FASEB
Federation of American Societies
for Experimental Biology

Physician Scientists

Assessing the Workforce

Howard H. Garrison, PhD and Anne M. Deschamps, PhD

December 11, 2013

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Executive Summary

Physician scientists make unique contributions to biomedical research, and the level of their participation is a topic of interest to educators, research institutions, and policymakers. In 1979, James Wyngaarden called clinician-scientists an “endangered species,” and, since then, there have been a series of examinations of physicians in biomedical research. Some have focused on National Institutes of Health (NIH) research grants (Dickler et al., 2007), while others have taken a more comprehensive perspective (Zemlo et al., 1999). Following the dramatic ebbs and flows in research funding that have taken place in recent years, a new study of the number of physicians engaged in biomedical research was undertaken using a broad range of indicators from national surveys (e.g., student career goals, training patterns, principal practice activity, faculty positions, research grants, and service on peer review panels).

In general, physicians are less likely to be involved in biomedical research than they were in the past, with the degree and form of change varying according to the measure of involvement used. Five patterns were observed:

- An extrapolation of earlier trends was found for some measures: increased medical school indebtedness, fewer applications and awards for postdoctoral research fellowships, rising age at first medical school faculty appointment, and declining percentage reporting research as their major professional activity.

- Along several dimensions, the situation has worsened at an accelerated rate in recent years (e.g., research fellowship applications and awards, applications for career

development awards, age at first medical school appointment, number of physicians reporting research as their primary career activity).

- For some measures, participation by MDs did not decrease in absolute terms, but their relative role is reduced as the number of PhD scientists increased at a greater rate (e.g., first-time R01 grant applications and awards, and faculty positions in basic science departments).

- Some indicators of research involvement are extremely sensitive to the ebbs and flows of research funding and are highly correlated with periods of increase and decline in NIH funding (e.g., career plans of matriculating medical students, and career development grant applications and awards).

- In many cases, the loss of MD scientists is partially offset by increased activity for MD-PhDs. In a few cases (e.g., number of medical school faculty members in basic science departments and membership on NIH peer review panels), the losses for MDs are completely balanced by increases for MD-PhDs.

Each indicator of research participation has its limitations, but taken collectively, the evidence of change is compelling. Overall, there were very few measures of research involvement that did not show some decline (either absolute or relative) in research participation by physicians.

Medical Education

Career plans. Surveys of matriculating and graduating medical students conducted by the Association of American Medical Colleges revealed that the percentage of students with an “exclusive” or “significant” interest in a research career declined during the 1990s. When funding for NIH rose after 1998, the percentage with interest in research careers increased sharply for both groups. When the pattern of steady NIH budget increases ended, so did growth in plans for research careers. For entering students, research career interest leveled off after 2006. For graduating students, growth continued for several more years until 2010.

Indebtedness. The cost of medical education and the indebtedness of new graduates have long been viewed as constraints on the pursuit of a research career. Debt levels for U.S. medical school graduates grew steadily from the early 1980s through 2008. Even when adjusted for inflation, the indebtedness rose for both public and private medical school graduates, and it was not until 2009 that the growth slowed.

Research Training

Traineeships. The number of MDs on NIH institutional training grants declined during the 1990s but rose steadily from 1999 through 2004. As was the case for medical student career plans, research training for MDs rose when funding for research increased and tapered off when the growth in funding ended.

Fellowships. The number of MDs applying for (and receiving) individual postdoctoral fellowship awards also grew during the era of large funding increases for NIH. Applications reached a peak in 2005 for MDs and 2006 for MD-PhDs before tapering off dramatically in subsequent years. By 2011, the number of applications from individuals with medical degrees had fallen by nearly one-half.

Early Career Investigators

Career Development Awards. The primary purpose of the NIH Mentored Clinical Scientist Research Career Development Awards (K08) program is "to prepare qualified individuals for careers that have a significant impact on the health-related research needs of the Nation." Applications for K08 awards grew steadily since the inception of the program in the early 1970s and reached a peak at the end of the period of major NIH budget increases. After the era of growth in research funding ended, the number of K08 applications dropped by one-third.

K23 awards (NIH Mentored Patient-Oriented Research Career Development Awards) were established in 1999 to provide protected time for individuals with a clinical doctorate who were interested in pursuing a career in patient-oriented research. Applications for this program also increased during the period of substantial NIH funding increases and declined when budgetary growth ceased. The shifts were smaller, however, than those for K08 awards, and there was a rebound in applications after 2009.

Medical school faculty positions. The percentage of MD faculty in clinical departments declined from 80.1 percent in 1981 to 75.8 percent in 2011. The fraction with MD-PhD degrees rose over the same time period compensating partially, but not completely, for the decline in MD faculty.

The number of MDs holding medical school faculty positions in basic science departments also declined over the past three decades. The decline in MD faculty has been offset by an increase in MD-PhD basic science faculty. The number of basic science faculty with PhD degrees, however, has nearly doubled since 1981, and as a result, the percentage of basic science faculty with MD or MD-PhD degrees declined from 30.0 percent to 18.7 percent.

The extended period of preparation required for a career in biomedical research may discourage many from the pursuit of this vocation. A prolonged apprenticeship also reduces the length of an independent research career for those who undertake it. Since 1970, the average age at first medical school faculty appointment has risen by four years for MDs and nine years for PhDs and MD-PhDs.

First-time R01. During the three decades since 1982, the first-time R01 success rates for MDs, MD-PhDs, and PhDs were nearly identical, with MD-PhDs holding a slight advantage. With equivalent success rates, the distribution of first-time R01 awards was largely a function of the number of applications. From 2000 onward, the share of first-time R01 awards to MDs declined, while PhDs and MD-PhDs increased their percentage of first-time R01 awards slightly during this period.

Not only have there been fewer physician scientists receiving NIH grants, it is also taking more time to become a principal investigator. From 1980 to 2011, the average age at first R01 rose by 7.4 years for MDs, 6.7 years for PhDs, and 8.2 years for MD-PhDs. In 2011, the average age of first-time MD R01 awardees was 45.1, nearly three years older than their PhD counterparts and almost one year older than MD-PhDs.

Established Investigators

Review panels. In 2011, reviewers with a medical background (MD or MD-PhD) were a smaller proportion of the reviewer population than they were in 1980. Since 1997, however, the decline in the percentage of MDs was balanced by a commensurate increase in the percentage of MD-PhDs.

Human subjects research. NIH research grants headed by scientists with MD degrees were twice as likely to involve human subjects as were projects headed by scientists with PhD degrees. Projects directed by MD-PhD scientists had rates of human subjects research that were slightly above those of PhD scientists but well below those of MDs.

