PERSPECTIVES

Inclusion in the Pulmonary, Critical Care, and Sleep Medicine Physician-Scientist Workforce

Building with Intention

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ABSTRACT

Physician-scientists comprise an exceedingly small fraction of the physician workforce. As the fields of pulmonary, critical care, and sleep medicine continue to invest in the development of the physician-scientist workforce, recruitment and retention strategies need to consider the temporal trend in the decline in numbers of trainees pursuing basic research, the challenges of trainees from underrepresented groups in medicine, and opportunities for career and scientific advancement of women physician-scientists. In this perspective article, we examine the headwinds in the training and education of physician-scientists and highlight potential solutions to reverse these trends.

Keywords:
diversity; basic science; pipeline; pulmonary and critical care

As early as 1979, the National Institutes of Health (NIH) recognized the vital contributions of physician-scientists and the implications of a shrinking physician-scientist workforce to the future of academic medicine, biomedical research, and human health (1, 2). In response to further declines, Dr. Francis Collins, the current director of the NIH, convened the Physician-Scientist Workforce (PSW)

(Received in original form February 29, 2020; accepted in final form July 14, 2020)

Supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health (NIH) grants R01 HL136143, R01 HL142084, HL140284-02S1, K24 HL143285, and R38 HL150207 (to J.S.L.); the Burroughs Wellcome Fund Postdoctoral Enrichment Program; the Winters Foundation Grant; and NIH grants KL2TR001856 (to T.L.S.), R01 HL125169, R01 HL136617, and R01 HL154343 (to E.R.N.). The content is solely the responsibility of the authors and does not necessarily represent the official views of their institutions, the NIH, or any other sponsoring agency.

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ATS Scholar Vol 1, Iss 4, pp 353–363, 2020

DOI: 10.34197/ats-scholar.2020-0026PS

working group in 2014 to evaluate the PSW and provide recommendations to enhance its robustness and diversity (3). The report defined a physician-scientist as an individual "with a professional degree who has training in clinical care" and spends the majority of their time "engaged in independent biomedical research." Relevant to the discussion of PSW composition, groups underrepresented in medicine (UIM) are defined by the Association of American Medical Colleges as "racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population," which historically has reflected African Americans, Mexican Americans, Native Americans (American Indians, Alaska Natives, and Native Hawaiians), and mainland Puerto Ricans (4).

These are unprecedented times with an even greater need for scientific discovery and physician-scientists. The pathophysiology of acute respiratory distress syndrome, interstitial lung diseases, pulmonary hypertension, chronic obstructive lung disease, and sleep disorders are just a few examples of dynamic research areas that provide fertile ground for trainees and junior investigators to build their careers in pulmonary, critical care, and sleep medicine. In addition, there is a gap in understanding of how disease mechanisms both reflect and impact health disparities within respiratory diseases. Severe asthma, smoking-related lung diseases, and neonatal pulmonary complications disproportionately impact minority and underserved communities (5, 6). However, the balance between research and demanding clinical obligations in these subspecialties can be tenuous, often leading trainees to believe that a physician-scientist career is not feasible. Perception and reality, combined with the limited pipeline of underrepresented groups, pose unique challenges as well as opportunities to develop a larger and more inclusive PSW within our field.

This perspective highlights three areas of opportunity relevant to the training of pulmonary, critical care, and sleep medicine physician-scientists as follows: *1*) the overall decline in the total numbers of applications from physician-scientist trainees with an emphasis on basic science; *2*) the dearth of UIM physician-scientist trainees; and *3*) career advancement opportunities for women physician-scientists. These groups are not mutually exclusive but represent areas for improvement when considering strategies to enhance the training, inclusion, and sustainability of the PSW.

THE CHALLENGES

There is reason to believe that the number of physician-scientists is declining to a greater extent in basic science research relative to the number in clinical research. This was previously noted by the more marked decline in the total numbers of physician-scientist K08 Mentored Clinical Scientist Research Career Development Award applications than that in the numbers of K23 Mentored Patient-Oriented Research Career Development Award applications between fiscal years (FY) 2005 and 2014 at the National Heart, Lung, and Blood Institute (NHLBI) and at the NIH in general (7, 8). The K08 funding mechanism is not exclusively for applicants pursuing basic science research, although the great majority are in contrast to the K23 program that requires training in patient-oriented research. In the last decade (FY 2010–2019), the K08 applicant pool at the NHLBI is approximately 60% of FY 2005 levels, in contrast to K23 applications for which the decline has been largely curtailed, with an encouraging uptick in recent years

