S. mailing addresses for 1,258 out of the 1,275 who responded to our initial survey mailing. We mailed the paper follow-up survey questionnaire along with a $50 incentive and received 1,066 responses (85% response rate).

Study data were managed using REDCap electronic data capture tools hosted at the University of Michigan. REDCap (Research Electronic Data Capture)[29] is a secure, Web-based application designed to support data capture for research studies, providing an intuitive interface for validated data entry; audit trails for tracking data manipulation and export procedures; automated export procedures for seamless data downloads to common statistical packages; and procedures for importing data from external sources.

Survey design and measures

We designed the two survey questionnaires after consideration of the published literature and previous instruments used to determine the characteristics and outcomes of academic careers. After developing a conceptual model that identified hypothesized relationships between key constructs, we conducted additional literature review to identify measures of those constructs and followed standard techniques of survey design and validation where existing measures were insufficient. This included intensive cognitive pretesting of the entire survey instruments with individuals similar to the intended target population, using verbal probing and think-aloud reasoning. Both questionnaires were 12-page booklets (Supplemental Digital Appendices 1 and 2, http://links.lww.com/ACADMED/A450).

T2 outcomes. Our primary dependent variable of interest was a composite measure of success measured at T2. This was defined as in our previous work as having accomplished any one or more of the following: attainment of > $1 million in grant funding as principal investigator (PI), publication of 35 or more peer-reviewed articles, or administrative leadership (service as dean, department chair, or division chief).

We also evaluated the individual components of the composite success measure separately (grant funding, publications, and leadership), along with several other measures of outcome at T2: academic rank, promotion (defined as increase in academic rank from T1 to T2), laboratory space, research time, and the individual's own perceptions of his or her success. We assessed whether respondents left or considered leaving the institutions at which they received their K awards, along with the reasons for this. We also evaluated whether respondents remained at T2 in the same jobs they had at T1 or whether they had changed institutions or careers.

T1 characteristics. We defined five categories of independent variables measured in the survey at T1: demographics, basic job characteristics, aspects of the work environment, priorities, and domestic responsibilities.

Demographic characteristics included gender, age, and race. Basic job characteristics included K award type (K08 vs. K23 to distinguish those pursuing basic science research from those pursuing patient-oriented research), year of K award (2006–2009), NIH funding institute tier (broken into three tiers as defined as in our previous work based on the total amount of R01 awards granted by the institute that funded the individual's K award), institution tier (broken into four tiers as defined in our previous work based on the NIH funding ranking of the individual's academic institution), degree (whether the individual held a PhD in addition to a clinical doctorate), and specialty (grouped by nature as in our prior work).[16]

Aspects of the work environment included measures of time allocation at work (overall work hours, hours devoted to clinical care, and hours devoted to research). We also included several measures of the mentoring received by the individual: frequency of weekly contact with the primary designated K award mentor, the number of monthly hours of one-on-one contact with the primary mentor, a scaled measure of the primary mentor's behavior (defined in our previous work),[6] a scaled measure of the prestige of the primary mentor, the collegiality of the relationship with the primary mentor, and satisfaction with mentoring from all sources. We included measures of access to resources, including perceived adequacy of research space, research equipment, secretarial support, access to grant administrators, and access to statistical support. Finally, we evaluated climate with items evaluating perceptions of being treated unfairly in one's job and perceptions of the supportiveness of the individual's department/division.

Measures of individual priorities included items evaluating the extent to which the individual indicated feeling a responsibility to contribute to the teaching mission of his or her department/division, conduct his or her own research, support the research of his or her colleagues, contribute to the clinical care provided by his or her department/division, and play a role in department/division administrative issues. We also included items evaluating the importance to the individual of leadership, high-quality research, publishing prolifically, and balancing work and other activities. Finally, we included measures of preferences for time spent on patient care and time spent on research.

Domestic responsibilities were evaluated through measures of marital status, parental status, spousal employment, weekly hours devoted to parenting and domestic tasks, elder care responsibilities, and personal/family dependence on respondent's income.

Analysis

We first compared the characteristics of individuals in our analytic sample of respondents (all of whom had responded to both surveys) versus those in the initial target population who failed to respond, for those characteristics which were known in the entire target population (determined based on Internet searching). We then described the

demographics, basic job characteristics, aspects of the work environment, priorities, and domestic responsibilities reported by the analytic sample at T1 by gender.

We next evaluated whether those in our analytic sample remained at T2 in the same jobs they had at T1 or whether they had changed institutions or careers, as well as whether they had at least considered doing so. We then compared, by gender (after adjustment for basic job characteristics), the reasons for leaving or considering leaving. We described career outcomes by gender, reporting *P* values comparing these outcomes by gender after adjustment for basic job characteristics in multivariable regression models.