Chapter 1 : Introduction

Physician scientists are uniquely capable of asking clinically relevant questions in research settings and bringing rigorous scientific inquiry to the care of patients. As such, they are a vital component of the biomedical research workforce (Thier et al., 1980). In the past decade, National Institutes of Health (NIH) grants to investigators with MD degrees were twice as likely to involve research with human subjects as were grants to scientists with PhD degrees (Rockey, 2013). Grants to researchers with both MD and PhD degrees were slightly more likely to involve human subjects than those awarded to scientists with a PhD only.

The desire to combine scientific observation with a clinical perspective has a long tradition, with roots going back to classical antiquity (Schafer, 2009). Success reaching the goal, however, has varied over time and place, and, for several decades, the number of physician scientists (researchers with MD or MD and PhD degrees) has been a concern for U.S. educators and policymakers.

Commenting on conditions in the U.S. in the 1970s, James Wyngaarden called clinical investigators an “endangered species,” and his seminal paper initiated a vigorous discussion of the role of medical training in biomedical research that has continued for more than three decades (Wyngaarden, 1979). He found that the most dramatic changes were at the earliest stages of the research career, pointing to a sharp decline in the number of research training fellowships for MDs from 1968 through 1977. Career development awards to young faculty members with MD degrees also declined during the same period but at a slower rate. Grant applications and awards to physician scientists remained stable during this period, but the percentage of applications and awards to physician scientists declined dramatically as a consequence of the growth in applications and awards to PhD scientists. Wyngaarden attributed this to changing social priorities (greater emphasis on medical care of underserved populations), unstable federal support for research and training, curriculum revisions (with less first-hand exposure to laboratory experiences), new requirements for specialty certification (reduced emphasis and delayed onset of research experience), and the payback provisions of the National Research Service Award training grants (which required those who did not enter research careers to reimburse the government for the cost of their stipends). Thier et al. (1980) pointed to several of the same factors and also raised concern about the rising student debt levels.

In another very influential essay about the involvement of physicians in biomedical research, Gill (1984) called attention to economic and intellectual changes. Training stipends paying well below prevailing compensation levels and financial risk resulting from new payback provisions instituted in the 1970s were seen as disincentives to entry into research careers. These developments, combined with slowed growth in research funding and faculty positions, made research careers less attractive. Changes in the organization of science, driven in part by the rise of powerful new tools derived from molecular biology, made it more difficult to combine research, teaching, and clinical practice. According to Gill, the complexity and the rate of change made research "more than a full time job."

Littlefield (1984) pointed out that many people entered medical careers with the intention of providing care for sick people, and the increasing complexity of biomedical research made it much more difficult for individuals to be part-time investigators. Cost containment polices were also seen as limiting opportunities for research in clinical settings (Moody, 1987). A decade later, Rosenberg (1999a) cited the growing debt burden of medical school graduates, the increased length of the postdoctoral training required for a successful research career, and instability inherent in a National Institutes of Health (NIH)-funded research career as disincentives.

In 1999, the Federation of American Societies for Experimental Biology (FASEB) undertook a major investigation of the education, employment and research activities of physician scientists (Zemlo et al., 2000). Building on the analytic model used by Wyngaarden (1979) and others, Zemlo et al. examined data on medical students (career plans and debt levels), faculty appointments, and research participation (major professional activities, NIH grant applications, and NIH research awards). Zemlo et al. found that the percentage of physicians reporting research as a major activity declined from the early 1980s through the mid-1990s, and the fraction of NIH-funded faculty members at medical schools with MD degrees declined as well. In this same time period, medical student intentions to pursue a research career plummeted while average debt levels of new medical school graduates steadily increased. There was a decline in the number of MDs supported on NIH training and fellowship grants, and the number of first-time grant applications submitted by MDs did not increase.

Subsequent studies have partially replicated and extended portions of the FASEB analyses. Ley (2009) examined NIH grant applications, awards, and success rates from 1992 through 2006 and found that the vast majority of the increase in research project grant applications were from PhDs. Dickler et al. (2007) reported that the number of physicians applying for NIH R01 grants rose modestly from 1,012 to 1,200 in the period from 1964-2004, while applications from PhDs rose substantially. Differences in success rates, however, were small over the period studied. Those physicians who were successful in obtaining a first R01grant, however, were less likely to receive subsequent NIH funding than their PhD colleagues.

It has been over a decade since there was a major examination of the participation of physician scientists in the biomedical workforce, and during that time there have been dramatic changes in the research environment. Funding for the NIH increased substantially in the late 1990s. From 1998 to 2003, the NIH budget doubled from $13.7 billion to $27.1 billion, with annual appropriations increases averaging over 14 percent. Growth ended abruptly, and the NIH budget grew by an average of only 1.3 percent annually since 2003.[1] In constant dollars, adjusting for inflation, the NIH budget in 2012 is $4 billion (19 percent) below the 2003 funding level.

During the late 1990s and early 2000s, institutions substantially expanded their research capacity and training levels as a result of the rapid increase in NIH-funding. Due to the time needed for construction and training, however, many of the new facilities and new researchers did not enter the system until several years after the funding growth had ended. Heinig et al. (2007) reported that medical schools increased their research space by an average of 2.9 percent in 2004 and 5.2 percent in 2005 and had projected increases of 4.6 percent, 6.8 percent, and 4.4 percent for 2006-2008. Academic research space for “biological and biomedical sciences” as well as “health and clinical sciences” continued to grow. From 2006 through 2012, these fields added more space

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[1] This excludes the stimulus funds provided in 2009 and 2010 by the American Recovery and Reinvestment Act. While making an important contribution to research, the stimulus funding in 2009 and 2010 did little to counter the long-term uncertainty facing research scientists and their employers.

than any other field. Expansion in 2008-2009 exceeded that for 2006-2007, and it was not until 2010 that the amount of new space added in “biological and biomedical sciences” began to slow. For “health and clinical sciences,” the growth in new research space did not begin to slow until 2012 (National Science Foundation, 2013). As a result of the expansion of facilities and the increased size of the research workforce, competition for research funding intensified in the post-doubling era. Success rates for NIH grants fell from 32.4 percent in 1999 to less than 18 percent in 2011. For researchers at medical schools, increasingly hired on the condition that their salaries come from research grant funding, this change was cataclysmic.

