

The Physician-Scientist Career Pipeline in 2005

Build It, and They Will Come

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PHYSICIAN-SCIENTISTS ARE DEFINED as individuals with an MD degree who perform medical research as their primary professional activity. These investigators have contributed much to this nation's preeminent position in medical science. The majority of physician-scientists have only 1 professional degree, an MD; a small fraction has a second (eg, PhD, MPH, JD, or MBA). Most physician-scientists conduct clinical investigation along a broad scientific continuum, from disease-oriented (seeking mechanisms that cause diseases and the means to diagnose and treat them) to patient-oriented (using direct patient contact to test hypotheses concerning etiology, pathophysiology, and management) to population-oriented (assessing disease incidence and susceptibility with epidemiologic and biostatistical tools). In addition, many physician-scientists perform basic research (studying fundamental biological processes).¹

The unique perspective that physician-scientists bring to the medical research workforce is that their scientific questions arise at the bedside and in the clinic. Regardless of the kind of research they perform, physician-scientists are imprinted by having cared for sick human beings.

Despite this perspective and the broad range of scientific questions emanating from it, the pipeline of physician-

Context Physician-scientists play a unique and critical role in medical research. Nonetheless, a number of trends followed during the 1980s and 1990s revealed that this career pathway was in serious jeopardy. Physician-scientists were declining in number and were getting older. A variety of factors were thought to contribute to this problem, including increasing indebtedness of medical school graduates caused by rapidly rising medical school tuition costs.

Objective To evaluate the impact of recently initiated programs from the National Institutes of Health (NIH) and several not-for-profit institutions designed to revitalize the physician-scientist career pipeline.

Design We assessed recent trends in the physician-scientist career pipeline using data obtained from the NIH, the American Medical Association, the Association of American Medical Colleges, and other sources.

Main Outcome Measures Total numbers of physicians performing research, grant application numbers and success rates for MDs, MD-PhDs, and PhDs at various stages in their careers, interest in research among medical students, medical school tuitions and postgraduate salaries, numbers and composition of applicants for NIH loan repayment programs, and gender distribution of young physician-scientists.

Results The number of physician-scientists in the United States has been in a steady state for the past decade, but funded physician-scientists are significantly older than they were 2 decades ago. However, the study of early career markers over the past 7 to 10 years has demonstrated increasing interest in research careers by medical students, steady growth of the MD-PhD pool, and a new burst of activity in the "late bloomer" pool of MDs (individuals who choose research careers in medical school or in residency training), fueled by loan repayment programs that were created by the NIH in 2002. Several recent trends for more established physician-scientists have also suggested improvement.

Conclusions Although it is too early to assess the impact of these indicators on the long-term career pathway, the recent growth in activity in the physician-scientist career pipeline is an encouraging development. Continued funding of these new programs, coupled with sustained support for physician-scientists committed to the pathway, will be required to maintain these positive trends.

JAMA. 2005;294:1343-1351

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scientists has a serious problem, first described more than a generation ago.² Simply put, the physician-scientist population in the United States is smaller and older than it was 25 years ago. These and other disturbing trends have led some thoughtful observers to conclude that the physician-scientist is

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an endangered species, or at least a threatened one.¹⁻¹⁶ Once this alarm was sounded, and the evidence for it confirmed, several National Institutes of Health (NIH)-sponsored groups, private foundations, and national organizations called for new initiatives aimed at revitalizing the physician-scientist career path.

Key players in the United States' medical research enterprise, particularly the NIH, have responded impressively to these calls.^{17,18} In 1998, the NIH established new career development

awards for young physicians being trained to carry out clinical research (K23), awards for established clinical investigators (K24), and awards for academic institutions with programs supporting clinical research training and infrastructure (K30). In 2002, the NIH put in place a series of competitive loan repayment programs (LRPs) offering at least 2 years of tax-free debt relief (up to \$35 000 per year) for young scientists with significant debt and a serious commitment to clinically oriented research training.^{19,20}

The private not-for-profit sector has responded too.^{16,18,21} Foundations (led by Burroughs-Wellcome and Doris Duke) created new awards for young and established physician-scientists. The Howard Hughes Medical Institute appointed 12 new MD investigators engaged in patient-oriented research. Finally, an increasing number of research-intensive medical schools and hospitals (where most physician-scientists work) have constructed multifaceted programs aimed at encouraging medical students to become involved with research before and after receiving their MD degree and at protecting the research time of young physician-scientists during their junior faculty appointments.²²⁻²⁴