Next, we evaluated the extent to which the measured factors mediated the relationship between gender and the composite measure of success. To conduct this mediation analysis, we first created a logistic regression model to evaluate the unadjusted association between gender and success, and then evaluated how the coefficient for gender changed in a model that included gender and all potential mediators (those variables found to be significantly associated on univariate analysis with the outcome variable—success—as well as significantly associated on univariate analysis with the principal predictor of interest—gender).

Finally, we constructed a multiple-variable logistic regression model of the composite success outcome, after considering all of the T1 characteristics listed in the measures section and Table 1 as candidate independent variables. Interactions between gender and the demographic, basic job characteristics, and domestic responsibilities in Table 1 were screened for during the model-building process. A backward elimination process was used to select important covariates based on consideration of the Akaike information criterion,[30,31] to reduce the number of theoretically important variables to those which are most important without sacrificing explanatory power. The model started with all covariates, including significant interactions. Variables were removed iteratively and the model recalculated until only significant covariates remained. For the final model, we report the area under the receiver operator curve (AUC),

Table 1

General Characteristics Measured at Baseline (2010) Among 1,066 Respondents to a Longitudinal Survey of Recipients of New National Institutes of Health K08 and K23 Awards From 2006–2009, From a Study of Factors Associated With Clinician–Researcher Success

Characteristic, measure[a]	Women: 493 (46.2%)	Men: 573 (53.8%)	*P* value[b]
Demographics			
Age, mean (SD)	40.0 (4.7)	40.4 (3.9)	.13
Race, no. (%)			.56
Non-Hispanic white	346 (70.2)	406 (70.9)	
Asian	105 (21.3)	128 (22.3)	
Other	42 (8.5)	39 (6.8)	
Basic job characteristics, no. (%)			
K award type			< .001
K08	171 (34.7)	349 (60.9)	
K23	322 (65.3)	224 (39.1)	
K award year			.50
2006	104 (21.1)	131 (22.9)	
2007	124 (25.2)	129 (22.5)	
2008	115 (23.3)	150 (26.2)	
2009	150 (30.4)	163 (28.5)	
K award funding institute tier			< .001
First	86 (17.4)	178 (31.1)	
Second	194 (39.4)	225 (39.3)	
Third	213 (43.2)	170 (29.7)	
Institution (at time of K award) funding tier			.69
First	91 (18.5)	107 (18.7)	
Second	129 (26.2)	161 (28.1)	
Third	130 (26.4)	157 (27.4)	
Fourth	143 (29.0)	148 (25.8)	
Degree			< .001
MD	292 (59.2)	338 (59.0)	
MD/PhD	72 (14.6)	175 (30.5)	
Non-MD	129 (26.2)	60 (10.5)	
Specialty (of those with MD)			< .001
Clinical specialties for women, children, and families	116 (31.9)	108 (21.1)	
Hospital-based specialties	47 (12.9)	81 (15.8)	
Surgical specialties	10 (2.8)	51 (9.9)	
Medical specialties	189 (51.9)	272 (53.0)	
Work environment			
Work hours, mean (SD)	53.3 (9.3)	58.4 (10.5)	< .001
Work hours spent on research, mean (SD)	34.8 (11.5)	38.5 (12.1)	< .001
Work hours spent on patient care, mean (SD)	7.1 (5.8)	9.7 (7.9)	< .001
Frequency of contact with primary K award mentor, no. (%)			.68
Less than once a week	132 (26.8)	160 (27.9)	
Once a week or more	361 (73.2)	413 (72.1)	
Monthly 1:1 meeting time with mentors, mean hours (SD)	4.6 (4.2)	5.1 (4.5)	.02
Mentor Behavior Scale, mean (SD)	5.8 (5.1)	5.9 (4.9)	.46
Mentor Prestige Scale, mean (SD)	5.9 (2.3)	6.0 (2.3)	.89
Collegial relationship with mentor, no. (%)	300 (60.9)	396 (69.1)	.005

(*Table continues*)

Table 1
(Continued)