The economic downturn of 2007 reduced nonfederal sources of research funding, increasing financial pressure on institutions and researchers. Other factors thought to affect decisions about research careers also changed. Cost containment policies have limited the private practice options for recent medical school graduates and may have made them less attractive. The disincentives to the pursuit of a research career may have been reduced by new NIH career development awards to support clinical researchers and by expanded education loan repayment programs designed to encourage more clinically trained individuals to become researchers.

In light of these changes, FASEB undertook a comprehensive re-examination of the role of physician scientists in biomedical research using longitudinal surveys and institutional records. Data on career plans, research training, major professional activity, faculty positions, and research grants were used to measure participation at several key stages of a research career.

Chapter 2 : Major Professional Activity of U.S. Physicians

Since 1980, the American Medical Association (AMA) has conducted an annual survey of the major professional activity of U.S. physicians. While subject to yearly variations in the number of physicians reporting their activities, this survey provides a unique perspective on practitioners in the field of medicine. The reporting categories include patient care, teaching, research, government service, administration, and business.

Teaching

The number of physicians reporting “teaching” as their major activity rose during the 1990s and then declined after 1996. From 1980 through 1993, approximately 8,000 U.S. physicians reported teaching as their major professional activity. This number rose steadily over the next three years, reaching a peak of 10,612 in 1996. During the late 1990s and early years of the 21st century, there was little change. An average of 10,300 physicians reported teaching as their primary professional activity in the 1996-2007 time period. There has been a decrease in the number of teachers, however, in every year since 2007, and in 2010, the number dipped below 10,000 for the first time since 1995.

When viewed as a percentage of the population of U.S. physicians, the fraction of teachers declined during the 1980s and early 1990s, falling from 1.8 percent in 1980 to 1.3 percent in 1993. The percentage rose during the next three years, reaching 1.6 percent in 1996. Since that time, the fraction has been decreasing, and by 2011 (the most recent survey year), only 1.1 percent of U.S. physicians reported that teaching was their primary professional activity.

Research

The number of physicians reporting research as a primary activity fluctuated during the 1980s and then decreased over the next two decades. In 1985, over 23,000 physicians reported that their major professional activity was research. This number declined over the next 10 years and by 1995 just over 14,000 physicians reported research as their principal professional activity.

From 1995 through 2007, the number of physicians in the AMA survey citing research as their major professional activity was remarkably constant, ranging from 14,340 to 14,650. After 2007, however, the number of physician researchers dropped, and by 2010, only 13,557 individuals reported research as their primary professional activity, the lowest number in more than three decades.

While there were year-to-year fluctuations in the number of physicians reporting research as their primary activity, there is less annual variation when researchers are viewed as a percentage of the physician workforce. In the early 1980s, nearly four percent of U.S. physicians reported research as their primary activity. In 1985, this figure reached 4.6 percent. Over the next quarter century, the percentage of U.S. physicians in research declined steadily. By 2011, only 1.6 percent of the physician population in the U.S. reported research as their major professional activity.

Figure 2.1: Number of US Physicians Reporting Research and Teaching as Primary Activities (1980-2011)

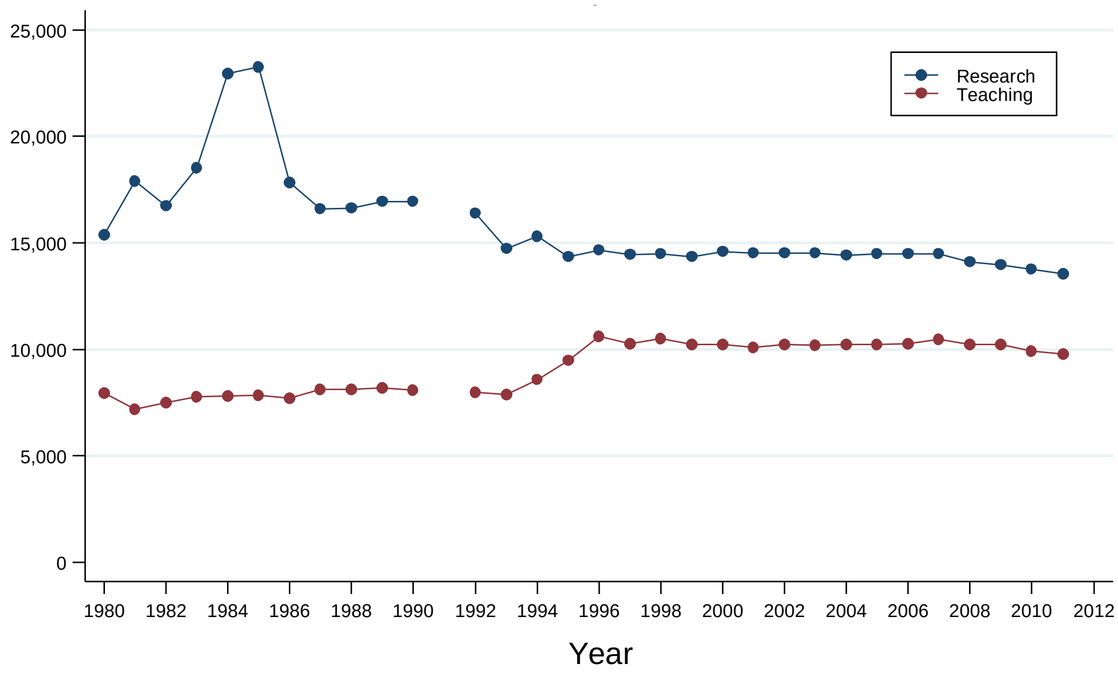
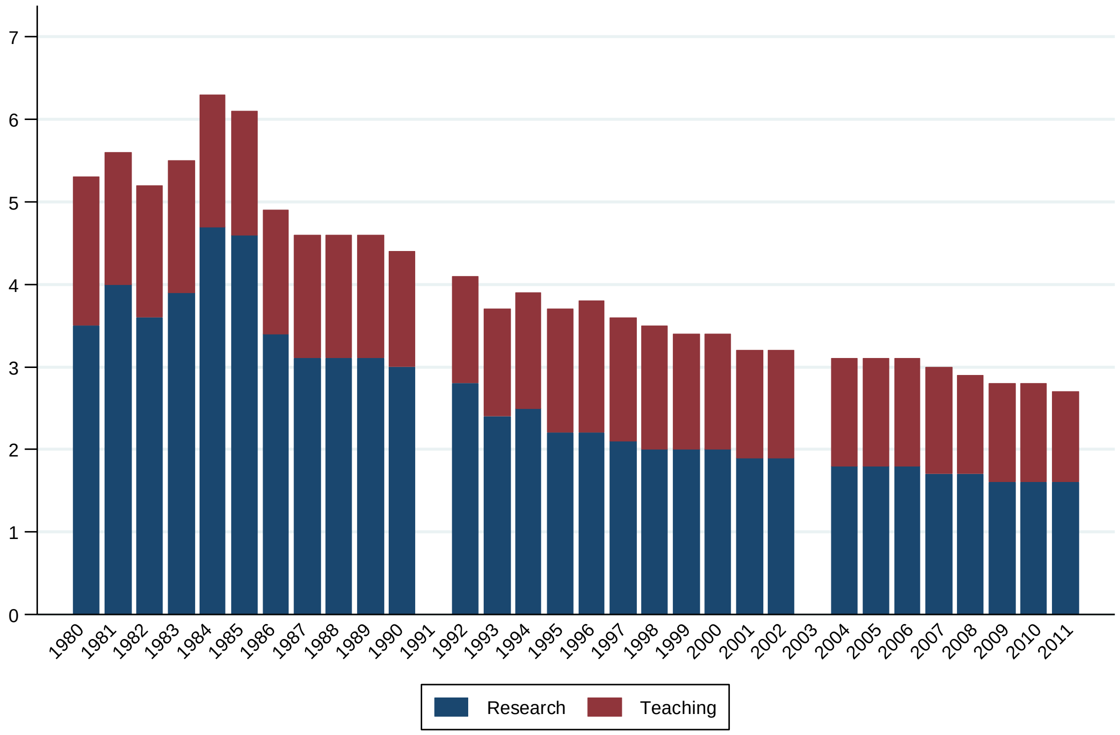