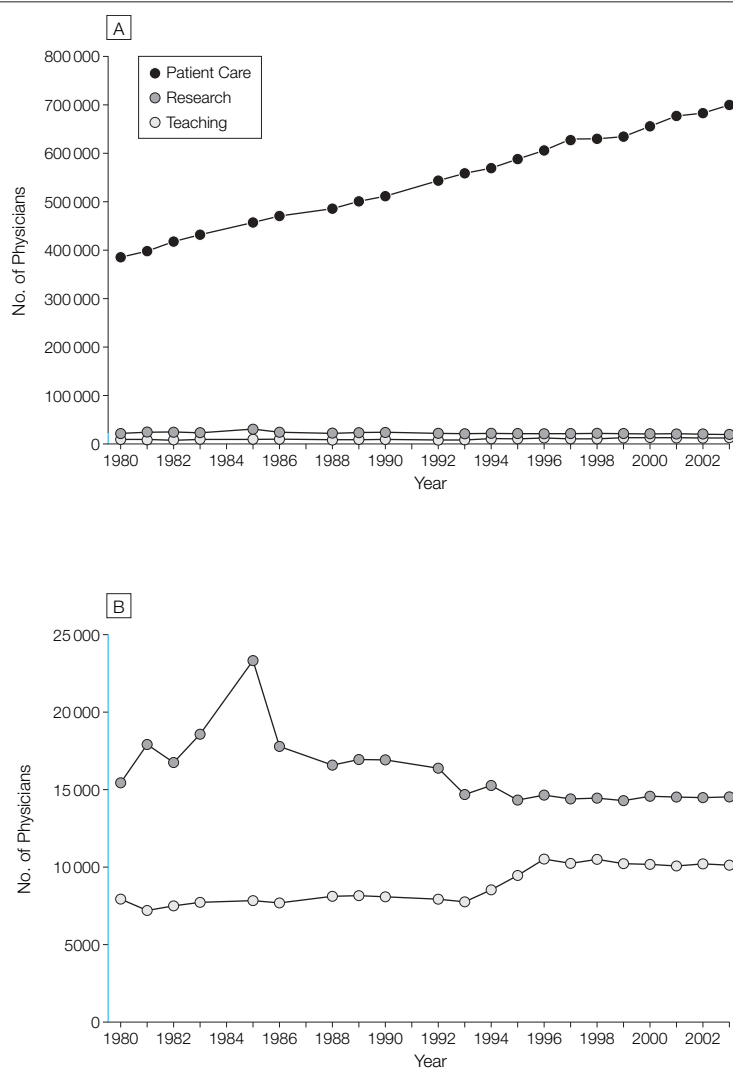
All of these initiatives, begun between 1998 and 2002, were undertaken against a very important backdrop: the commitment by Congress and the Administration to double the NIH budget from approximately \$14 billion in 1998 to approximately \$28 billion in 2003. This remarkable growth has increased funding for most NIH programs, and it raised the tide of confidence for all those engaged in medical research.

In this report, we attempt to define the effects that all of these budgetary and institutional initiatives have had on the physician-scientist career path. Our data-driven survey relies on information obtained from the NIH, the Association of American Medical Colleges (AAMC), the American Medical Association (AMA), and other sources. Our findings offer a more encouraging picture of this professional cadre than similar surveys performed 5 to 10 years ago.

METHODS

We obtained the data used in this study from the National Center for Research Resources, the Division of Information Services of the Office of Extramural Research, and the Office of Loan Repayment and Scholarship (all at the NIH), the AMA, and the AAMC. Specified data sets were directly requested from the described agencies by the authors. No data sources were pooled. Un-

Figure 1. Composition of the Physician Workforce in the United States, 1980-2003



A, Number of physicians engaged in each of the major professional activities. B, Data for physicians engaged in research or teaching as their major professional activity is shown on an expanded scale for increased clarity. Source: American Medical Association.

modified data were used in all cases. Some data were extracted by the authors from the Matriculating and Graduating Student Questionnaires of the AAMC, available online at <http://www.aamc.org/data/msq/allschoolreports/start.htm> and <http://www.aamc.org/data/gq/allschoolsreports/start.htm>. Data regarding matriculating MD-PhD students at 42 medical schools with NIH-supported Medical Scientist Training Programs and 15 schools without such NIH support were provided by the AAMC and Harvard Medical School. All individual measurements were followed as a function of time and presented in a variety of formats designed to highlight selected points deemed relevant by the authors. All data sets were assembled and analyzed in Excel spreadsheets (Microsoft Inc, Redmond, Wash). All of the data sets used to create the figures shown are available on request from the corresponding author (T.J.L.).

RESULTS

Current Demographics of Physician-Scientists

The number of physicians engaged in patient care in the United States has increased steadily for the past 30 years (FIGURE 1A). In contrast, the number of physicians engaged in research as their major professional activity declined from peak reported values of 18 535 in 1983 and 23 268 in 1985 to 14 340 in 1995, where it has since remained virtually constant (14 521 in 2003; Figure 1B). The number of physicians engaged in teaching and research represents a very small portion of the total physicians in the United States. Moreover, the percentage of physicians engaged in research has declined steadily from a peak of 4.6% in 1985 to a level of 1.8% in 2003, both because the pool of physicians in practice has grown and because the number of physician-scientists has declined.

Physician-scientists who successfully compete for NIH research project grants (RPGs, which include R01, R03, R15, R21, R22, R23, R29, R33, R34, R35, R36, R37, R55, P01, P42, PN1,

PN2, UC1, U01, and U19 grants) are getting older (FIGURE 2). In 1986, 306 (24.8%) of the 1234 RPGs awarded to MDs were to persons older than 50 years; in 2004, this proportion had increased to 43.7% (741/1696). Approximately 35% (504/1422) of all awards given to MD-PhDs in 2004 were held by individuals older than 50 years, while nearly 38% (2593/6868) of awards to PhDs went to this age group. All 3 groups demonstrate the same aging trend, but the effect is most pronounced for MDs.

Is the aging effect due to an inability of young physician-scientists to successfully compete for NIH grants? To answer this question, we examined the success rates for all NIH grant applicants as a function of experience and degree (FIGURE 3). When all applicants are considered, it is clear that MDs, MD-PhDs, and PhDs are similarly successful at obtaining grants from the NIH (with MD-PhDs having a small advantage in the past; Figure 3A). When experienced (ie, previously funded) investigators are considered (Figure 3B), there is again no evidence that physician-scientists are less competitive. When previously unfunded investigators are evaluated (Figure 3C), MDs and PhDs have equivalent success rates, while MD-PhDs are slightly more successful. Previously unfunded investi-

gators are less successful at obtaining NIH grants, no matter what degree they hold. In 2003, success rates for all groups were indistinguishable.

