Original Report:
Workforce Strengthening

Mentoring Experiences and Publication Productivity among Early Career Biomedical Investigators and Trainees

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Objective: To identify which mentoring domains influence publication productivity among early career researchers and trainees and whether publication productivity differs between underrepresented minority (URM) and well-represented groups (WRGs). The mentoring aspects that promote publication productivity remain unclear. Advancing health equity requires a diverse workforce, yet URM trainees are less likely to publish and URM investigators are less likely to obtain federal research grants, relative to WRG counterparts.

Participants: Early career biomedical investigators and trainees from the National Research Mentoring Network (NRMN), N=115.

Methods: A mentoring-focused online follow-up survey was administered to respondents of the NRMN Annual Survey who self-identified as mentees. Publications were identified from a public database and validated with participant CV data. Bivariate and multivariate analyses tested the associations of publication productivity with mentoring domains.

Results: URM investigators and trainees had fewer publications (M = 7.3) than their WRG counterparts (M = 13.8). Controlling for career stage and social characteristics, those who worked on funded projects, and received grant-writing or research mentorship, had a higher probability of any publications. Controlling for URM status, gender, and career stage, mentorship on grant-writing and funding was positively associated with publication count (IRR=1.72). Holding career stage, gender, and mentoring experiences constant, WRG investigators and trainees had more publications than their URM counterparts (IRR=1.66).

Conclusions: Grant-writing mentorship is particularly important for publication productivity. Future research should investigate whether grant-writing mentorship differentially impacts URM and WRG investigators and should investigate how and why grant-writing mentorship fosters increased publication productivity. *Ethn Dis*. 2021;31(2):273-282; doi:10.18865/ed.31.2.273

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Introduction

Underrepresented racial and ethnic minorities (URMs) are less likely to graduate from high school, attend college and major in biomedical sciences, and obtain doctoral degrees than non-Hispanic Whites.[1] Persistent educational disparities occur across the lifecourse and extend beyond academic preparation pathways and into career trajectories.[1,2] African Americans/Blacks, Latinos/Latinas, American Indians or Alaska Natives, Native Hawaiians, and other Pacific Islanders are URMs in the biomedical sciences, while non-Hispanic Whites and Asians are well-represented groups (WRGs) in the biomedical sciences.[3] The Ginther report found that African American/Black applicants were less likely than Whites to be awarded R01 NIH research funding, controlling for education, country of origin, training, previous research awards, publication record, and employer characteristics.[4] These disparities stem in part from the proposal's topic choice, and the relatively lower funding rates at NIH Institutes and Centers where Black investigators disproportionately apply (eg, NIMHD).[5,6] This evidence underscores the need to address inequitable educational and

career patterns in biomedical fields.

The NIH has launched efforts to diversify the biomedical workforce through the development of the Diversity Program Consortium (DPC), which includes the National Research Mentoring Network (NRMN). NRMN aims to link senior investigators from diverse disciplines with early career investigators and trainees.[7] NRMN was designed to create a national network of mentors and mentees from biomedical disciplines to provide mentorship, training, professional development, and networking to engage a more diverse field of individuals in biomedical research careers.[8–11]

To mitigate barriers faced by URM trainees and investigators,[22,23] it is particularly important to provide effective mentorship among this segment of the workforce.

Investigators' publication history influences research funding competitiveness and accounts for some of the racial variation in funding rates.[12] Publication record is a central measure used to determine employment offers, tenure, and promotion at research institutions.[13,14] URM investigators publish at lower rates than their WRG counterparts.[8,13] Among students and trainees, the lower publishing rates of URMS relative to WRG counterparts, are associated with lack of structure in the doctoral program or unclear expectations,[15] and faculty members' lower interest in collaborating and mentoring URM students.[16] Similar trends are observed in academic medicine, such that URM faculty are less likely to receive promotion, relative to WRG faculty.[17] This evidence underscores the importance of publishing for investigators' career trajectories and highlights how URM investigators face unique challenges that undermine publication productivity.

