The Physician-Scientist

Past Trends and Future Directions

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Abstract

The physician-scientist workforce is vital to the advancement of biomedical research and the practice of medicine. Physician-scientists are a unique link between basic science research and clinical practice that facilitates new discoveries in the understanding and treatment of human disease. However, the number of physicians reporting science as a primary career activity in the United States has remained stagnant despite an increasing number of total practicing physicians. In 2014, just 1.5% of all practicing physicians reported research as their primary activity. In addition, there are concerns that women and minorities are disproportionately underrepresented in the physician-scientist workforce relative to the overall physician workforce. The present review synthesizes the trends and concerns of many prominent voices in the physician-scientist community. Furthermore, it provides recommendations for interventions aimed at repairing the “leaky” pipeline that recruits and trains

medical students for careers in research.

Introduction

Concerns over the state of the physician-scientist workforce were first brought to the attention of the research community in 1979 by James Wyngaarden, then professor at Duke University and later director of the National Institutes of Health (NIH), in a symposium addressed to the Committee on Medical Education of the New York Academy of Medicine. In his symposium, Dr Wyngaarden famously warned that the clinical investigator had become an “endangered species.”¹ At the time, Dr Wyngaarden was distressed by waning numbers of young MD and MD/PhD graduates involved in research careers. This early call to action would be echoed in the following decades by other prominent research.²⁻⁵

To date, the state of the physician-scientist workforce continues to be a source of great concern for many in the research community.⁶⁻⁹ In their 2014 report, the NIH Physician-Scientist

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Workforce Working Group found that of the nearly 1 million physicians in the United States, only 14 000 (1.5%) reported research as their primary focus.^{6,10} In a review of the literature, Kosik et al identified more than 1200 peer-reviewed publications as of the year 2014 devoted to the topic of rescuing the physician-scientist workforce.⁷ In 2008, the Association of Professors of Medicine published a special report proposing recommended actions for repairing the “leaking physician-scientist pipeline.”¹¹ Furthermore, an increasingly sparse funding environment at the NIH has only further exacerbated the situation.^{9,12}

Physician-scientists play an essential role in biomedical research and the advancement of medicine. With a unique blend of experiences in research and clinical practice, they are poised to ask and answer scientific questions aimed at improving clinical outcomes. Physician-scientists often play leading roles in patient-oriented research, including clinical trials, behavioral studies, and epidemiology. Without their contributions to these endeavors, the transition of basic science research to clinical practice would be significantly compromised.

Given these concerns, the present paper reviews the current preoccupations and recommendations of many prominent figures in the research community regarding the uncertain future of the United States’ physician-scientist workforce. In doing so, it aims to highlight the importance of proper training, mentorship opportunities, and incentives for medical trainees who seriously aspire to become physician-scientists.

Methods

PubMed and Google Scholar were searched electronically for peer-reviewed publications relevant to the topic of the physician-scientist workforce. Key phrases included physician-scientist workforce, clinical research, biomedical research, medical scientist training program, NIH, and pipeline model. Articles were included and reviewed in full based on their relevance to the topic.

Review

Past and Present Issues

The trend that drew Dr Wyngaarden’s concern in 1979 were the reduced number of total NIH applications and awards belonging to young MDs and MD/PhDs. Between 1968 and 1978, NIH postdoctoral traineeships awarded to physicians dropped from 3200 per year to just 1400 per year. During the same period, physicians qualifying for NIH research career development awards dropped from 43% to 24%. Furthermore, new principal investigators on NIH research projects who were physicians declined from more than 41% to less than 20%.¹

Similar trends would continue to emerge in the following decades. In 2000, Zemlo et al noted a 6% decline in the percentage of physicians reporting research as their primary career over the previous 17 years, from 15 377 in 1980 to 14 340 in 2002.¹³ During the same period, physicians reporting patient care as their principal career activity nearly doubled, from 376 512 in 1980 to more than 700 000 in 2002.^{13,14} This increase was proportionate to the total number of physicians in the United States between 1980 and 1997. By 2014, physician-scientists made up only 1.5% of all physicians, down from 5% in 1987 (Table 1).^{6,13} In other words, a growing number of graduating physicians disproportionately elect to pursue nonresearch activities.