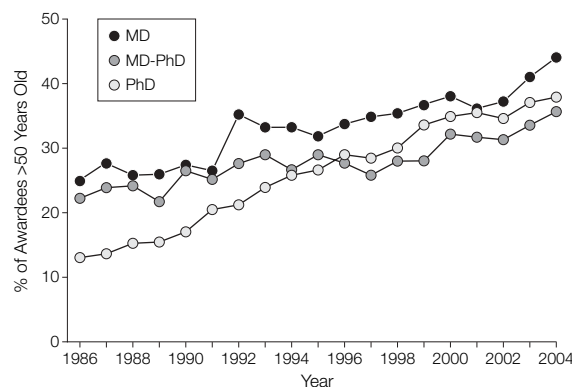
Our results suggest that physician-scientists, once in the career pipeline, are successful at obtaining and maintaining long-term grant support. Why, then, has there been no growth in the national pool of physician-scientists? To address one potential explanation, we asked whether medical students are now less interested in research careers than they were a generation ago.

Medical Student Interest and Participation in Research

For several decades, the AAMC has performed surveys of medical students at matriculation and again at graduation. Using information obtained from these surveys, we analyzed the number of medical students who were "exclusively" or "significantly" interested in research as a career activity at the beginning and end of medical school (FIGURE 4A).

During the decade between 1988 and 1997, research interest declined among both matriculating and graduating students. Since 1997, there has been a small but steady increase in interest in research as a career activity among both matriculating and graduating students. Interest in research has consis-

Figure 2. Aging of Funded NIH Investigators, 1985-2004



The percentage of total research project grant awards awarded to investigators older than 50 years is shown for each degree type. For this and all other figures, MDs include individuals with an MD degree alone plus all individuals with an MD plus another professional degree other than PhD. Similarly, MD-PhDs include all individuals with these 2 degrees plus any other professional degrees. Source: National Institutes of Health (NIH).

tently been 1% to 2% higher in graduates than in matriculants, suggesting that the medical school experience contributes to an interest in research (the “late bloomer” effect). Since 1980, a progressively larger fraction of graduating medical students have indicated that they have an interest in research and teaching as part of their career activity. The vast majority of students are interested in clinical topics, not basic research (Figure 4B).

Because the percentage of medical students who are female has nearly doubled in the past 2 decades, we also wished to examine women’s attitudes toward research careers. However, none of the questionnaire responses shown

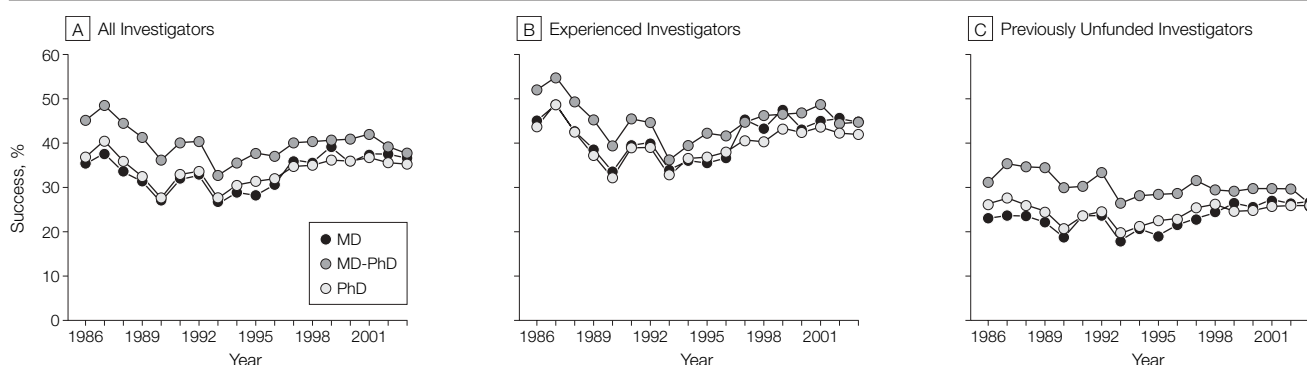
in Figure 4 was classified according to gender. We therefore examined the gender composition of MD-PhD programs in the United States, which have exhibited slow but steady growth over the past decade. Nearly all of this growth has been due to an increase in the number of women (FIGURE 5), a trend matched by an equivalent growth in the number of female applicants (data not shown).

These data do not explain why more young physicians have not chosen research careers. We therefore turned our attention to another potential disincentive to research careers, the large debt burdens caused by rapidly rising medical school tuition costs.