Prior research highlights the importance of mentorship in the development and success of trainees and early career investigators.[18,19] Effective mentoring and developmental networks are linked with career success through access to information, access to resources, and career sponsorship.[20] Having effective mentors is associated with various types of career success (eg, higher productivity, earlier promotions, and retention). However, it remains unclear which aspects of mentoring most effectively contribute to scientific productivity.[21] Scholars have urged this line of research to focus on mentoring relationships, rather than mentors alone.[21] To improve mentoring among early career biomedical researchers and improve workforce development, we must delve deeper into mentoring and identify the specific mentoring components linked with positive career outcomes—an essential one being publication productivity. Likewise, to mitigate barriers faced by URM trainees and investigators,[22,23] it is particularly important to provide effective mentorship among this segment of the workforce.

The purpose of this study was to examine the relationship between mentoring and publication productivity. We: 1) determined the mentoring domains correlated with publication productivity; 2) identified mentoring domains predictive of publication productivity, controlling for gender, URM status, and career stage; and 3) assessed publication productivity between URM and WRG investigators and trainees.

Methods

Data

For this study, data came from individuals who self-identified as mentees during registration for NRMN programs and who completed the Diversity Program Consortium's 2017-18 Coordination and Evaluation Center's (CEC) NRMN Annual Survey.[24] Respondents were from across the United States and territories and from the full range of biomedical disciplines. NRMN mentees who completed the Annual Survey (N= 499) were invited to participate in this study via e-mail and offered a $25 gift card for completion. The survey response rate was 43.9% (217 of 499 invitees). The sample for the analyses presented here (n = 115) was limited to those for whom we had publication data and who reported having mentors. To have a sample of early career investigators and trainees, we excluded those who had: missing NRMN registration data (n = 4), du-

plicate cases (n = 1), missing publication data due to name disambiguation (n = 11), zero reported mentors (n = 27), missing mentoring items (n = 1), and those who were senior faculty (n = 3) or were undergraduate, post-baccalaureate, and master's students (n = 55). The final sample includes assistant professors, instructors, post-doctoral trainees, PhD and MD trainees, and unknown/missing.

Data for this study consist of participants': 1) self-reported mentoring experiences with their primary mentor; 2) publication record; and 3) demographic information. Mentoring data were obtained from survey items asking the mentee to indicate the type of mentoring and support they received from their mentor. Respondents were instructed that, "A mentor is someone who provides guidance, assistance, encouragement, and inspiration on professional and academic issues. A mentor can be either someone who is more experienced (or senior) than you or someone who is at a level similar to you (a 'peer'). A mentoring relationship can be formal (with a set schedule and perhaps arranged by your institution) or informal." Respondents were allowed to report 0 - 3 mentors. The present analysis focuses only on responses related to participants' primary mentors (Mentor 1).

The outcome of interest, participants' publication productivity, was assessed using a two-step process. First, a list of publications for all participants was collected using PubMed (a publicly available database) to ensure a systematic approach across the full sample. Second, we referred to a list of publications (curriculum vitae) provided by participants to crosscheck data collected from PubMed. Half (55/115) of the sample provided a list of publications in the CEC NRMN Annual Survey. The list of publications was used to crosscheck and validate the number of publications queried using the PubMed database.

Demographic information (eg, race, ethnicity, gender, career stage) was obtained from the NRMN registration system. This research was approved by the institutional review board (IRB) at UCLA. All procedures followed were in accordance with ethical standards of the IRB and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants included in the study.

Independent Variables

Mentoring Domains

Nine distinct mentoring domains, as they relate to their primary mentor, were assessed: 1) communication frequency; 2) length of mentoring duration; 3) whether participants worked on funded projects with this mentor, and whether participants received mentorship on: 4) grant-writing and funding; 5) general research; 6) specialized research; 7) career planning; 8) personal support; and 9) whether the primary mentor served as an inspiration or role model. Communication frequency was measured by asking participants, "Please tell us how frequently you have communicated on average with Mentor 1 during the past year." Response options were Never, Annually or less, A few times a year, and Monthly or more often. Due to the small number of responses, Never, Annually or less, and A few times a year were combined. Mentoring duration was measured by asking participants, "How long has Mentor 1 been your mentor?" Response options were Less than one year, 1 – 2 years, 3 – 4 years, and 5 or more years. Response options were combined as Two years or fewer and Three or more years. Respondents were also asked if they had "worked on funded projects with this mentor" (yes/no).