Characteristic, measure[a]	Women: 493 (46.2%)	Men: 573 (53.8%)	*P* value[b]
Overall satisfaction with mentoring from all sources, no. (%)			.59
Very/somewhat satisfied/neutral	436 (88.4)	513 (89.5)	
Very/somewhat dissatisfied	54 (11.0)	57 (10.0)	
Research space, no. (%)			.61
Less than adequate	100 (20.3)	126 (22.0)	
Adequate or better	379 (76.9)	442 (77.1)	
Research equipment, no. (%)			.70
Less than adequate	66 (13.4)	86 (15.0)	
Adequate or better	382 (77.5)	465 (81.2)	
Access to secretarial support, no. (%)			.01
Less than adequate	276 (56.0)	278 (48.5)	
Adequate or better	213 (43.2)	291 (50.8)	
Access to grant administrators, no. (%)			.001
Less than adequate	177 (35.9)	152 (26.5)	
Adequate or better	313 (63.5)	420 (73.3)	
Access to statistical support, no. (%)			.02
Less than adequate	238 (48.3)	232 (40.5)	
Adequate or better	242 (49.1)	314 (54.8)	
Have you felt you were treated unfairly at your job? no. (%)			< .001
Infrequently/never	300 (60.9)	410 (71.6)	
Regularly/frequently/sometimes	188 (38.1)	159 (27.8)	
Supportive climate of primary department, no. (%)			.13
No	173 (35.1)	177 (30.9)	
Yes	313 (63.5)	390 (68.1)	
Priorities, no. (%)			
Feel a responsibility to …			
Contribute to the teaching mission of our department/division			.89
Somewhat/a little/not at all	223 (45.2)	259 (45.2)	
A lot/quite a bit	265 (53.8)	313 (54.6)	
Conduct your own research			.43
Somewhat/a little/not at all	11 (2.2)	9 (1.6)	
A lot/quite a bit	480 (97.4)	563 (98.3)	
Support the research of your colleagues			.50
Somewhat/a little/not at all	219 (44.4)	268 (46.8)	
A lot/quite a bit	270 (53.1)	270 (54.8)	
Contribute to the clinical care provided by your department/division			.007
Somewhat/a little/not at all	210 (42.6)	201 (35.1)	
A lot/quite a bit	271 (55.0)	366 (63.9)	
Play a role in department/division administrative issues			.72
Somewhat/a little/not at all	333 (67.6)	394 (68.8)	
A lot/quite a bit	157 (31.9)	177 (30.9)	
Importance of having a department, school, or national leadership position			.18
Somewhat/not at all	320 (64.9)	351 (61.3)	
Very/quite important	169 (34.3)	220 (39.4)	

(*Table continues*)

a measure of the predictive ability of the model, with 1 being perfect prediction and 0.5 being expected from random chance. Finally, to explore whether different factors explain success in men versus women, we also constructed separate models of success for men and for women, again using backward elimination, as described earlier.

Analyses were conducted using SAS statistical software, version 9.4 (SAS Institute Inc., Cary, North Carolina); *P* values < .05 were considered significant throughout.

Results

Although response rate did not differ by gender, several other differences were observed upon comparison of the 1,066 individuals who responded to both our baseline and follow-up surveys versus the 653 who did not respond but who also received new K08 or K23 awards in 2006–2009. Specifically, response rate varied significantly by degree (69.5% [189/272] among non-MDs, 61.5% [630/1,024] among MDs, and 58.8% [247/420] among MD/PhDs, *P* = .02); K award type (58.6% [520/888] among K08s vs. 65.7% [546/831] among K23s, *P* = .002); year of K award (57.7% [235/407] for 2006, 62.0% [253/408] for 2007, 59.8% [265/443] for 2008, and 67.9% [313/461] for 2009, *P* = .01); specialty (65.8% [221/336] for women/children/families, 56.2% [123/219] for hospital-based, 61.2% [60/98] for surgical, 60.0% [443/738] for medical, 55.6% [30/54] for basic science, and 69.5% [189/272] for other, *P* = .02); K award funding institute tier (59.3% [264/445] for first, 58.8% [419/712] for second, and 68.1% [383/562] for third, *P* = .001); and K award institution tier (58.2% [198/340] for first, 59.7% [290/486] for second, 60.5% [287/474] for third, and 69.6% [279/401] for fourth, *P* = .004).

Table 1 describes the demographics, basic job characteristics, aspects of the work environment, priorities, and domestic responsibilities reported by the respondents at T1 by gender. Women and men did not differ by age or race. Several basic job characteristics did differ by gender, with 65% (322) of women holding K23s and 61% (349) of men holding K08s, suggesting that women were more likely to be among the patient-oriented researchers and men among the

Table 1
(Continued)