The Debt Obstacle to Research Careers

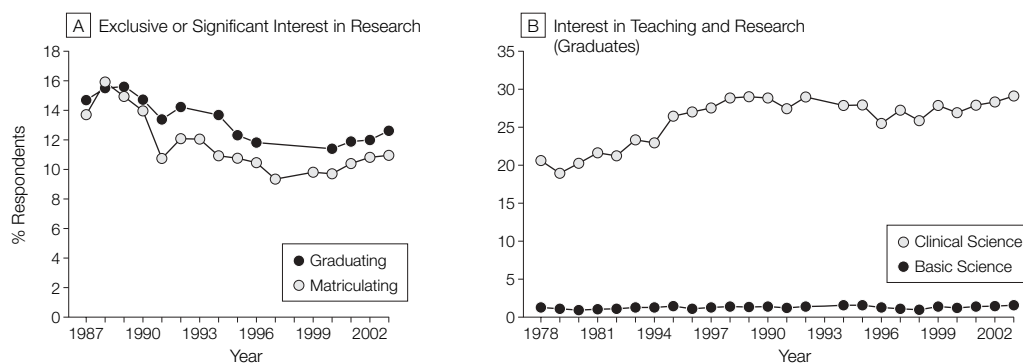
Jolly²⁵ and Morrison²⁶ have recently summarized the growing problem of escalating medical school debt. The median educational debt for those graduating from private medical schools in 2004 was more than \$130 000, while those graduating from public schools had median debts of approximately \$100 000.^{25,26} At graduation, nearly all physicians obtain additional training that affords relatively low salaries compared with those of physicians in practice. Physicians who choose research careers take on many extra years of training and are therefore more strongly affected by the relatively low wages

Figure 3. NIH RPG Funding Success Rates for MD, MD-PhD, and PhD Investigators, 1985-2003



A, Funding success rates for all investigators, regardless of experience. B, Funding success rates for previously experienced investigators (ie, investigators with a previously funded research project grant [RPG] award). C, Funding success rates for investigators who have not previously been awarded an RPG are shown. Source: National Institutes of Health (NIH).

Figure 4. Medical Student Interest in Research



A, Percentage of Association of American Medical Colleges (AAMC) questionnaire respondents (surveys taken at medical school matriculation or graduation) exhibiting an exclusive or significant interest in pursuing research as a career activity, 1987-2003. B, Percentage of graduating respondents who exhibited an interest in clinical or basic science teaching or research as part of their careers, 1977-2003. Source: AAMC Matriculating and Graduating Medical Student Questionnaires.

of residency and fellowship training programs.

To evaluate the consequences of debt for young physicians, we compared the average 4-year tuition costs of public and private medical schools with the average national postgraduate year 1 (PGY-1) salary (FIGURE 6). Postgraduate year 1 salaries have increased over the past 2 decades at a rate that matches inflation (data not shown). However, 4-year tuition costs at private medical schools have increased at a much faster rate. In 1978, the average cost of 4 years of tuition for private medical schools (\$15 953) was only slightly more than the average PGY-1 salary (\$13 965), while the average 4-year tuition bill for public medical schools was considerably less (\$4781). In 2004, the average 4-year tuition bill for private schools (\$115 128) was nearly triple that of the average PGY-1 salary (\$40 788); the 4-year tuition of public schools (\$47 143) also now exceeds it. This dramatic shift may represent a disincentive for highly indebted students to obtain additional training at relatively low wages.

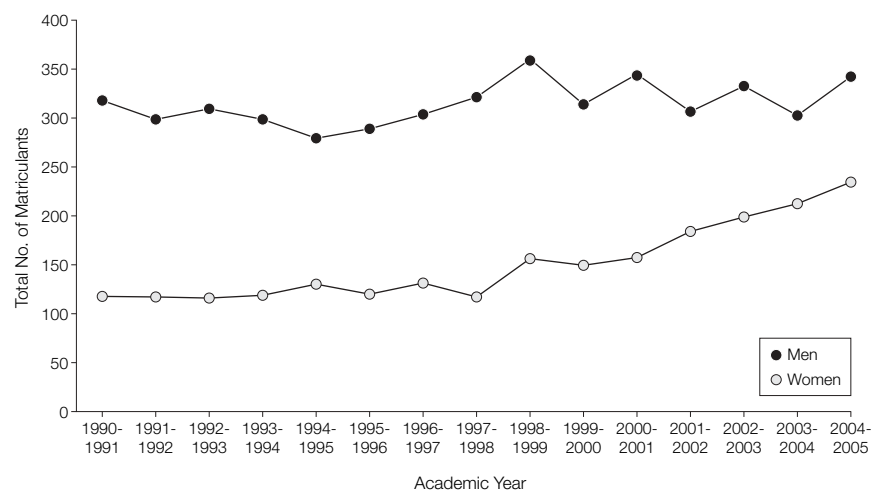
Overcoming the Debt Obstacle: Loan Repayment Programs

President Clinton signed several initiatives passed by the 106th Congress that were designed to encourage heavily indebted young professionals to enter careers in clinical research. Four LRPs (<http://www.lrp.nih.gov>) were created by the NIH for clinical research, pediatric research, health disparities research, and clinical research for individuals from disadvantaged backgrounds; these were added to an older LRP focused on contraception and infertility research. Individuals with substantial amounts of debt were encouraged to apply for LRPs if they were actively receiving training in clinically oriented research. Individuals could receive up to \$35 000 per year in tax-free debt relief for 2 years and were eligible for a third year of support with an approved extension. In 2002, applicants also had to be the recipient of an NIH grant or training grant. This requirement was changed in 2003 (applicants could be funded by the NIH or any domestic not-for-profit organization), resulting in a large increase in applications (FIGURE 7A).