Figure 2.2: Percentage of US Physicians Reporting Research and Teaching as Primary Activities (1980-2011)



Chapter 3 : Medical Student Interest in Research Careers

For most of the past three decades, the Association of American Medical Colleges (AAMC) surveyed matriculating students (1987-2006) and graduating students (1982-1996 and 2000-2011) about their career intentions. Plans for research careers among matriculating and graduating medical students have moved in tandem, suggesting that the same factors were influencing the aspirations of both populations. Student plans for research careers rose during the period of rapid increases in NIH appropriations and declined when the budget growth ended.

Matriculating Students

In 1988, nearly 16 percent of the matriculating medical students reported strong interest in a research career.[1] This fraction decreased in eight of the next nine years, and by 1997, only 9.4 percent indicated strong interest in a research career. In 1998, plans for research careers began to rise among matriculating medical students, and by 2005, 13.1 percent intended to pursue research careers. Although the surveys did not record reasons for the change in career goals, it is interesting to note that aspirations for research careers rose during the years of large increases in the NIH budget.

Graduating Students

A similar pattern was found in the graduation survey. The percentage of graduating medical students with exclusive or significant interest in research careers reached its peak in the late 1980s and then declined in nearly every subsequent year through 1996, when only 11.9 percent

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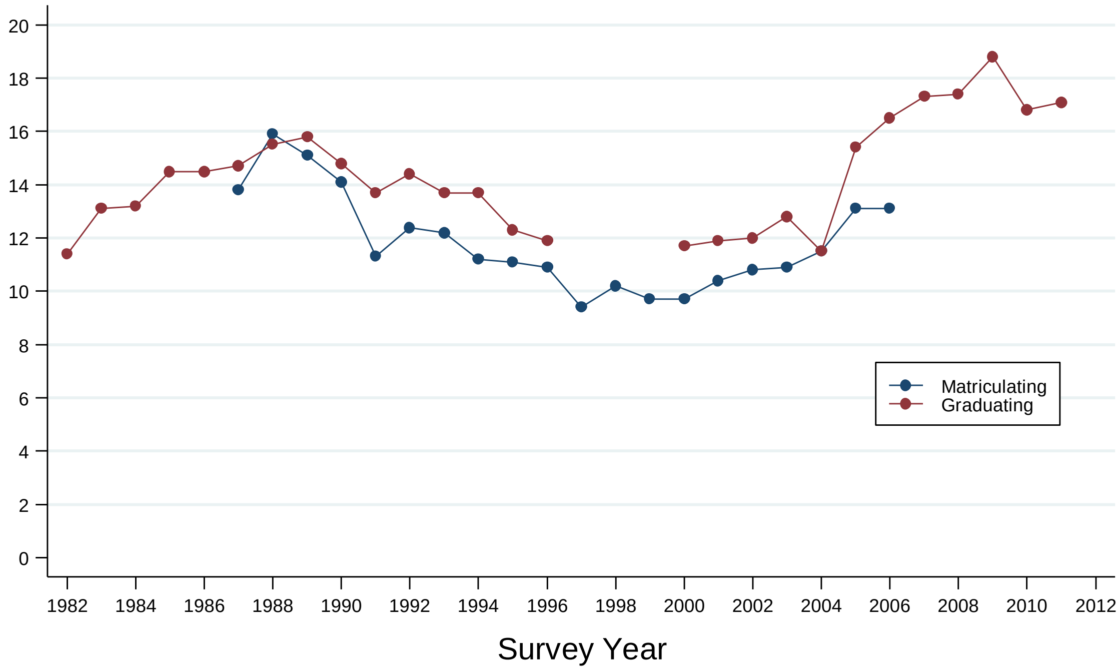
[1] "Strong interest" includes those reporting an "exclusive" or "significant" interest in a research career.

intended to pursue research careers. Graduates who were medical school students during the height of the NIH funding increases, however, were more likely to plan research careers. In 2005, 15.4 percent of graduates expressed exclusive or significant interest in a research career. Aspiration for a career in research rose in each of the subsequent four years and reached 18.8 percent in 2009, the year when the American Recovery and Reinvestment Act provided NIH with a $10 billion increase in funding.

Figure 3: Percentage of Matriculating and Graduating Medical Students with Exclusive or Significant Interest in a Research Career (1982-2011)



Chapter 4 : T32 Institutional Awards for Postdoctoral Training

Several NIH Institutes make institutional training grants to research universities and medical schools to provide postdoctoral training in the biomedical and behavioral sciences. For PhDs, these T32 programs provide specialized training in a new or emerging area of research. For MDs, these programs often support the first intensive research training experience.