Characteristic, measure[a]	Women: 493 (46.2%)	Men: 573 (53.8%)	*P* value[b]
Importance of publishing high-quality research			.60
Somewhat/not at all	12 (2.4)	17 (3.0)	
Very/quite important	478 (97.0)	554 (96.7)	
Importance of publishing prolifically			.09
Somewhat/not at all	162 (32.9)	217 (37.9)	
Very/quite important	327 (66.3)	352 (61.4)	
Importance of balancing work and other activities			.002
Somewhat/not at all	20 (4.1)	50 (8.7)	
Very/quite important	471 (95.5)	521 (90.9)	
Preference about the time you spend on research			.02
Decrease	38 (7.7)	27 (4.7)	
Same	299 (60.7)	328 (57.2)	
Increase	152 (30.8)	213 (37.2)	
Preference about the time you spend on patient care			.09
Decrease	122 (24.8)	142 (24.8)	
Same	304 (66.5)	381 (66.5)	
Increase	50 (10.1)	38 (6.6)	
Domestic responsibilities			
Marital status, no. (%)			.004
Married or domestic partnership	431 (87.4)	530 (92.5)	
Single (never married)	48 (9.7)	26 (4.5)	
Divorced or widowed	13 (2.6)	16 (2.8)	
Children, no. (%)			.006
Yes	376 (76.3)	475 (82.9)	
No	117 (23.7)	98 (17.1)	
Number of children, mean (SD)	1.9 (0.7)	2.3 (1.0)	< .001
Spousal employment (those married or with domestic partner), no. (%)			< .001[c]
Yes	400 (92.8)	395 (74.5)	
Full-time	367 (85.2)	251 (47.4)	
Part-time	33 (7.7)	144 (27.2)	
No	30 (7.0)	133 (25.1)	
Elder (adult dependent) home care responsibilities, no. (%)			.21
Yes	33 (6.7)	28 (4.9)	
No	457 (92.7)	541 (94.4)	
Weekly hours on parenting/domestic tasks, mean (SD)	37.8 (17.5)	30.9 (14.2)	< .001
Dependence upon income, no. (%)			< .001
Not at all/somewhat	113 (22.9)	57 (9.9)	
Moderately/very much	375 (76.1)	511 (89.2)	

Abbreviation: SD indicates standard deviation.
[a]Where column percentages do not total 100% by sex, this reflects low levels of item nonresponse.
[b]The comparison excludes "Not reported" category if it exists.
[c]The comparison is between employed (full- and part-time) versus not employed.

laboratory researchers. Women were also less likely to hold awards from the NIH institutes in the highest tier for funding (17% [86] vs. 31% [178]). Women were less likely to be MD/PhDs (15% [72] vs. 31% [175]) and more likely to be non-MDs (26% [129] vs. 11% [60]). Women were more likely to have a specialty focused on women/children/families (32% [116] vs. 21% [108]) and less likely to have a surgical specialty (3% [10] vs. 10% [51]).

Other features of the work environment also differed by gender, with men reporting longer mean weekly total work hours (58 vs. 53), hours in clinical care (9.7 vs. 7.1), and hours in research (38.5 vs. 34.8). Most mentoring measures did not vary significantly by gender, with the exception of longer mean monthly one-on-one meeting time for men (5.1 vs. 4.6 hours) and greater proportions of men perceiving collegiality in the mentoring relationship (69% [369] vs. 61% [300]). Although women did not report less adequate space or equipment, they did report less adequate access to human resources, including secretaries (56% [276] vs. 49% [278]), grants administrators (36% [177] vs. 27% [152]), and statisticians (48% [238] vs. 41% [232]). Women were more likely to have perceived being treated unfairly in their jobs (38% [188] vs. 28% [159]).

Few differences were observed in the priorities of the men and women among these respondents, but men were more likely to report a strong sense of responsibility to contribute to clinical care in their departments (64% [366] vs. 55% [271]), and women were more likely to report strong importance of work–life balance (96% [471] vs. 91% [521]). Domestic responsibilities differed substantially between men and women, with women less likely to be married or partnered (87% [431] vs. 93% [530]), less likely to have children (76% [376] vs. 83% [475]), and more likely to have a full-time employed partner if married or partnered (85% [367] vs. 47% [251]). Women spent more time on parenting or domestic tasks (mean weekly hours 37.8 vs. 30.9) and reported less dependence on their own income for family support (23% [113] vs. 10% [57] reporting being somewhat or not at all dependent).

Figure 1 shows respondents' career paths. Overall, 765 (71.8%; 362 [73.4% of females] and 403 [70.3% of males]) were still at the institution at which they received their initial K awards. Of those who had left their original K award institution, about three-quarters (76.4%) had gone to work for another academic institution, with 12.6% leaving for a community-based or private medical practice, and 7.3% having gone to work for industry. Overall, 315 (63.9%) women and 382 (66.2%) men had at least considered leaving their institution. Although few gender differences were observed in these outcomes, significant