Six dimensions of mentoring support assessed the functional and socio-emotional support provided by primary mentors, with academic and subject knowledge support subdivided into three areas relevant to early career investigators.[25] Participants responded yes or no to the following, "Which of the following areas does your mentor provide guidance, assistance, or encouragement?": Grant-writing and funding; Research in general; Specialized research issues; Career planning; Personal support; and Inspiration/role model.

Covariates

To assess gender identity, participants were asked, "Which of the following best describes your gender identity?" Response options were Male, Female, and Other (including Prefer Not to Report). Race and ethnicity were assessed using two items: "What race(s) do you identify with" and "Are you Hispanic or Latino?" Both items were used to generate a racial and ethnic group variable, with eight racial and ethnic categories: Latino; African American; American Indian; Native Hawaiian, Pacific Islander; Asian; White; Multi-ethnic, and Other. Based on groups that have been identified as underrepresented

in the scientific workforce,[3] non-Hispanic Whites and Asians were categorized under WRG, while Latino, African American, Native Hawaiian, Pacific Islander, and Multiethnic were categorized as URM. Those who reported only Other or did not provide information on race and ethnicity were categorized as Other/Missing for URM status.

Education/career level was assessed by asking, "Where are you in your education?" and "Where are you in your career?" Responses for both items were used to generate a career stage variable, aimed to capture the spectrum from PhD or MD trainee to junior faculty: PhD or MD trainee; Post-doctoral Fellow or Research Fellow; Instructor; Assistant Professor; and Other (Other career/professional employment, missing). Due to the effect of the small sample size on the stability of the regression models, response options were dichotomized as Assistant Professor or Other.

Dependent Variable: Publication Productivity

Publication productivity was assessed in two ways: any peer-reviewed publication and total number of peer-reviewed publications.

Analysis

Data analysis was conducted in four steps using Stata 13.[26] First, descriptive statistics were used to describe the sample (Table 1). Second, bivariate tests were used to assess the mentoring domains and social characteristics associated with publication productivity. Chi-square tests (Table 2) were performed for the binary publication productivity outcome (1= has peer-reviewed publications, 0 = has no peer-reviewed publications). T-tests and one-way ANOVAs were performed for the publication count outcome. Third, multivariable logistic regression was used to examine the odds of having ever published regressed on mentoring domains. The mentoring domains assessed in the logistic regression were selected based on the chi-square results presented in Table 2. Logistic regression models included one mentoring domain at a time and controlled for gender, URM status, and career stage (Table 3). Fourth, given the skewed distribution of publication count, negative binomial regression was used to assess the relationship between mentoring domains and publication count (Table 4). The mentoring domains assessed in the negative binomial regression were selected based on the t-test and one-way ANOVA results that evaluated the relationship between mentoring domains and publication productivity. Model 1 assessed the direct relationship between the mentoring domains and publication count. Model 2 added URM status and Model 3 added gender as covariates. Model 4 regressed publication count on mentoring domains, controlling for URM status, gender, and career stage.

For ease of interpretation, we presented odds ratios for logistic regression results and incidence rate ratio (IRR) for negative binomial regression results.[27] Odds ratios measure the association between a binary outcome variable and the occurrence of a given event.[28] An odds ratio of 1.60 suggests the group in question has 60% higher odds of the outcome, relative to the reference group. The IRR represents the change in the outcome variable in terms of a percentage change.[27] For continuous predictors, an IRR of 1.27 suggests that the dependent variable increased by approximately 27% with every one unit increase in the independent variable. For categorical predictors, an IRR of 1.66 suggests the group in question has a rate 1.66 times greater for the outcome, relative to the reference group.

Results

The majority (66%) of participants in the sample were women (Table 1). Post-doctoral fellows or research fellows comprised the largest proportion (37%) of the sample, followed by assistant professors (20%), PhD/MD trainees (18%), Instructors (7%), and Unknown/Missing (17%). Non-Hispanic Whites (29%) comprised the largest racial or ethnic group. There was a balanced proportion of WRG (38%) and URM (39%) investigators and trainees; the rest (23%) were unspecified other or unknown race. Over three-fourths (78%) of the sample had authored a peer-reviewed publication, with an average of 12 (SD=10.7) publications.