These trends were reflected in the makeup of faculty members at academic institutions. Between 1982 and 1996, there was a decline in the number of MD faculty members in basic science departments, from 2381 to 2195.¹⁴ The number of MD faculty members actively involved in research as principal investigators receiving NIH funding had also declined, from 481 in 1982 to 348 in 1997.¹⁴

Meanwhile, a “large and persistent” gender gap continues to exist among physician-scientists, starting with the negative effects of medical school experiences among women interested in research careers.¹⁵ The NIH Physician-Scientist Workforce report noted that among physician-scientists applying for NIH grants, there were 3 times as many male as female applicants, despite the relative gender

TABLE 1. Total Number of Physician-Scientists, 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total*	864355	872458	884276	897293	915641	927258	943972	954115	964251	980377
MD	4297	4325	4413	4287	4226	4162	4132	4149	4204	4192
Asian	439	482	522	541	568	602	631	664	679	693
Black	75	85	84	85	79	78	74	85	89	95
Hispanic	165	166	170	171	184	182	188	194	195	189
White	3483	3463	3505	3362	3261	3156	3079	3024	3019	2954
Other	135	129	132	128	134	144	160	182	222	261
MD/PhD	3859	4002	4061	4075	4102	4041	3955	3991	4069	4086
Asian	700	797	875	907	962	1004	1007	1056	1107	1110
Black	50	58	55	53	53	56	57	53	53	51
Hispanic	146	153	168	160	169	171	174	177	184	180
White	2904	2929	2889	2874	2830	2703	2600	2574	2574	2577
Other	59	65	74	81	88	107	117	131	151	168

*Total number of physicians practicing in the United States

Source: NIH Physician Workforce Report, 2014

parity in medical and graduate school applications.^{6,10} One cohort study following women through medical school showed that they were less likely than men to maintain any intentions of pursuing a career as a physician-scientist by the time of graduation.¹⁵ Other studies have shown that women are also less likely than men to participate in clinical scientist training programs, such as the Medical Scientist Training Program (MSTP) and the Howard Hughes Medical Institute/NIH-sponsored Cloister Program.^{5,15,16}

Explanations

Various explanations for the declining numbers of physician-scientists have been explored. In the pipeline model, missed opportunities occur as early as “recruitment into the pipeline,” or during premedical and early medical school.^{9,13} First, although many medical school admissions committees do place an emphasis on research

experience, the priority for most institutions is the selection of future physicians, not necessarily future physician-scientists.^{9,17} Second, available opportunities for students interested in research careers are limited. The NIH-funded MSTP accounts for just 2% of all matriculating first-year medical students, a number that has remained stagnant for decades.^{16,18} For the other 10% of medical students who have strong intentions to pursue a career in research,¹⁷ structured training programs are available but limited. Some notable examples include programs established by the NIH, the Howard Hughes Medical Institute (HHMI), and the Doris Duke Charitable Foundation.¹⁹⁻²¹ A select group of medical schools currently also offers 12 months of dedicated research time during the 4 years of medical school, including the Cleveland Clinic Lerner College of Medicine, Duke University School of Medicine, and Baylor College of Medicine.⁹

Only approximately 50% of all graduates of physician-scientist training programs choose careers in academic medicine.⁷ The most effective of these are the NIH-funded MSTP, from which 83% of graduating students pursue careers in academic medicine.⁷ Non-MSTP, such as the yearlong fellowships funded by the HHMI and Doris Duke Charitable Foundation, are less effective, with only approximately 20% of graduates choosing careers in academic medicine.⁷ Finally, postgraduate training programs, including research training during and after residency, are similar to the MSTP in their success at graduating physicians who ultimately go into academia.⁷

For those who have completed graduate medical education with strong intentions to pursue a career in research, “attrition from the pipeline” also occurs at the transition point from traineeship to independent physician-scientist.^{9,22} Specifically, Daye et al point to the time period from when young researchers obtain their first NIH career development awards (K awards) to when they obtain a research grant (R award). Reasons for this attrition include a lack of support at the transition point and the inflexibility of K awards in terms of minimum percent effort and maximum total duration.⁹ With heavy clinical duties, high minimum percent effort requirements and time period restrictions make balancing research and clinical practice a difficult proposition for many.