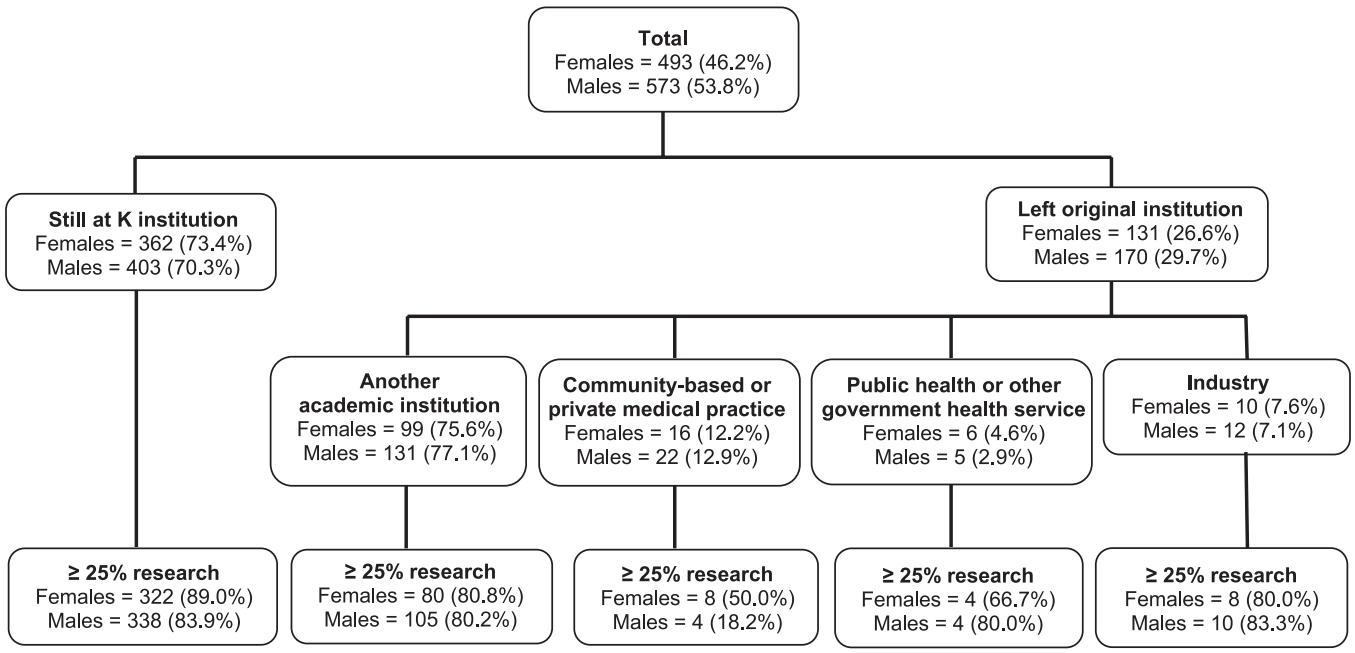

Figure 1 Distribution, by number and percentage, of positions held in 2014 by the 1,066 respondents to a survey of a cohort of individuals who received new K08 and K23 awards in 2006–2009, from a study of factors associated with clinician–researcher success.

gender differences did emerge when those who left or considered leaving were asked about their reasons. Men were more likely to have left or considered leaving for a better opportunity elsewhere (60.8% [129/212] of men vs. 34.2% [63/184] of women, $P = .05$), and women were more likely to have left or considered leaving because of job opportunities for a spouse/partner/significant other (13.6% [25/184] of women vs. 8.0% [17/212] of men, $P = .04$). Similar proportions of men and women reported that they left or considered leaving because of dissatisfaction with mentoring (29.9% [55/184] of women and 28.8% [61/212] of men, $P = .42$), inadequate protected research time (31.0% [57/184] of women and 22.2% [47/212] of men, $P = .55$), or dissatisfaction with work–life balance (48.9% [90/184] of women and 29.2% [62/212] of men, $P = .10$).

Table 2 summarizes the career outcomes of our respondents by gender, with comparisons by gender adjusted for basic job characteristics in multivariable regression models. Women were more likely than men to be at the rank of assistant professor (51% of women [233] vs. 42% of men [224]) at the time of the follow-up survey. Women were less likely to hold institutional (6% of women [27] vs. 11% of men [57]) or national leadership positions (41% of women [191] vs. 49% of men [261]). Women reported less grant funding as PI (mean $780,000 vs. $1,120,000, $P = .002$), with 28% of women (131) and 38% of men (201) ($P = .006$) reporting that they had attained > $1 million in funding as PI or co-PI. Women published fewer papers overall (mean 33 vs. 45) and as first author (13 vs. 15) or senior author (6 vs. 10), along with significant differences in other types of publications, presentations, and perceptions of success and career progress.

With a composite measure of success, defined as funding success (R01 attainment at T2 or >$1M in other PI grant funding), publication success (35 or more peer-reviewed publications), or institutional leadership (becoming a dean, department chair, or division chief), 648 respondents (60.8%) reported success: 53.5% (264/493) of women and 67.0% (384/573) of men (Figure 2). In a logistic regression model of this composite success outcomes measure explained by gender alone, the odds ratio (OR) for females versus males was 0.56 (CI: 0.44–0.72) and was highly significant ($P < .001$). After including all variables from Table 1 that were potential mediators, the OR increased only slightly to 0.62 (CI: 0.46–0.84) and was still highly significant ($P = .002$).