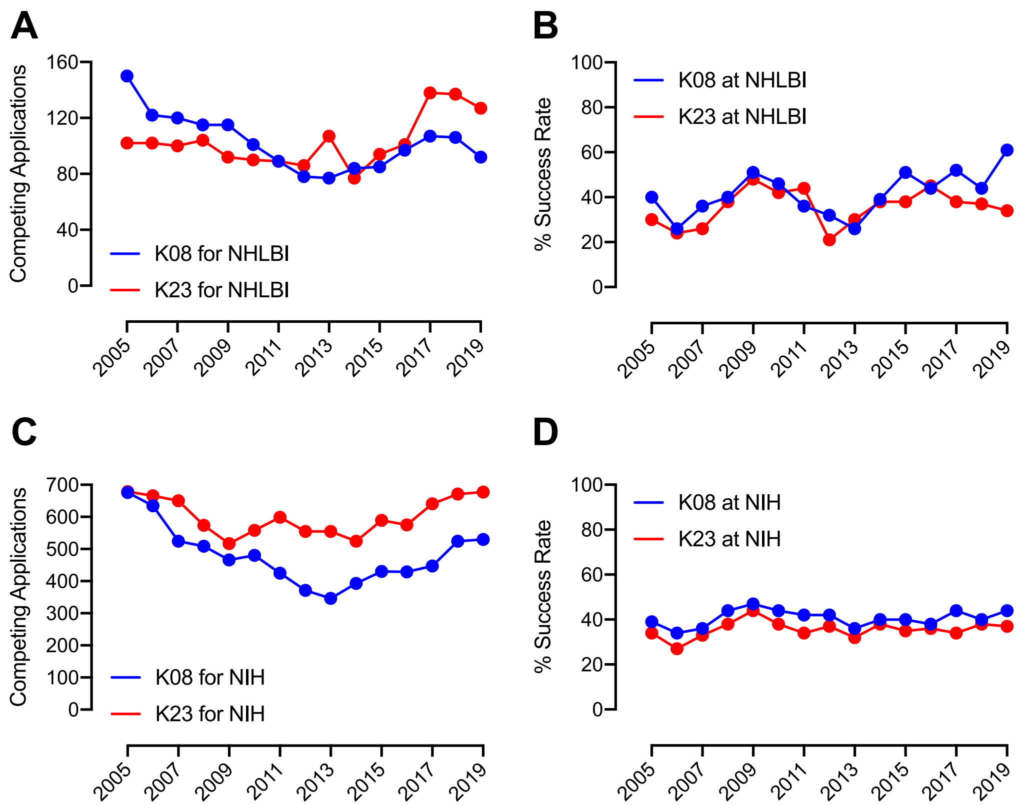

Figure 1. (*A*) Data represent numbers of K08 and K23 applications to the National Heart, Lung, and Blood Institute (NHLBI) from fiscal years 2005–2019. (*B*) Data represent the success rates (number of applications funded/number of applications reviewed) of K08 and K23 awards from the NHLBI from fiscal years 2005–2019. (*C*) Data represent numbers of competing K08 and K23 applications from the National Institutes of Health (NIH) from 2005 to 2019. (*D*) Data represent the success rates (number of applications funded/number of applications reviewed) of K08 and K23 awards from the NIH from fiscal years 2005–2019. Data was provided by NIH Research Portfolio Online Reporting Tools (RePORT) (9) and Lindman and colleagues (7).

(Figure 1A) (9). Although the success rate is generally similar if not higher for K08 grants at the NHLBI (Figures 1A and 1B), the overall decline in K08 applications is concerning because it suggests a growing pipeline problem. Similar trends are seen in competing K08 versus K23 applications for the NIH overall in the last 20 years, despite similar success rates (Figures 1C and 1D).