From 1982 through 1992, NIH supported approximately 4,000 postdoctoral positions per year on T32 institutional training grants. These programs expanded in the 1990s. During the 1998-2003 period of large NIH budget increases, the number of individuals supported rose from 4,408 in 1998 to 5,235 in 2003. After 2003, approximately 5,000 people per year were supported by these training grants.[1]

The number of MDs in T32 training programs rose from 1,421 in 1982 to 1,624 in 1992. But from 1993 through 1997, the number of MDs on T32 grants decreased. Increased participation by MD-PhDs offset some (but not all) of the loss of medically trained T32 postdocs. In the years during which NIH had substantial budget increases (1998-2003), the number of MDs on T32 grants once again increased. By 2003, the number of MDs on training grants reached 1,700 and remained at this level for the rest of the decade.

In the late 1980s, the T32 postdoctoral training slots were filled by equal numbers of PhDs and physicians (MD and MD-PhDs). This pattern changed after 1989, however, when the number of PhDs supported on T32 training grants rose dramatically. During the early 1990s, the rising

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[1] Data for 2010 are incomplete, and NIH was unable to provide T32 data by degree for subsequent years

number of PhDs on T32 grants, combined with a declining number of MDs in T32 programs, shifted the fraction MDs downward. There was a slight rebound in the share of postdoctoral training slots held by MDs during the 1998-2003 doubling period. But when the funding growth ended, the number and percentage of MDs declined. By 2010, physicians (MDs and MD-PhDs combined) comprised less than 40 percent of the T32 trainees.

Figure 4.1: Number of Positions Supported on T32 NIH Postdoctoral Institutional Training Grants, by Degree (1982-2010)

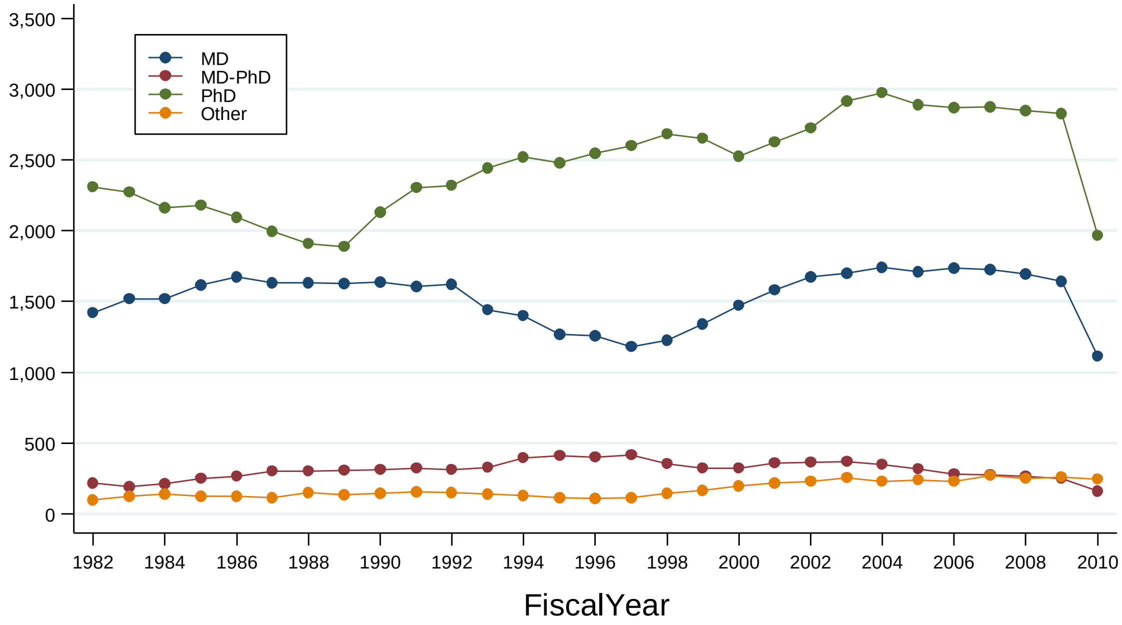
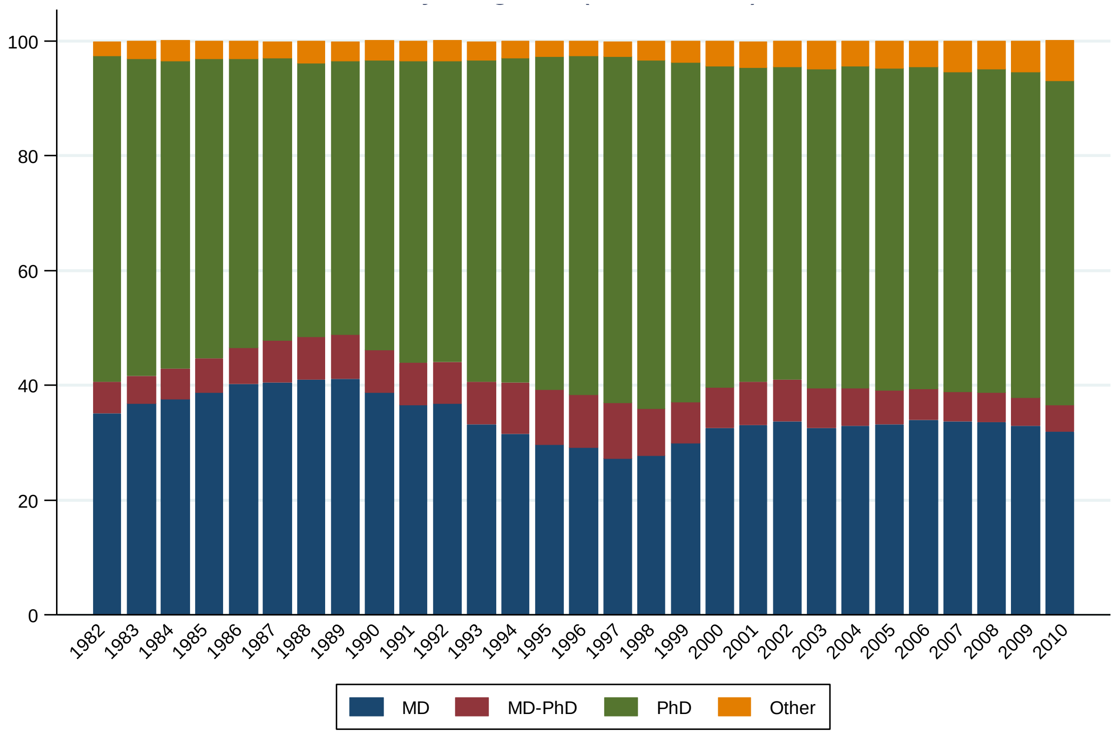


Figure 4.2: Distribution of Positions on NIH Postdoctoral Institutional Training Grants, by Degree (1982-2010)



Chapter 5 : F32 Postdoctoral Fellowship Applications, Awards, and Success Rates

NIH supports postdoctoral research training through many mechanisms. In addition to the T32 grants to institutions, many postdoctoral scholars are supported on research grants. Others are supported on F32 fellowship grants to individual scholars on the basis of a competitive application process. Several studies have found that recipients of NIH F32 postdoctoral fellowship grants, awarded to individual applicants on the basis of merit, have the most successful outcomes (Garrison and Brown, 1986; Mantovani et al., 2006; and Levitt, 2010). These prestigious awards support talented and highly motivated early career scientists and help them to establish a record of independent achievement.