In addition to the “leaky pipeline” metaphor, authors have attempted to explain the declining numbers of physician-scientists as the result of a lack of interest in research among medical trainees. On the other hand, some sources cite increasingly heavy debt accumulation through many years of training and relatively low wages that follow in residency and fellowship programs.¹³ In recent years, the NIH has established Loan Repayment Programs (LRPs) to address this issue, offering \$35 000 annually in loan repayment to trainees with heavy debt who are engaged in NIH mission-relevant research.²³ Still other authors cite length of training as a deterrent, which for students in the MD-PhD track has increased from an average of 6.6 years in the 1980s to a current average of

8 years.^{9,16,17} The average age to first R01 or equivalent grant has increased from less than 38 in 1980 to more than 45 as of 2013.²⁴ Burnout may also be a source of midcareer attrition, with physician-scientists specifically citing work overload, time limitations, and a lack of incentives.^{25,26}

The Contribution of Physician-Scientists

Physician-scientists are essential to the advancement of the field of medicine. Physician-scientists, traditionally defined as MDs who perform medical research as a primary professional activity,¹³ are a crucial link between bench and bedside.²⁷ Their clinical experience provides an ideal setting for asking research questions,² making physician-scientists an important force in the transition from clinical observations to testable and applicable research hypotheses.¹⁴ In other words, physician-scientists are the bridge between basic science and its application to human disease.²⁸ Examples of their contributions include new or improved surgical techniques; an increased understanding of adverse drug reactions; new insights into hereditary diseases, including novel diagnostics and therapeutics; and the identification and treatment of emerging infectious disease.¹⁴ Indeed, patient-oriented research—namely, clinical trials, behavioral studies, epidemiology, and disease pathophysiology studies—would suffer without a robust physician-scientist workforce.²⁹

Outside of their research endeavors, physician-scientists also play a critical role in the education of medical students, imparting the foundations of clinical reasoning in the form of the scientific method and its use in evidence-based medicine.¹⁴ For trainees interested in careers in research, physician-scientists serve as important role models and mentors. Thus, with their involvement in research, education, and patient care, physician-scientists are among the few individuals who independently embody the tripartite mission of most major US academic medical centers.

Looking to the future, physician-scientists are also poised to lead innovations in medicine. One example is the current trend toward personalized

medicine. Physician-scientists with expertise in genetic medicine, pharmacogenetics, and bioinformatics would be uniquely suited to lead patient-oriented discoveries in the evolution of medicine toward personalized care.¹⁴

Recommendations

If we consider the pipeline model of physician-scientist development, then it is important to engage students early—at the level of premedical or medical training—to foster an interest in research careers.³⁰ One way to increase recruitment to the pipeline may be to involve more research faculty in the medical school admission process.¹⁷ Doing so would secondarily shift the focus of medical school admissions to include applicants' intentions to pursue research careers.

Additionally, interested medical schools could commit a set portion of their incoming class to a non-MSTP research track. One example is the Scientific Discovery Path of Excellence at the University of Michigan, which spans all 4 years of medical school. As part of this research track, medical students are paired with a faculty mentor and complete a research project before graduation.³¹ The path gives students opportunities to engage in high-quality research experiences with dedicated research time during medical school.³¹ This and similar research tracks at other medical schools give students an additional entry point into the physician-scientist pipeline.