The association between each mentoring domain and having authored any publication is presented in Table 2. Relative to those who had never published, those who had published communicated with their primary mentors monthly or more often, had longer periods of time working with their primary mentor, and engaged in funded projects, received grant-writing and funding,

and research mentorship from their primary mentor. For instance, 64% of those who had published received specialized research mentorship from their primary mentor, relative to 32% of those who had never published, P = .004. Additionally, 67% of those who had published received grant-writing and funding support from their primary mentor compared with 28% of those who had never published, P = .001.

The bivariate relationship between mentoring experiences and publication count was also assessed. Publication count varied significantly across both mentoring duration and grant-writing mentorship. Investigators and trainees who had been working with their primary mentors for three or more years published more (*M* = 11.33, *SD* = 1.48) than those who reported working with their mentors for fewer years (*M* = 6.37, *SD* = 7.74), P = .013. Investigators and trainees who engaged in grant-writing and funding with their primary mentor published more (*M* = 11.51, *SD* = 1.33) than those who did not receive this mentorship (*M* = 6.02, *SD* = 1.37), P = 0.006.

Chi-square tests (Table 2) showed no significant differences between URM and WRG participants on having ever published. Although not statistically significant, it is noteworthy that nearly half of URM investigators and trainees had never published, relative to 20% of WRG investigators and trainees. Conversely, there were significant differences between URM and WRG investigators and trainees when publication productivity was measured as a count. URM investigators and trainees had fewer publications (*M* = 7.3, *SD* = 8.2) than those from WRGs (*M* = 13.8, SD = 2.0), P = .006. This holds true even when analyses are restricted to those who have published, P = .035.

Table 1. Participant characteristics, N = 115

	%	Mean (SD)
Social Characteristics		
Gender		
Female	66.1	
Male	20.9	
Other	13.0	
Career Stage		
Assistant professor	20.0	
Other	80.0	
PhD or MD trainee	18.3	
Post-doctoral fellow or research fellow	37.4	
Instructor	7.0	
Other career/professional employment, missing	17.4	
Underrepresented minority status		
Underrepresented minority (URM)	39.1	
Latino (any race)	15.7	
African American	17.4	
American Indian	1.7	
Multiple races	4.4	
Well-represented (WR) racial or ethnic background	38.3	
Asian	10.4	
White	28.8	
Other, missing	22.6	
Other	7.0	
Missing	15.7	
Publication productivity		
Published		
Yes	78.3	
No	21.7	
Number of publications (among those published [1,48][a]		11.8(10.7)

a. Variable ranges included in brackets.
Percents may not add up to 100 due to rounding.

Mentoring Domains and the Odds of Having Ever Published

Table 3 presents the odds of having published regressed on mentoring domains, controlling for gender, URM status, and career stage. Four of five mentoring domains were associated with higher odds of having published. Participants who received grant-writing and funding mentorship had more than five times the odds of having published, relative to those who did not receive this mentorship, P = .002. Those who had general research mentorship had more than four times the odds of having published, relative to those who did not receive this mentorship, P = .004. The length of the mentoring relationship was not related to having ever publishing when other factors were controlled.

Table 2. Mentoring experiences and social characteristics by publication status, N = 115

	Have published, n = 90	Have not published, n = 25	
	%	%	P
Number of Mentors			.180
One	15.6	32.0	
Two	25.6	20.0	
Three	58.9	48.0	
Communication frequency			.055
A few times a year or less	12.2	28.0	
Monthly or more often	87.8	72.0	
Mentoring duration[a]			.047
Two or fewer years	37.8	60.0	
Three or more years	62.2	40.0	
Worked on funded projects together	71.1	40.0	.004
Grant-writing and funding[a]	66.7	28.0	.001
General research	77.8	48.0	.004
Specialized research	64.4	32.0	.004
Career planning	81.1	72.0	.321
Personal support	62.2	68.0	.596
Inspiration/role model	57.8	60.0	.842
Social characteristics			
Gender			.064
Female	65.6	68.0	
Male	24.4	8.0	
Other	10.0	24.0	
Career stage			.024
Assistant professor	24.4	4.0	
Other	75.6	96.0	
Underrepresented minority status			.097
Underrepresented minority (URM)	36.7	48.0	
Well-represented (WR) racial or ethnic background	43.3	20.0	
Other, missing	20.0	32.0	

Chi-square tests evaluated the relationship between mentoring domains and having published ever. T-tests evaluated the relationship between mentoring domains and publication count. Table 2 presents results from the chi-square tests. T-test results are not presented in a standalone table.
a. Mentoring domains that were significantly associated with publication count.