Applications

When the NIH budget increased, applications from MDs for F32 postdoctoral fellowship rose as well. Applications rose from 171 in 2002 to 250 in 2005. When the NIH budget growth ended, applications from MDs began to decline, and in 2011 there were only 129. F32 fellowship applications from MD-PhDs followed the same pattern. Applications from PhD scientists also increased during the early years of the 21st century but did not decrease as sharply in the post-doubling era as did those from MDs and MD-PhDs.

As a result of the declining number of applications from medically trained individuals and the relative stability in applications for PhD, the share of applications submitted by MDs declined. In 2002, 13.4 percent of the fellowship applications came from individuals with medical training

(MD or MD-PhD). This fraction decreased in subsequent years, and by 2010, medically trained applicants comprised only 9.5 percent of the F32 applicant pool.[1]

Awards

The number of F32 fellowship awards to MDs has decreased since the 1980s. Zemlo et al. (2000) reported that F32 awards to MDs declined from 314 in 1985 to 180 in 1997, with most of the loss coming after 1993. More recent data indicate a continuation of this trend. In 2002, there were 73 F32 awards to MDs and only 50 in 2010. F32 awards to MD-PhDs declined by 50 percent over this period. In both cases, the pattern of declining number of awards was temporarily reversed during (and immediately after) years of significant NIH budget growth. However, after several years without growth in the NIH budget, the number of awards to physicians decreased.

Success rates for F32 applicants have declined steadily since 2002, falling from 39.4 percent to 28.0 percent in 2010. The rate did not rise during the years of major NIH budget increases. While there were annual variations, success rates were generally highest for MD-PhDs. Applicants with MD and PhD degrees had similar success rates over this period.

The distribution of F32 awards also changed over the 2002-2010 timeframe. In 2002, 11.9 percent of the F32 awards went to MDs, and 3.3 percent went to MD-PhDs for a combined total of 12.3 percent. By 2010, their relative share of the F32 awards fell to 7.7 and 1.5 percent, respectively. Since the success rates did not show an advantage for PhDs, virtually all of the

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[1] In 2011, the large fraction of applications from individuals with “other” degrees suggests that there was a change in data collection or coding practices. Therefore, data for this year are not analyzed.

disparity across degree category is due to different rates of application. MDs who applied for F32 awards were typically as successful as their PhD counterparts.

Figure 5.1a: Applications, Awards, and Success Rates for NIH Postdoctoral Fellowships, MD Holders (2002-2011)

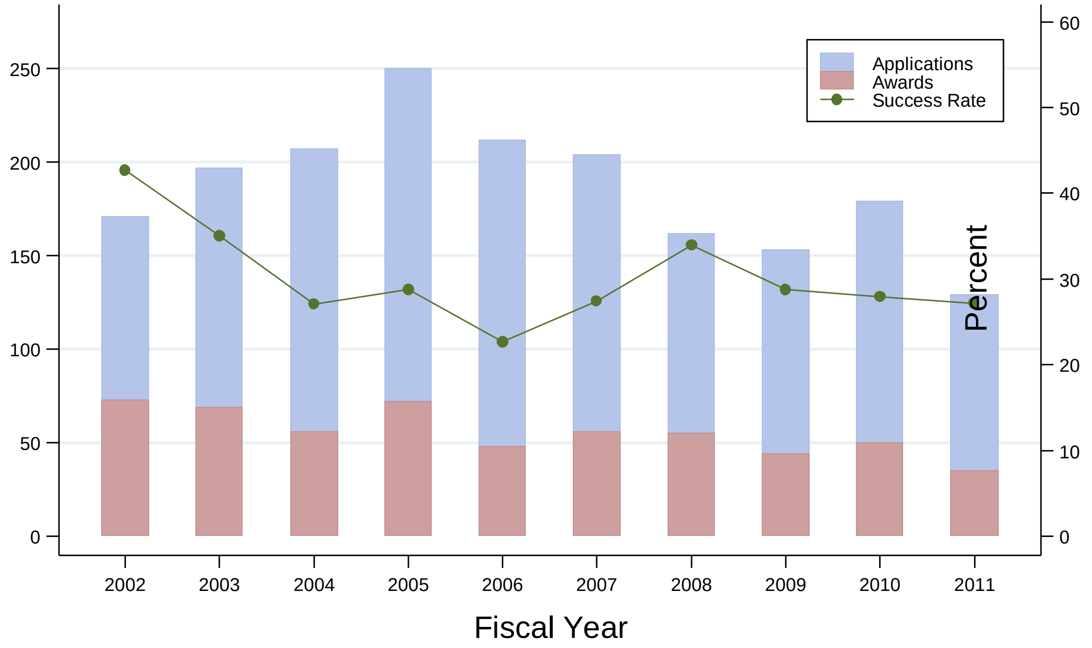


Figure 5.1b: Applications, Awards, and Success Rates for NIH Postdoctoral Fellowships, MD-PhD Holders (2002-2011)