Table 3 presents a best parsimonious multiple-variable logistic regression model of the composite measure of success, with an AUC of 0.76. The one significant interaction observed, between gender and K award grant type, was retained in this multiple-variable model. The direction of this interaction was such that the gender association with success appeared confined primarily to those with K23 grants, the grant type awarded to 65.3% (322) of female and 39.1% (224) of male respondents. Female K23 recipients were much less likely to be successful than male K23 recipients (OR = 0.32). The direction of this interaction effect is apparent in the observed rates of success in the four groups of gender by K award type without covariate adjustment: 59.0% (206/349) among male K08 awardees, 79.5% (178/224) among male K23 awardees, 51.5% (88/171) among female K08 awardees, and 54.7% (176/322) among female K23 awardees.

In the multiple-variable model, in addition to gender and K award type, variables significantly associated with success, listed in order of importance after standardizing each coefficient estimate by a function of its variance, were specialty, K award year, work hours, funding institute tier, higher feeling of responsibility to play a role in department/division administration, high importance of publishing prolifically, lower feeling of responsibility to contribute to clinical care, higher importance of publishing high-quality research, greater collegiality of the mentoring relationship,

Table 2

Career Outcomes in 2014 by Gender for 995 Faculty Still in Academia in a Longitudinal Survey of Recipients of New National Institutes of Health K08 and K23 Awards From 2006–2009, From a Study of Factors Associated With Clinician–Researcher Success

Characteristic, measure[a]	Women: 461 (46.3%)	Men: 534 (53.7%)	*P* value[b]
Academic rank, no. (%)			.007[c]
Full professor	20 (4.3)	32 (6.0)	
Associate professor	198 (43.0)	262 (49.1)	
Assistant professor	233 (50.5)	224 (42.0)	
Instructor/Post doc/Fellow	9 (2.0)	12 (2.2)	
Promotion (of those not full professor at T1), no. (%)	205 (44.6)	247 (46.8)	.68
Leadership			
Institutional (Dean/Department chair/Division chief), no. (%)	27 (5.9)	57 (10.7)	.006
National	191 (41.4)	261 (48.9)	.002
Research time (as % of weekly work), mean (SD)	56.6 (22.1)	52.5 (23.6)	.051
Research time (hours per week), mean (SD)	30.8 (13.4)	30.8 (15.0)	.77
Lab space (among those with lab-based research), mean square feet (SD)	659.0 (503.3)	771.4 (563.3)	.23
Grants (R01 or equivalent)			
Number submitted as PI, mean (SD)	2.1 (2.1)	2.5 (2.4)	.11
0	93 (20.2)	101 (18.9)	
1	122 (26.5)	117 (21.9)	
2	89 (19.3)	107 (20.0)	
3	66 (14.3)	77 (14.4)	
4+	86 (18.7)	125 (23.4)	
Number submitted as co-PI, mean (SD)	1.0 (1.6)	1.1 (1.7)	.02
0	245 (53.2)	260 (48.7)	
1	105 (22.8)	111 (20.8)	
2+	102 (22.1)	154 (28.8)	
Grant funding, $			
As PI, no. (%)			
< 1 million	319 (69.2)	329 (61.6)	.002[d]
1 million+	113 (24.5)	186 (34.8)	
As PI or co-PI (total), no. (%)			
< 1 million	312 (67.7)	320 (59.9)	.006
1 million+	131 (28.4)	201 (37.6)	
Publications, mean (SD)			
Peer reviewed			
All	33.2 (21.8)	44.5 (31.6)	< .001[e]
As first author	12.9 (9.4)	14.7 (11.5)	< .001[e]
As senior author	5.8 (8.0)	9.5 (12.5)	< .001[e]
Book chapters	3.4 (3.9)	4.7 (6.0)	< .001[f]
Review articles	4.1 (5.6)	5.8 (8.1)	< .001[f]
Oral podium presentations at national meetings	12.3 (18.2)	15.7 (23.1)	.02[f]
Invited lectures	17.0 (38.3)	17.6 (27.3)	.48[f]
Book written/edited			
Zero	349 (75.7)	378 (70.8)	.04
One or more	58 (12.6)	91 (17.0)	

(*Table continues*)

Table 2
(Continued)

Characteristic, measure[a]	Women: 461 (46.3%)	Men: 534 (53.7%)	*P* value[b]
Perceived success, no. (%)			
Present professional status			.02
Far above or above average	194 (43.3)	267 (51.2)	
Average or less	251 (56.0)	252 (48.3)	
Progress in your career			< .001
Much or somewhat faster than average	121 (27.0)	216 (41.4)	
Average or less	324 (72.3)	304 (58.2)	