Mentoring Domains and Publication Count

The relationship between mentoring domains and number of publications is presented in Table 4. The mentoring domains assessed (mentoring duration and grant-writing and funding mentorship) were selected based on the t-test results that evaluated the relationship between mentoring domains and publication productivity. Model 1 examined the relationship between the two mentoring domains and number of publications. Results indicate that working with one's primary mentor for three or more years (IRR=1.76; 95% CI=1.10 - 2.81) and working on funded projects (IRR=1.89; 95% CI=1.18 – 3.02) were positively associated with number of publications. In Model 2, the inclusion of URM status attenuated the effect of mentoring duration on publication count so that it was no longer significant. Grant-writing mentorship (IRR=1.74; 95% CI=1.09 – 2.78) remained positively associated with number of publications. Notably, investigators and trainees from WRGs had more publications than their URM counterparts (IRR=1.78; 95% CI=1.06 – 2.97). Gender was included in Model 3 and the mentoring domains continued to be positively associated with number of publications. With the addition of

career stage (Model 4), grant-writing mentorship remained positively associated with number of publications (IRR=1.72; 95% CI=1.11 – 2.69), but the length of the relationship was not significantly associated. WRG investigators and trainees continued to have more publications than URM investigators and trainees (IRR=1.66; 95% CI=1.04 – 2.65).

Given the differences in publication count between URM and WRG participants, further analysis was conducted. We estimated the predicted number of publications associated with grant-writing mentorship across URM status, controlling for gender and career stage. Results indicate that the publication gap between URM and WRG investigators and trainees was even wider among those who had received grant-writing mentorship. URM investigators and trainees who did not receive grant-writing mentorship had lower publication counts (M = 7.18) than their WRG counterparts (M = 10.59), and the gap increased between URM (M = 8.60) and WRG (M = 12.69) participants who did receive grant-writing mentorship. Although these differences were not statistically significant, the trends in the data highlight a potential problem worth investigating with larger sample sizes.

Table 3. Odds of ever publishing regressed on mentoring experiences, N = 115

	OR	95% CI
3+ year mentoring duration, Reference= <3 years	1.98	.76, 5.19
Funded projects	4.44[b]	1.60, 12.33
Grant-writing	5.42[b]	1.88, 15.65
General research	4.58[b]	1.64, 12.83
Specialized research	3.45[a]	1.27, 9.41

Each logistic regression controls for gender, URM status, and career stage.
a. P<.05; b. P<0.01 (two-tailed tests).

Discussion

Prior research suggests that mentored early career investigators (eg, junior faculty) are more likely to publish, relative to those not mentored.[29,30] Although mentoring has a well-documented role in the success of early career investigators,[18,19] less is known about the particular mentoring aspects that most effectively contribute to scientific productivity.[21] This study assessed the impact of multiple mentoring components on scientific productivity to determine the most influential mentoring elements. Findings suggest that distinct mentorship is important for publication count vs having authored any peer-reviewed publication. For instance, four mentoring domains were associated with higher odds of having any peer-reviewed publications, controlling for URM status, gender, and career stage: working on funded projects with primary mentor, receiving grant-writing and funding mentorship, and receiving general and specialized research mentorship. For publication count, only grant-writing and funding mentorship were associated with higher publication counts, controlling for

Table 4. Number of publications regressed on mentoring experiences, N = 115

	Model 1		Model 2		Model 3		Model 4	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
3+ year mentoring duration, Ref=<3 years	1.76[a]	(1.10, 2.81)	1.53	(.96, 2.43)	1.62[a]	(1.04, 2.53)	1.35	(.87, 2.09)
Grant-writing	1.89[b]	(1.18, 3.02)	1.74[a]	(1.09, 2.78)	1.62[a]	(1.02, 2.55)	1.72[a]	(1.11, 2.69)
URM group, Ref=URM								
WRG			1.78[a]	(1.06, 2.97)	1.75[a]	(1.07, 2.85)	1.66[a]	(1.04, 2.65)
Other			.79	(.43, 1.47)	1.51	(.68, 3.32)	1.57	(.73, 3.35)
Gender, Ref=Female								
Male					.85	(.49, 1.47)	1.04	(.60, 1.81)
Other					.19[b]	(.07, .53)	.25[b]	(.09, .68)
Career stage, Ref=Other								
Asst Professor							2.24[b]	(1.31, 3.83)

a. P<.05; b. P<0.01; (two-tailed tests).
Ref, reference; URM, underrepresented minority; WRG, well-represented racial and ethnic group.