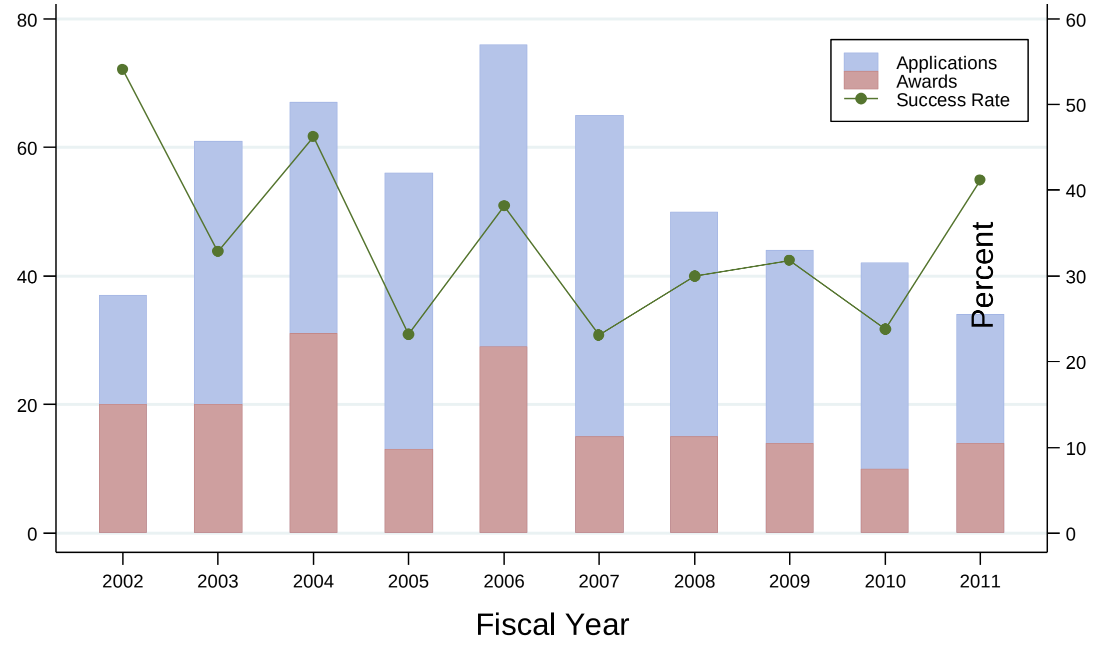


Figure 5.1c: Applications, Awards, and Success Rates for NIH Postdoctoral Fellowships, PhD Holders (2002-2011)

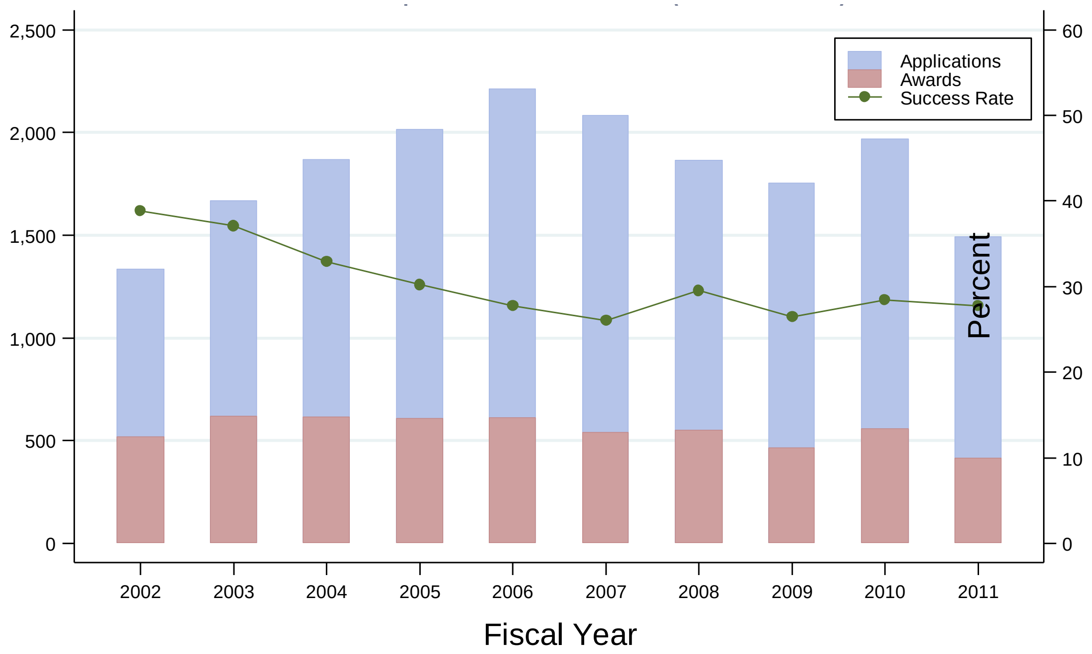


Figure 5.1d: Applications, Awards, and Success Rates for NIH Postdoctoral Fellowships, Other Degree Holders (2002-2011)

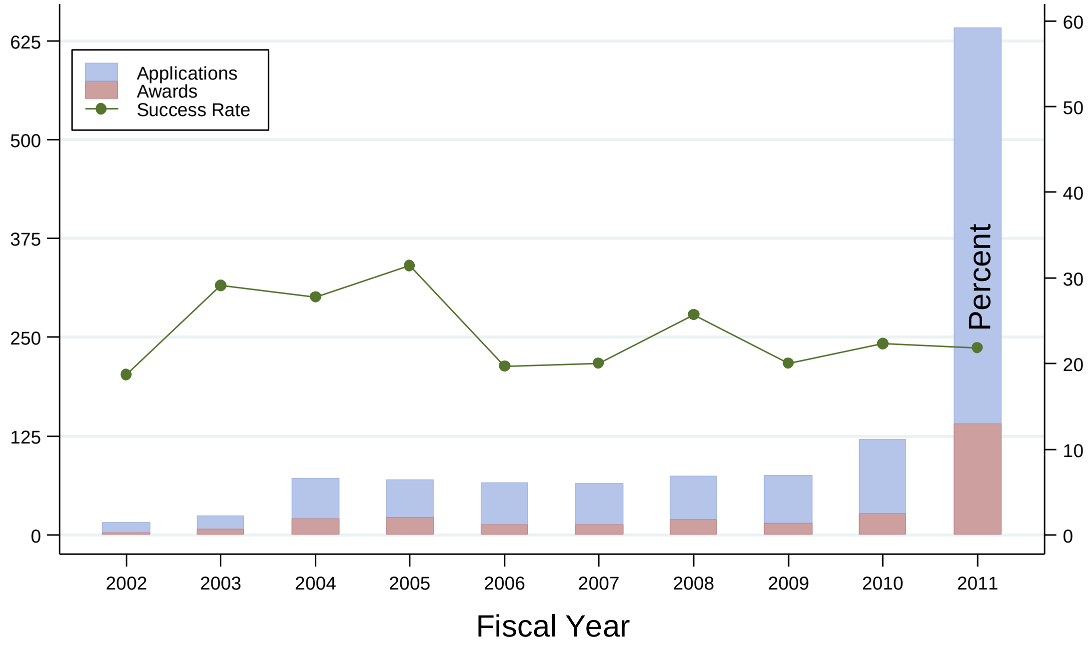


Figure 5.2a: Percentage Distribution of Applications for NIH Postdoctoral Fellowships, by Degree (2002-2011)