Medical school is a second important point of intervention for reversing the troubling trends in the physician-scientist community. Early exposure of non-MSTP medical students to mentored research projects could open students to the possibilities of integrating clinical research into their careers. A study from the University of Tennessee Health Science Center and Vanderbilt University that followed 1000 students over 25 years enrolled in NIH-sponsored Medical Student Research Fellowship programs found that interest in academic careers significantly increased.³² On follow-up, approximately one-third of respondents reported

that research was a significant part of their postresidency careers.³²

Another approach might be to increase the available positions in structured training and mentorship programs for young scientists, as exemplified by the HHMI, NIH Medical Research Scholars Program, HHMI Medical Fellows Program, and Doris Duke Charitable Foundation programs. Although limited, outcome data from these programs have been shown to increase interest in research and academic careers.³² In one study, 21% of HHMI NIH Medical Research Scholars Program graduates and 24% of HHMI Medical Fellows Program graduates had received NIH postdoctoral awards.¹⁹ These percentages were significantly higher than for nonawardees, of whom between 10% and 13% had received NIH postdoctoral awards.¹⁹

Furthermore, changing medical school curricula to include more problem-based learning and dedicated research time has been shown to increase medical students' interest in research.³³ In 2003, 70% of medical school deans reported using problem-based learning in their curriculum.³⁴ However, only 6% used problem-based learning for more than half of formal teaching, and 45% used it for less than 10% of formal teaching.³⁴ Additionally, only a handful of US medical schools include dedicated research time in their curriculum. Notable examples include Duke University School of Medicine, Cleveland Clinic Lerner College of Medicine, Stanford University School of Medicine, and Baylor College of Medicine. With dedicated research time, medical student journals provide students an additional opportunity to engage in the research process and have been shown to increase students' interest in research.³⁵

From the perspective of pipeline retention, changes including adjustments to K awards may lessen the attrition of physician-scientists.⁹ Currently, Mentored K awards (eg, K08, K23) require a minimum of 75% effort, making balancing clinical duties and research a difficult proposition.³⁶ Furthermore, structured programs blending residency and research training may help retain aspiring

physician-scientists. In the standard pathway, medical trainees can go 6 or more years between significant research experiences in medical school (eg, MSTP research years, 1-year medical research fellowships) and their first opportunities to resume research after residency and/or fellowship.²² Additionally, expansion of programs aimed at addressing the burdens of heavy debt, such as the NIH LRP, may also increase interest in research careers. Finally, making more reasonable clinical and research workloads for physician-scientists may help minimize midcareer attrition and increase the effectiveness of student mentorship.

Conclusion

Various alarming trends, which started to emerge as early as the 1960s and continue to the present day, indicate that the growth of the US physician-scientist workforce is lagging behind that of the rest of the medical profession. Fewer medical students are expressing an interest in research careers, fewer medical graduates are applying for NIH project funding, and fewer MDs have positions in basic science departments. Reasons for these downward trends may include inadequate recruitment, limited structured training programs, and the burdens of debt and time constraints in the

postgraduate years. Physician-scientists are essential to the advancement of patient-oriented medical science and clinical practice. They bridge bench research and clinical application and embody the tripartite medical mission of patient care, research, and education. There are several promising widespread changes to medical school curricula and LRPs are steps in the right direction. Further changes may include expansion of better recruitment to the physician-scientist pipeline, more structured training programs, and changes to postgraduate funding mechanisms. Additionally, for trainees who decide to leave the physician-scientist pipeline, alternative opportunities should exist to maximize their interest in academic-based clinical research or teaching with funding for placements in medical education, public policy, epidemiology, behavioral science, and other fields.³⁷ Ultimately, a multipronged approach (Table 2) that both fosters interest in research careers and addresses weak points in the trainee pipeline is the most promising solution to our declining physician-scientist workforce.

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TABLE 2. Recommendations

1	Actively include physician-scientist faculty in the medical school admission process.
2	Reserve a set number of positions in medical school admissions for students with demonstrated interest in research.
3	Include more problem-based learning in medical school curricula to encourage scientific reasoning and questioning.
4	Develop a research track within the medical school curriculum to give interested students opportunities to engage in research.
5	Increase the number of available positions in structured physician-scientist training and mentorship programs.
6	Change the requirements for early-career NIH research awards to allow more clinical time.
7	Expand loan repayment programs to encourage interest in research careers.

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