Abbreviations: SD indicates standard deviation; T1, time 1; PI, principal investigator; Post doc, postdoctoral fellow.
[a]Where column percentages do not total 100% by sex, this reflects low levels of item nonresponse.
[b]*P* values are reported from regression models after adjusting for K award type, year of K award funded, funding institute tier, institution tier (at time of initial K funding), degree, and specialty. Dictated by the distribution of the outcome of interest, the functional form of the regression model is logistic when the outcome is binary, cumulative logit for ordinal outcomes, linear for continuous outcomes with a large range, and Poisson for count outcomes of rare events.
[c]The comparison excluded the Instructor/Post doc/Fellow category.
[d]Comparing those with ≥ $1 million versus < $1 million in funding.
[e]After a square root transformation of the outcome in order to normalize the distribution.
[f]Poisson regression used to model rare events.

adequacy of research equipment, and supportive climate of the primary department or division.

In a separate model considering women alone, variables significantly associated with success in a best parsimonious model, again listed in order of importance (full model details provided in Supplemental Digital Appendix 3 at http://links.lww.com/ACADMED/A450), were K award year, funding institute tier, higher feeling of responsibility to play a role in department/division administration, lack of desire to increase or decrease time spent on research, hours spent on research, and importance of publishing prolifically. For men alone, the variables in the best parsimonious model of success were K award grant type, K award year, work hours, specialty, supportive climate of the primary department or division, higher importance of publishing high-quality research, greater collegiality of the mentoring relationship, race, and lower feeling of responsibility to contribute to clinical care.

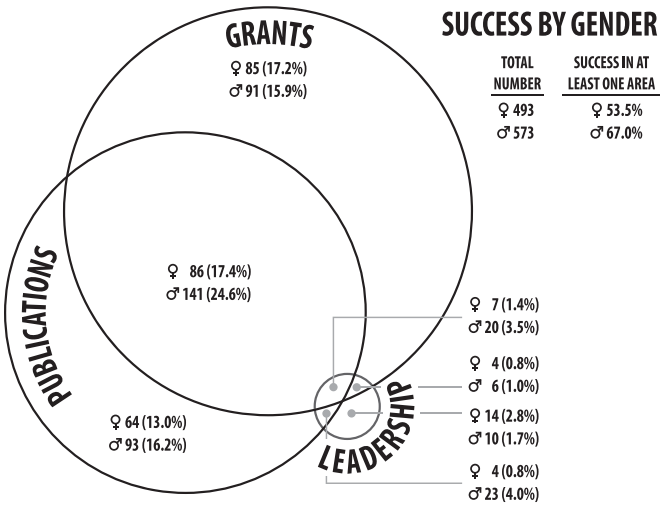

Figure 2 Venn diagram of success depicting the distribution of the 1066 K08 and K23 awardees, 2006–2009, responding to both surveys who were deemed successful at T2, from a study of factors associated with clinician–researcher success. Success in funding was defined as attainment of > $1 million in grant funding (direct funding) as principal investigator. Success in publication was defined as publication of 35 or more peer-reviewed articles. Success in leadership was defined by institutional administrative service as dean, department chair, or division chief. Within each segment, the numbers represent the number of individuals of that gender who reported success in that category; the percentages are of all individuals of that gender who reported success in that category. For example, as shown in the nonoverlapping portion of the grants circle, 85 of the 493 women (17.2%) reported grant success only, and 91 of 573 men (15.9%) did so. Success in all three areas (represented by the small area of overlap of all three circles) was reported by 7 of the 493 women (1.4%) and 20 of the 573 men (3.5%).

Discussion

Our work sought to understand barriers facing junior physician faculty researchers, particularly women, to inform efforts to improve gender equity in academic medicine. We focused on an extremely selective cohort of research-oriented junior faculty members—namely, recipients of K08 and K23 mentored career development awards from the NIH. In so doing, our study design minimized the impact of potential gender differences in the desire to pursue research and in access to monetary support, allowing for the impact of other challenges and barriers to be isolated. We included a large number of factors that have previously been hypothesized to affect success and to mediate gender differences in outcomes.