Over the past four decades, the limited investigator pool comprised of individuals with a Doctor of Medicine (MD) degree has not substantially increased, with a peak of 4.7% in 1984 and currently 1.5% in 2014 (2, 3). Women and UIM groups represent a disproportionately smaller number of physician-scientists relative to the national population (10–12). The NIH has supported the Medical Scientist Training Program since 1964 to target training for physician-scientists, which has been largely successful, with approximately 80% of graduates remaining in academia after earning their MD and Doctor of Philosophy (PhD) degrees (11). Within the most recent MD–PhD cohort studied (2005–2014), women make up 34.5% of MD–PhD graduates, whereas UIM graduates represent 10.8%, which is consistent with steady improvement over the past 40 years (12). The most limited representation was for Native Americans and Pacific Islanders at 0.2% and 0.6%, respectively (12). Internal medicine currently represents the largest group of

MD–PhD alumni at 26% (13). Of this group, only 4.9% are trained in pulmonary and critical care medicine, in contrast to oncology (25.4%), cardiology (11.6%), and infectious diseases (11.1%). Pediatrics represents 16% of MD–PhD alumni, with strikingly low numbers in pediatric pulmonology, representing only 2.3% of the 2005–2014 cohort, whereas critical care medicine and neonatology represent 2.7% and 3.7%, respectively (13). MD–PhD matriculants remain less demographically diverse than the MD-only cohort, and the composition of medical school matriculants overall is also less representative of the U.S. population (14, 15). At earlier stages of training, only 17% of bachelor's degrees in science and engineering are earned by minority groups as defined by the NIH (16). Even starker is the dearth of UIM physician-scientists, especially within basic science research fields (11, 17, 18). These data raise significant concerns that diversity within the pipeline to physician-scientist careers remains limited, and interventions to expose trainees to career possibilities in biomedical research need to occur earlier in education and be sustained throughout training.

The research project grant (RPG) traditionally marks the successful transition from junior to independent investigator. Although men and women earn RPGs at similar rates, the overall applicant pool remains disproportionately male. As of 2019, women represent 34% of all RPGs, consistent with improving trends (19). Of the MD–PhD graduates surveyed, 22% of women had current funding via RPGs compared with 34% of men. Although NIH RPG awards for women physician-scientists have been steadily rising since 1999, women encounter specific threats to their career advancement that are particularly keen in basic science research (20). Recent data are lacking for UIM physician-scientists, but follow-up of the 1997–2004 MD and MD–PhD cohorts showed that RPG award rates for UIM applicants were significantly lower than those of majority applicants (21). In addition to a funding rate gap of almost 10%, UIM investigators represent only 1.6% of RPG awardees, well below this group's representation in the biomedical research workforce (22). Overlapping data for race and sex are often missing from similar studies. Although achievement in the NIH funding pipeline often predicts future success and independence, data suggest that metrics historically associated with a fundable priority score did not apply to African American and Hispanic investigators who matched the education, training, productivity, NIH experience, characteristics of the academic institutions, and citizenship status of majority counterparts (23).

Trends within the pipeline for women have improved; women now constitute 50.5% of matriculating medical students (as of 2019) and 41% of academic medicine faculty (24–26). However, women currently represent only 26% of full professors in academic medicine (25). UIM women represent 13% of faculty, with a large majority at the instructor or assistant professor ranks. Of women who are full professors, Black/African American and Hispanic/Latino women comprise 3.0% and 2.8%, respectively (26). These statistics do not reflect the even smaller numbers of UIM physician-scientists. The absence of role models reflecting the demographics of the very candidates who are recruited into the pipeline likely compounds the challenges of training. High-quality mentorship can mitigate the impact of implicit biases, microaggressions, and discrimination within institutional training environments. Discrimination on the basis of race and sex leads to decreased job satisfaction, increased attrition, and can decelerate career trajectories (27–29). Facets of the "minority tax," which is defined as the disproportionate burden on UIM faculty for diversity efforts and institutional service through committees without contributing to career advancement, add to the labor of sustaining a career in academic medicine (30, 31). As racism, police brutality, and health disparities rise to the forefront of national discourse, the emotional labor has only intensified for UIM trainees and faculty leaders nationwide.

For physician-scientists, rising demands in the clinical and research domains complicate efforts to excel. The time from when the first RPG is awarded to scientific independence has lengthened (10, 11, 32). High productivity demands during prime child-rearing years disproportionately impact women in the pipeline. Basic science research is, in general, less portable than clinical research, further limiting the ability to meet benchmarks during these challenging years. In addition, academic faculty accept a significant reduction in salaries relative to those of private practices after completing training. Protracted training duration and student loan debt can make research careers less attractive and provide "economic disincentives" as described by Dr. James Wyngaarden, the NIH director in 1979, that deter physicians from biomedical research (1). Academic centers are facing increasing economic pressures that often translate to increased clinical productivity demands for junior faculty. The changing dynamics in health care that contribute to physician burnout also complicate the experience of individuals who navigate the dual arenas of clinical medicine and biomedical research. The most recent comprehensive study on burnout among physician-scientists surveyed 816 physician-scientists 5–8 years after K-level funding (42% women) and showed that 42% of women spent more than 44 hours per week on domestic tasks compared with 17% of men (33). Women also had a lower appraisal of their work climate, worked fewer overall work hours, and were more likely than men to report burnout (33). These disparities pose challenges for career advancement of women in the PSW and require awareness by both institutions and funding agencies. However, studies on the dynamics of burnout for physician-scientists that include both sex and UIM status are lacking.