URM status, gender, and career stage. Findings from this study bolster prior research on the value of working on research projects and receiving funding for publication productivity.[31,32] Moreover, these findings begin to unpack which mentoring practices promote first publication and which mentoring practices are associated with higher publication counts.

Results bolster prior research documenting how URM investigators and trainees publish at significantly lower rates than their WRG counterparts.[8,13] WRG investigators and trainees have a rate 1.66 times greater for publication count than URM investigators and trainees, controlling for gender and career stage. Interestingly, the unadjusted analysis produced discordant findings between any publications and publication count. Unadjusted analyses suggest significant publication count differences between URM and WRG investigators and trainees. However, there were no URM/WRG differences when productivity was assessed using any publications as the central measure. The discordant findings underscore the need to operationalize publication productivity in several ways.

These findings begin to unpack which mentoring practices promote first publication and which mentoring practices are associated with higher publication counts.

Grant-writing mentorship was consistently and positively associated with publication productivity, which is consistent with prior research documenting the importance of writing-focused interventions (eg, grant-writing, writing groups) for publication productivity.[33] Yet, the data demonstrated a trend where grant-writing mentorship may be a larger benefit to WRG participants than URM participants. URM investigators and trainees who did not receive grant-writing mentorship had lower publication counts than their WRG counterparts, and the difference increased between those who did and did not receive grant-writing mentorship. Findings suggest that grant-writing mentorship may be a driver in increasing the publication gap between URM and WRG investigators and trainees.

Study Limitations

Results should be considered in light of limitations. First, data for this study are cross-sectional, so causal associations between mentoring and future publishing activity cannot be assessed. Second, although data for this study come from a sample of mentees from the NRMN, this group is not a nationally representative sample of biomedical researchers. As such, our sample limits the generalizability of the findings to the broader early career biomedical workforce population. Moreover, this study focuses on mentoring domains among those who have mentors. Participants with zero mentors were excluded from this analysis. Future research will need to assess whether the findings observed among this group of NRMN mentees are representative of biomedical researchers more generally. Third, publication data were collected using PubMed, so it is possible that publication productivity was underestimated. However, we compared number of publications in curriculum vitae and Web of Science to those captured in PubMed and obtained similar results, which minimizes concerns related to extracting publication data from the PubMed database.

Future Research

Future research should examine the role of institutional context (eg, institutional resources) in the relationship between mentoring and publication productivity. Additionally, future research with large sample sizes should further investigate whether grant-writing mentorship differentially impacts URM and WRG investigators and trainees. Finally, future research will need to address training received by mentors to assess whether training can also have long-term effects on mentee career trajectories.

Conclusion

This study identifies the distinct mentoring elements shaping publication productivity. To promote having at least one peer-reviewed publication, it will likely be important that mentees work on funded projects with their mentor and receive grant-writing and research mentorship. To promote higher pub-

lication counts, mentees will likely benefit from receiving grant-writing mentorship. This study documents publication productivity differences between URM and WRG investigators and trainees. To minimize inequitable career trajectories within the biomedical workforce, it is critical to identify factors that can help balance publication productivity between URM and WRG investigators.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Design and concept of study: Gutierrez, Guerrero, McCreath, Wallace; Acquisition of data: Gutierrez, McCreath, Guerrero, Wallace; Data analysis and interpretation: Gutierrez, McCreath, Guerrero, Wallace; Manuscript draft: Gutierrez, Guerrero, McCreath; Statistical expertise: Gutierrez, McCreath; Acquisition of funding: Gutierrez, McCreath, Wallace; Administrative: Gutierrez; Guerrero; McCreath; Wallace; Supervision: Wallace

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