Our findings suggest that men and women continue to have different experiences both at work and at home, as well as different career outcomes and academic success as traditionally defined. We evaluated whether the substantial

Table 3

Best Multiple-Variable Model Predicting Composite Success Among 957 Respondents With Complete Variable Information in a Longitudinal Survey of Recipients of New National Institutes of Health K08 or K23 Awards From 2006–2009, From a Study of Factors Associated With Clinician–Researcher Success

Characteristic	OR	95% CI	*P* value
Gender-by-K-award-type interaction[a]			< .001
Females compared with males: K23 grant type	0.32	0.20–0.51	
Females compared with males: K08 grant type	0.94	0.61–1.44	
K08 compared with K23: females	0.81	0.52–1.26	
K08 compared with K23: males	0.28	0.17–0.44	
Weekly work hours at T1			.003
+1 hour	1.03	1.01–1.04	
K award year			< .001
2006	2.67	1.77–4.09	
2007	2.66	1.77–3.98	
2008	1.48	1.01–2.17	
2009	1		
Funding institute tier			.03
First	1.69	1.16–2.47	
Second	1		
Third	1.16	0.82–1.64	
Specialty			< .001
Clinical specialties for women, children, and families	0.69	0.47–0.99	
Hospital-based specialties	1.30	0.80–2.11	
Surgical specialties	6.38	2.50–16.23	
Medical specialties	1		
Non-MD	0.91	0.06–13.47	
Collegial relationship with mentor			.02
Yes	1.45	1.07–1.97	
No	1		
Adequate research equipment			.02
Yes	1.64	1.09–2.47	
No	1		
Feel responsibility to contribute to the clinical care provided by your department/division			.008
Yes	0.65	0.47–0.89	
No	1		
Feel responsibility to play a role in department/division administrative issues			.003
Yes	1.67	1.19–2.35	
No	1		
Supportive climate created by your primary department/division			.01
Yes	1		
No	0.67	0.49–0.92	
Importance to publish high-quality research			.009
Yes	4.15	1.44–12.00	
No	1		
Importance to publish prolifically			.002
Yes	1.64	1.20–2.24	
No	1		

Abbreviations: T1 indicates Time 1; OR, odds ratio; CI, confidence interval.

[a]These ORs were derived from the following findings: Main effect of gender, females compared with males: log(OR) = −1.13, 95% CI: 0.68, 1.60, $P < .0001$. Main effect of K award type, K08 compared with K23: log(OR) = −0.21, 95% CI: −0.65, 0.23, $P = .35$. Interaction of gender by K award type, log(OR) = −1.08, 95% CI: −1.69, −0.46, $P = .0006$.

differences we have observed in factors such as domestic responsibilities, work hours, and adequacy of human resources could explain gender differences in outcomes in this cohort, finding a strong association between gender and success even after accounting for these factors. We found that beyond basic job characteristics (including K award type and year, specialty, and funding institute tier), certain factors are associated with success. These include aspects of the work environment (including work hours, a collegial relationship with one's mentor, adequacy of research equipment, and a supportive institutional climate) and certain personal priorities. Yet even after including these mechanistic factors, gender differences in outcomes persisted, primarily among those clinically oriented researchers holding K23 awards. Other research has focused on the particular challenges of obtaining funding for clinical research,[32–34] which was the focus of the majority of the female K awardees in our study population; why male K awardees pursuing clinical research (who constituted only a minority of the men) were more successful requires further investigation. Given that prior work has identified the submission of competing continuation applications to be a potentially important explanation for differences in funding success between clinical and nonclinical applications, it would be particularly interesting to examine whether gender differences in this regard might contribute. Our findings suggest that much remains to be done to understand the causes of gender differences in career outcomes and to ensure gender equity and success of the promising pipeline of individuals pursuing careers in academic medicine.

Like any survey study, our findings are vulnerable to bias. Although our response rates were high, our respondents were dissimilar from nonrespondents in certain meaningful ways, although not by gender. Survey responses are further vulnerable to measurement error, despite our best efforts to use valid measures of the key constructs we considered. In particular, if men are more prone to inflating their responses in comparison with women when reporting variables such as hours worked or achievements, this could explain some of the gender difference observed; still, given the number of outcomes evaluated and consistent findings even with respect

to outcomes such as academic rank, which should not be vulnerable to misestimation, we do not believe this is the sole explanation for our observations. Although our study included many factors, our model had only moderate predictive ability, suggesting that unmeasured factors exist that are important in explaining success. Finally, the experiences of this elite group of career development award recipients may differ from those of less able or motivated junior faculty without such awards.

Nevertheless, these findings from a large national sample of clinician–researchers are timely and relevant for policy makers seeking evidence to inform their efforts to improve gender equity and the health of the physician–scientist pipeline. In particular, given that time for research appears important for women's success, institutions must learn from one another to adopt best practices that may increase women's access to time for research. Creative approaches, ranging from unique bridge funding programs[35] that provide support for "extra hands" to allow women to make best use of their time to interventions that call attention to implicit gender biases[36] that may affect women's ability to secure protected time for research, have been shown to have meaningful impact. Our current study underscores the need for more widespread adoption of such approaches, as well as the need for further research in this area, as the goals of gender equity and more widespread success in academic medicine remain unfulfilled, even amongst the best and brightest who have recently entered our field.

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