OPPORTUNITIES TO ENHANCE SUSTAINABILITY OF THE PULMONARY, CRITICAL CARE, AND SLEEP MEDICINE PHYSICIAN-SCIENTIST PIPELINE

From a systems perspective, increased exposure to high-quality research opportunities and physician-scientist mentors during residency training represents one opportunity in building and sustaining the physician-scientist pipeline. The recently launched Stimulating Access to Research in Residency NIH funding opportunity (R38) is one such example available to institutions to recruit, retain, and shepherd the transition of resident investigators to individual career development research awards (34). The Burroughs Wellcome Fund Physician-Scientist Institutional Awards were also launched to address the growing need to expand the pool of MD-only physician-scientists in basic research by creating partnerships with institutions that promote tailored training, with the ultimate goal of successfully transitioning them into independent investigators (35). These institutional awards, coupled with concerted efforts by fellowship programs to immerse trainees in fundamental concepts and skills in basic research in the form of "boot camps" during their research years, may help reduce further erosion of the pipeline.

One key area in which the pulmonary, critical care, and sleep medicine community can harness its strengths and resources is through its academic professional organizations, such as the American Thoracic Society (ATS). ATS programs such as the Minority Trainee Development Scholarship support travel for UIM trainees to attend the ATS International Conference and present their work. Junior investigator grant mechanisms, assembly awards, early stage investigator programming, and mentoring and/or networking opportunities foster a sense of community, collegiality, and support within the larger academic community. The expansion of these successful programs and informing mentors about these opportunities for their trainees can have significant impact over time to promote inclusion within the physician-scientist pipeline.

The NIH loan repayment program (LRP) has been an important mechanism to directly address the educational debt burden faced by many physician-scientists. The program has traditionally focused on investigators pursuing clinical research that has been defined broadly. One possible solution to expand and sustain the pool of physician-scientists interested in basic research is to enable meritorious applications without requiring human subjects as a criterion. The pediatric research program within the LRP is one such example, and this model could provide the framework to expand the pool of talented LRP recipients and sustain their ability to pursue more basic science training.

One concern stemming from the growing pipeline problem is that it predicts declining numbers of established physician-scientists who can serve as mentors and role models in the future. Therefore, increasing the funding opportunities for established physician-scientists deeply committed to mentoring will enhance sustainability of the workforce. The Midcareer Investigator Award in Patient-Oriented Research (K24) is one such mechanism. The eligibility criteria could be expanded to include investigators who mentor medical students, clinical residents, clinical fellows, and/or junior clinical faculty interested in pursuing basic research (36). Moreover, the partnering of physician-scientists with PhD scientists to mentor trainees also provides a larger pool of established mentors from which to acquire technical skills and knowledge.

Research experience, paper authorship, and F32 awards are predictors of successful mentored K award applications, and this association is particularly strong for UIM groups (37). However, high-quality mentorship for developing physician-scientists who will persist beyond the early stages in academia is of vital importance. Surprisingly, little attention has been paid to prepare, educate, and train mentors themselves to support trainees from more diverse backgrounds. Noncongruent sex and race in mentoring is fruitful when the mentor is available, transparent, and understanding of the road traveled by their trainee (38). The most successful efforts emphasize cultural competency, effective communication, needs assessments of mentees, emotional intelligence, and the promotion of trainee independence (Table 1) (39, 40).