The applicant pool for LRPs has been stable from 2003 to 2005, with 800 to 1000 new applications each year for MDs, 600 to 800 for PhDs, and 100 to 150 for MD-PhDs. Success rates for new applications have been substantial, ranging from nearly 80% in 2002 to about

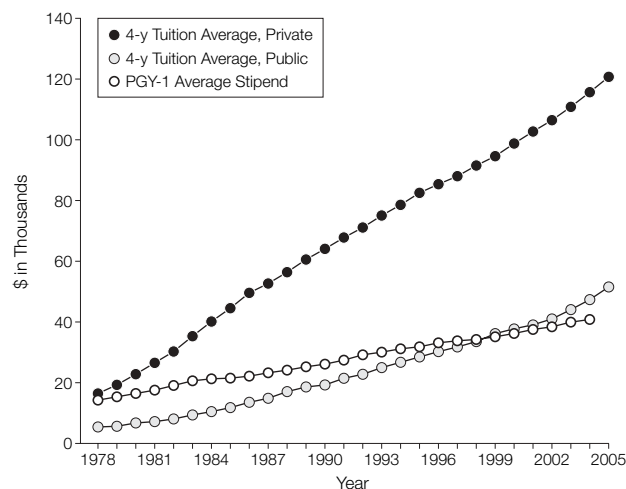
39% in 2005. A total of 1791 LRPs were awarded to MD researchers in the first 4 years of the program, with 1356 awarded to PhDs and 303 to MD-PhDs. The number of LRPs awarded annually far exceeds the number of 250 per year that was originally suggested by the NIH leadership in 2002.¹⁹ As expected, indebtedness for MD recipients of LRPs was substantially greater than for that of either PhDs or MD-PhDs. For ex-

Figure 5. Numbers of Matriculating MD-PhD Students in the United States, 1990-2004



The total number of male and female matriculants is shown. Source: Association of American Medical Colleges and Harvard Medical School.

Figure 6. Average 4-Year Medical School Tuition Costs Compared With Average Postgraduate Year 1 (PGY-1) Wages, 1977-2004



Average 4-year tuition costs were obtained by adding the average costs for each of the 4 years ending in the date shown. Source: Association of American Medical Colleges.

ample, in the clinical and pediatrics programs (which fund the largest number of applicants), the average debts for successful MD applicants were \$126 000 (clinical) and \$139 000 (pediatric) in 2004. In contrast, the average debts for successful PhD applicants were \$56 000 (clinical) and \$64 000 (pediatric) and for funded MD-PhD applicants, \$80 000 (clinical) and \$69 000 (pediatric). Women have constituted 46% to 48% of the first-time MD applicants each year and 24% to 29% of the MD-PhD group (Figure 7B). Men and women have had approximately equivalent success in receiving awards among all 3 degree-holding groups (data not shown).

Recent Trends of the Early to Mid-Career Physician-Scientist Pool

To assess the numbers of physician-scientists entering the career pathway via the NIH granting mechanism, we evaluated the growth of applications for early career awards primarily targeted for the support of young physician-scientists. The K08 awards are mentored early career awards designed to support individuals performing clinically oriented investigation that can be either basic or translational in nature. Since the inception of the K08 program in 1972, the NIH has increased its total funding to

nearly \$38 million in 2004 (FIGURE 8A). As funding has increased, the applicant pool has likewise increased but the number of funded awards has remained virtually constant over the past decade (Figure 8B). For this reason, the success rate for K08 applications has decreased from the 60% level in the mid 1990s to its current level of 40% (Figure 8C). The growth of the K08 applicant pool is further examined in FIGURE 9A. Most of the growth in applications over the past decade has come from MD-PhDs, with more modest growth from MD applicants. Both have been increasing at the same rate over the past 4 years.

The K23 awards, initiated in 1999, are mentored early career awards for individuals doing patient-oriented research. This program has expanded rapidly over the past several years, with most applications coming from MDs (Figure 9B). Few MD-PhDs have sought this type of career development support.

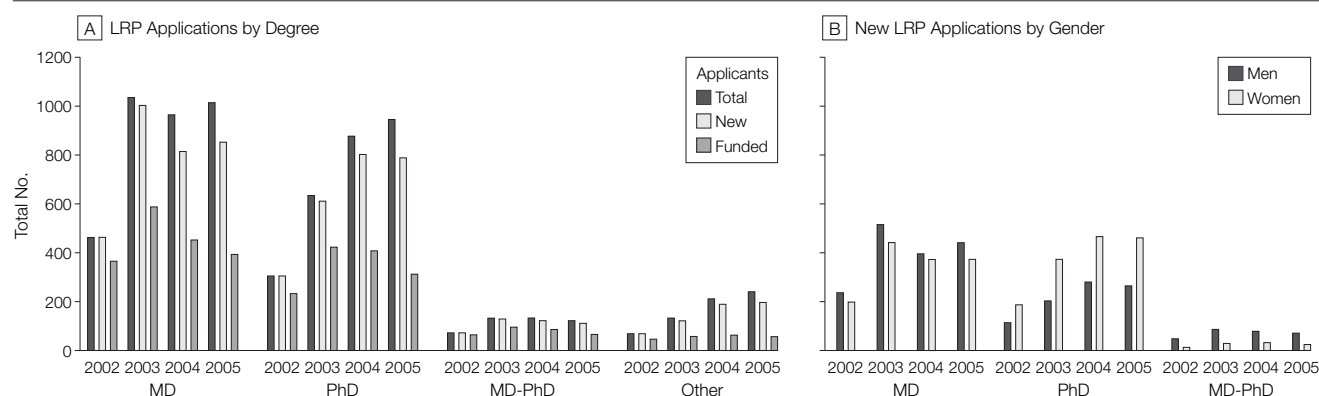
We also examined the number of "first-time" applicants for RPG awards as an indicator of the size of the pool of physician-scientists entering academic positions (Figure 9C and Figure 9D). Although there has been an overall increase in the number of first-time applicants in recent years (perhaps engendered by the concurrent

doubling of the NIH budget), this growth has been largely caused by an increased number of applications from PhDs (Figure 9C). First-time MD applicants, whose numbers hovered at 750 to 800 between 1995 and 1999, have slowly increased recently, reaching a total of 995 in 2003 (Figure 9D). First-time RPG applicants with MD-PhD degrees have steadily increased, from 133 in 1970 to 600 in 2003. The growth in total R01 applications (the largest component of RPGs) is shown in Figure 9E and Figure 9F; most of the recent growth has come from PhD candidates (Figure 9E). Even though MD-PhDs comprise only a small percentage of medical school graduates, the number of R01 applications from MD-PhDs in 2004 (3859) is now approaching that of MDs (4409; Figure 9F).

COMMENT

The data we have collected offer a more encouraging picture of the physician-scientist career path than any presented over the past 5 to 10 years. While it is much too early to declare that the problem of rescuing the physician-scientist population has been solved, many indicators are now going in the right direction. Of the 12 indicators we have examined, 9 offer encouraging trends, and these extend from the ear-

Figure 7. NIH Loan Repayment Program (LRP) Activity, 2002-2005



A, Applications by degree and year. Definitions of MDs, MD-PhDs, and PhDs were described in the legend for Figure 2. All data were obtained by summing information from all of the LRPs except for contraception and infertility, which was established before 2002 and which is very small compared with the new programs. New applications refer to applicants who had not previously applied for an LRP. B, New (first-time) applications by degree and gender. Small numbers of applicants did not specify gender, accounting for the small difference between the total number of new applicants shown in panel A and the data shown here. Source: Office of Loan Repayment and Scholarship, National Institutes of Health (NIH).

liest cohort (medical students) to the most mature (established NIH investigators). Some of these trends warrant special emphasis.

Medical Students

If there is to be a secure future for physician-scientists, it must begin with medical students. We are heartened that a progressively larger fraction of both matriculating and graduating medical students have recently indicated serious interest in research careers. This positive trend reverses one noted since the late 1980s.^{11,14} Since interest is higher in the graduating cohort, the data suggest that the medical school experience actually enhances research interest. Furthermore, during the past 20 years, a growing fraction of medical students have indicated that they want teaching and research to be part of their career activities. These trends are important, since medical students represent the critical pool from which the next generation of physician-scientists (particularly the late bloomers) must be drawn.

Young Postdoctoral Trainees

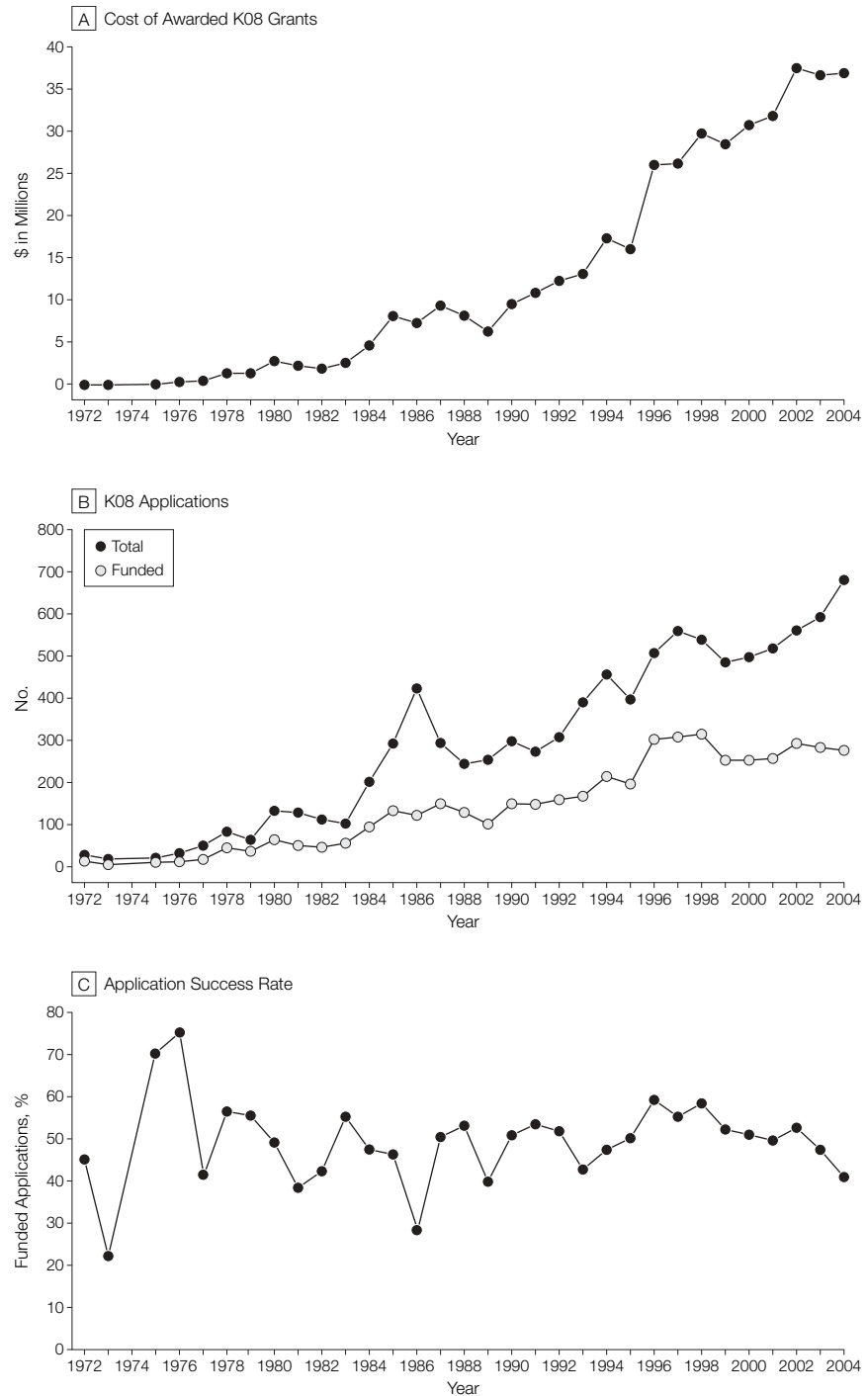
Three of the sampled indices (LRP, K08, and K23 applications) survey physician-scientists during the first several years of their research training experience. Each of these populations is characterized by positive trends. For example, examination of the first 4 years of the LRP program shows that there is a large, sustained pool of MDs and MD-PhDs whose indebtedness matters enough to apply (and, almost certainly, to affect career choice). If a reasonable fraction of the nearly 2100 MDs and MD-PhDs who have been awarded LRPs join the ranks of committed physician-scientists, this will change the demographics of the career ladder in a significant way. Likewise, the number of applications for K08 awards has increased during the past 5 years for MDs and MD-PhDs alike. So, too, have applications submitted by MDs for the newer K23 award. Sustaining these positive trends is a major challenge that we will further discuss herein.