Guidance with clear delineation of milestones, constructive real-time feedback, and seeking out opportunities for women and UIM trainees is important, and mentoring should be provided with an understanding of the life experiences and vantage point of the trainee. The mentor should encourage mentee participation during journal clubs, clinical and research

Table 1. Proposed modifications to improve mentoring for UIM and women physician-scientist candidates

Understand mentee's background, past and current challenges, and short- and long-term goals
Increase familiarity with funding opportunities specific to women and UIM trainees and disseminate to mentees
Provide sponsorship in some capacity and engage other colleagues who can provide support in this role for mentees
Engage in open discussion of one's own challenges and authenticity
Establish clear guideposts for mentee and identify risk factors for attrition with support and resources at each stage
Encourage visibility in academic settings (research meetings, conferences, and presentations)
Promote networking opportunities among women and UIM groups within academic institutions and professional organizations

Definition of abbreviation: UIM = underrepresented in medicine.

conferences, and laboratory meetings while emphasizing that the mentee's voice matters in these spaces. This is essential to building confidence within academia. One of the most critical contributions mentors can make is that of their own authenticity while supporting and nurturing the authenticity of the trainees during their career development. This approach reflects honesty about the mentor's own setbacks, pitfalls, and disappointments, which strengthens the mentoring relationship and provides teachable moments to guide the mentee. Authenticity requires time, investment, and a consistent longitudinal commitment from both the mentor and the physician-scientist in training.

Honest dialogue is needed by institutional and program leadership to acknowledge and address implicit bias within the research enterprise that can actively discourage women and UIM investigators from advancing in their careers. Trainees should be encouraged to build mentorship teams to meet different needs for their scientific pursuits and career development. Also, these teams should provide critical sponsorship to launch them into more career-defining opportunities (41). The promotion of peer networking opportunities for women and UIM groups at all levels of training is vital to building a sense of community and support within and across institutions. Mentors should also familiarize themselves with unique funding opportunities for women and UIM fellows and junior faculty, such as NHLBI diversity supplements, minority faculty development programs (such as the Harold Amos Medical Faculty Development Program), the NIH-supported Programs to Increase Diversity among Individuals Engaged in Health-Related Research, and the Hanna H. Gray Fellows Program supported by the Howard Hughes Medical Institute (16, 42).

Although early challenges and setbacks surrounding research funding can derail some careers, persistence and resiliency through those early setbacks can be predictive of later success (43). However, such resilience is more often reflective of the support, resources, and institutional culture surrounding the investigator than an individual's intrinsic potential to succeed in academia. In addition, life circumstances and the road traveled during these transition points, such as mentorship changes, childbirth, economic hardship, and personal health crises, also impact careers. Protected time, equitable start-up packages, institutional infrastructure and support, and quality mentoring are essential for fellows and junior investigators to overcome these setbacks, and we would argue that this is even more important for physician-scientists. Bridge funding and technical support for career transitions, including the end of a career development award and the first RPG, are essential. Trainees who see junior investigators ahead of them supported at this vulnerable stage are more likely to be retained and to continue their research endeavors because they see that their values and aspirations align with their institution. Highlighting career development and peer mentoring opportunities for women and UIM fellows and faculty should also be integrated. An excellent model is the Association of American Medical Colleges professional development seminars for women and UIM junior faculty to provide mentoring and professional development tools essential for succeeding at early stages in academic medicine (44). In the context of work–life balance, support for childcare and expanded jeopardy coverage for unexpected physician or family illness would improve overall quality of life. Innovative approaches such as time banking for improved physician wellness have also yielded positive results (45). All of these efforts require institutions to reappraise their own values and invest in creative solutions that will target faculty that have selective disadvantages. Ultimately, this posture will benefit all members of the academic community. The net effect will be recruiting and retaining a more representative cadre of successful physician-scientists within their institutions and nationwide who can then mentor the next generation's leaders in biomedical research.

WHY IT MATTERS: SUMMARY STATEMENT

A diversified workforce has been shown to increase productivity, promote creativity, and to better address scientific problems (46, 47). Scientific and demographic diversity of the PSW will ultimately make the U.S. research enterprise more competitive and sustain the longevity of academic institutions whose mission is to seek new cutting-edge knowledge. The institutional commitments to improve retention and overall well-being of physician-scientists should recognize the unique challenges of the UIM and women PSW. This mindset will be crucial as we look forward in our field. The ATS can also support these efforts by providing the infrastructure for networking, mentoring, and research support for not only trainees and junior faculty but also midlevel career investigators. As our field navigates the unchartered territory of the coronavirus disease (COVID-19) pandemic that is currently disproportionately impacting minority groups, the inclusion of these groups within pulmonary, critical care, and sleep medicine is even more essential and will enhance scientific inquiry moving forward (48, 49). Providing sustained training opportunities for MD-only physicians interested in basic science research and promoting the careers of UIM and women physician-scientists will advance scientific discovery to improve health in respiratory diseases, critical illness, and sleep disorders.

Author disclosures are available with the text of this article at www.atsjournals.org.

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