Established Investigators

Five of the indicators we examined evaluate trends for this population. The

picture is mixed, but this is expected because most of the recent initiatives taken by the NIH and medical schools

Figure 8. The NIH K08 Program, 1972-2004



A, Total cost in millions of funded K08 awards from all National Institutes of Health (NIH) institutes, 1972-2004. B, Total numbers of K08 applications and funded awards by year. C, Percentage of funded K08 applications by year. Source: NIH.

have been directed toward young scientists and because there has not been sufficient time for these efforts to have a discernible effect on the larger population of established scientists. Thus, we are not surprised that the overall national population of physician-scientists is not currently increasing, nor that the fraction of grants awarded to NIH-funded investigators older than 50 years has increased over the past 2 decades (for MDs, MD-PhDs, and PhDs alike). However, 3 other indices in this group are encouraging. Since 1998, more MDs and MD-PhDs are applying for their first NIH research project

grants than in the recent past, and the same trend is noted for R01 applications. Importantly, MDs also remain as competitive as PhDs for NIH project grants, whereas MD-PhDs have performed slightly better than either of them. Thus, there is reason to believe that an increase in the pool of trained physician-scientists applying for NIH grants will be translated into a larger number who are funded.

MD-PhDs

Seven indicators offer information about this important population. First, the national population of MD-PhD stu-

dents is remarkably small at fewer than 600 total matriculants in 2005, or approximately 4% of the total medical student population. Over the years, however, MD-PhD graduates have constituted a growing fraction of funded physician-scientists, and that trend continues. They are overrepresented in the pool of K08 applicants, first-time RPG applicants, and R01 applications, clearly indicating the success of this program for producing successful physician-scientists with sustained academic careers.

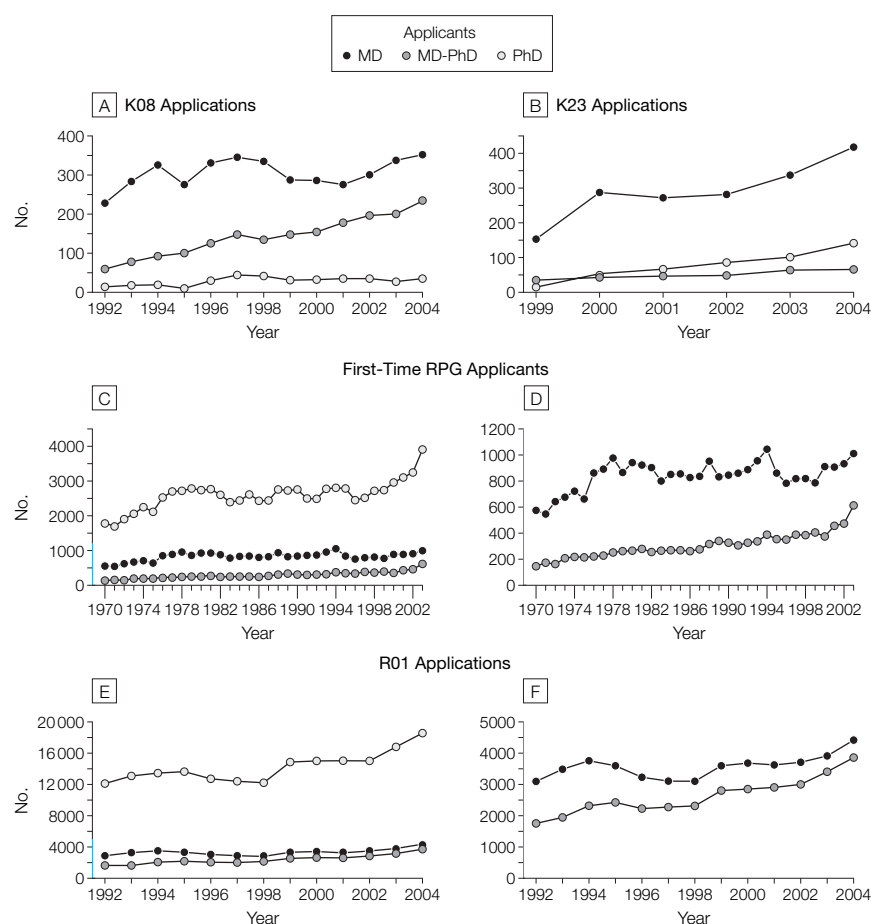
Late Bloomers

Because the MD-PhD pool is growing slowly, and because MD-PhDs tend to perform basic and disease-oriented research,¹⁴ late bloomers who become attracted to research during and after medical school will continue to be an essential source of future physician-scientists (especially for patient-oriented research). Several pieces of evidence support the view that this pool can be expanded. The increasing interest of medical students in research is one example. The impressive and unexpectedly large number of applicants for LRPs is another. The growing number of applicants for K08s and K23s is a third. A combined approach demonstrating that this career path is plausible and feasible, coupled with sustained efforts to remove financial and institutional obstacles, is warranted in light of these encouraging trends.^{17,19}

Participation of Women

Because half of incoming medical students are now women and because women have lagged behind men in their preference for research careers,^{27,28} we are particularly heartened by 3 indicators in our survey. The first shows that the fraction of MD-PhD students who are women has increased markedly during the past 7 years (from 27% of the total in 1997 to 41% in 2005). The second and third evaluate the gender breakdown of the LRPs: in each year for which we have data (2002-2005), women constituted 46% to 48% of the

Figure 9. Application Trends for NIH Grants



A, Applications for K08 grants by degree, 1992-2004. Degree holders were defined as in Figure 2. B, Applications for K23 grants by degree, 1999-2004. C, First-time applicants for all research project grant (RPG) awards by degree, 1970-2003. D, Data for MD and MD-PhD applicants are shown on an expanded scale. First-time applicants indicates that no other RPG application had been submitted before. E, Total R01 applications by degree, 1992-2004. F, Applications from MD and MD-PhD applicants are shown on an expanded scale. Source: National Institutes of Health (NIH).

new MD applicant pool for LRPs, and their funding success was not different from that of men.

The Future

We are encouraged by the results in this report but also are mindful of the many uncertainties they raise. First, given that the “doubling era” for the NIH budget is over, that further growth in that budget will be very modest, and that the initiatives we have described all cost money, how can the positive trends be continued? The answer is simply that the leadership of the NIH and other constituencies in the US medical research enterprise must accord these initiatives a high enough priority to be sustained (or even expanded) in the years ahead. For example, attracting large numbers of MDs to research via LRPs must be followed by sufficient funding of K08 and K23 awards. Continued strong funding of RPG applications will also be required to sustain careers beyond the entry phase.

Second, when can we expect to see a younger physician-scientist workforce? If the recipients of LRPs and early career awards are successful at the next

stage of their careers, the average age of physician-scientists should begin to decrease during the next decade (that decrease in age may not be dramatic, however, since research careers now begin later in life than a generation ago because of lengthened training requirements).

Third, preparing this report has once again reminded us of the pressing need for a national database that is capable of tracking the indices we have examined and others like them. Such a database is essential to monitor trends, discern issues, and make corrections as needed. We hope that the Institute of Medicine, AAMC, and NIH will work together to address this pressing infrastructure need.

CONCLUSION

New programs recently initiated by the NIH and private foundations are beginning to have a positive impact on the decisions of young physicians to pursue research careers. To maintain this trend, strong funding commitments will be required beyond the entry level. If these commitments are sustained, we are cautiously optimistic that they will

result in an increase in the population of physician-scientists in the United States in the near future.

Author Contributions: Drs Ley and Rosenberg had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Ley, Rosenberg.

Acquisition of data: Ley, Rosenberg.

Analysis and interpretation of data: Ley, Rosenberg.

Drafting of the manuscript: Ley, Rosenberg.

Critical revision of the manuscript for important intellectual content: Ley, Rosenberg.

Statistical analysis: Ley.

Obtained funding: Ley.

Administrative, technical, or material support: Ley.

Study supervision: Ley, Rosenberg.

Financial Disclosures: None reported.

Funding/Support: The Alan and Edith Wolff Chair provided support for Dr Ley.

Role of the Sponsor: The funding source had no role in the design and conduct of the study, in the collection, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript.

Acknowledgment: We are grateful to Alfred Johnson, Office of Loan Repayment and Scholarship, NIH, Robert Moore, and the staff of the Division of Information Services Office of Extramural Research, NIH, Derek Smart at the AMA, and Le'Etta Robinson and Gwen Garrison at the AAMC for fulfilling our many requests for data in a timely and professional manner. We also thank Linda Burnley at Harvard Medical School for providing data regarding the MD-PhD matriculants. We thank Denise Kampwerth and Jason Books, Washington University Medical School, for help with data management and Marcy Hartstein and Andrea Myles at Washington University's MedPic for creating the figures. Nancy Reidelberger, Washington University Medical School, and Patricia Fox, Princeton University, provided expert assistance with manuscript preparation.

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