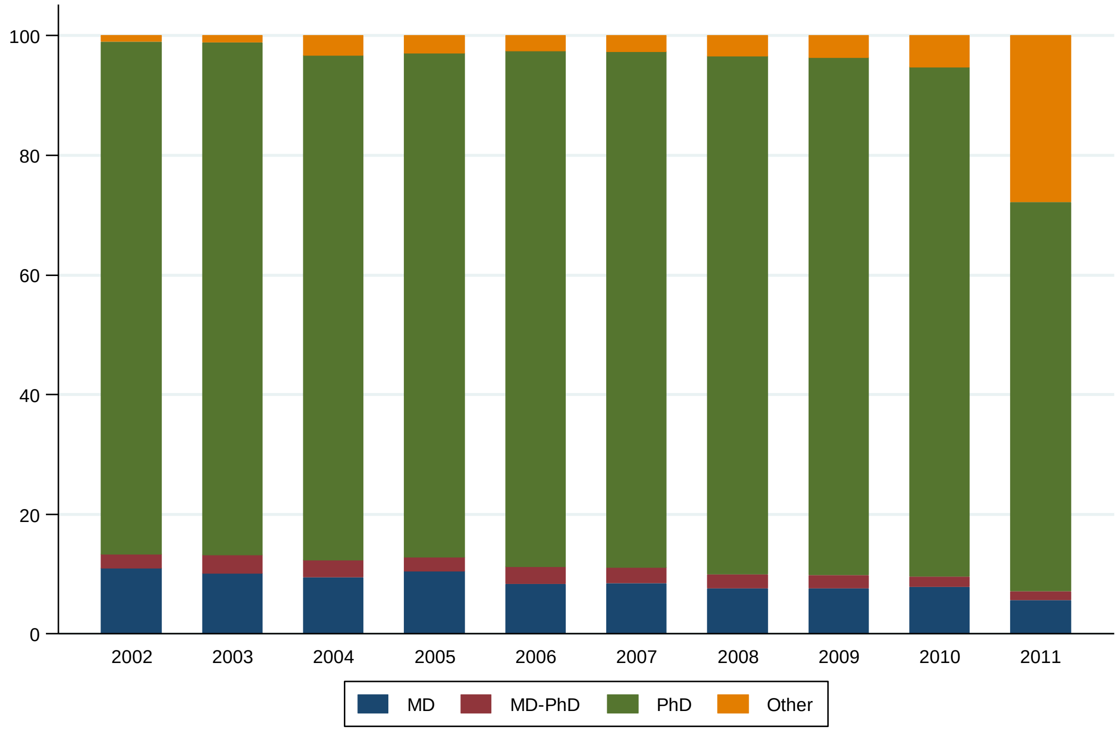
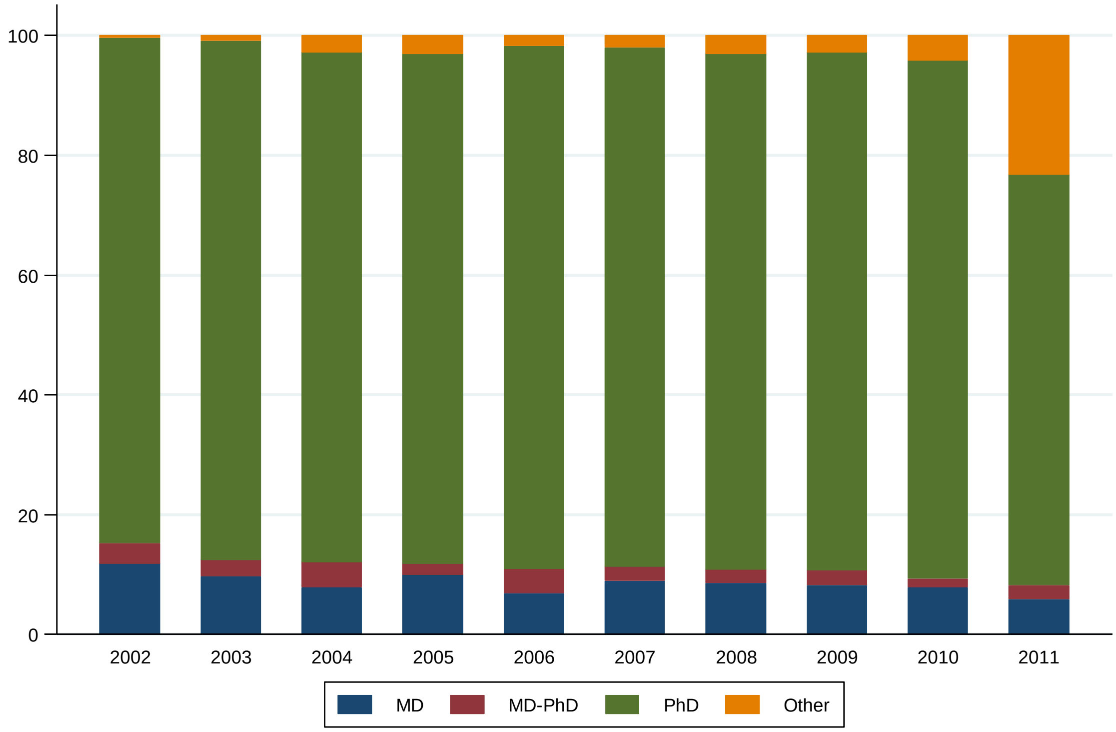


Figure 5.2b: Percentage Distribution of Awards for NIH Postdoctoral Fellowships, by Degree (2002-2011)



Chapter 6 : Indebtedness of U.S. Medical School Graduates

Large debt burdens may constrain new physicians' career options and limit their willingness to pursue research careers (Rosenberg, 1999b). An extended period of research training will suppress earnings for several years, and lower salaries in academic medicine make loan repayment much harder. Moreover, the terms of academic employment, with increased dependence on grant funding for salaries and job security, add an element of uncertainty to an equation that is already weighted against a research career. [1]

The indebtedness of U.S. medical school graduates has risen significantly over the past three decades. In 2011, the average graduate from a private medical school incurred a debt of $179,099, a seven fold increase over the comparable figure for 1982. Adjusting for inflation, the average debt level of a private medical school graduate tripled over this period. For those graduating from public medical schools, the overall level of debt was lower, but the rate of growth was similar.

Looking at aggregate trends in debt burden and career outcomes, we were unable to examine the relationship between indebtedness and individual decisions. However, several studies have looked at this issue. Andriole *et al.* (2010) found that MDs with higher levels of debt at graduation were less likely to have faculty positions. The relationship between debt and faculty position, however, was not significant in multivariate models that included other variables, suggesting that the effect of debt is a complex one that is correlated with other career choices and

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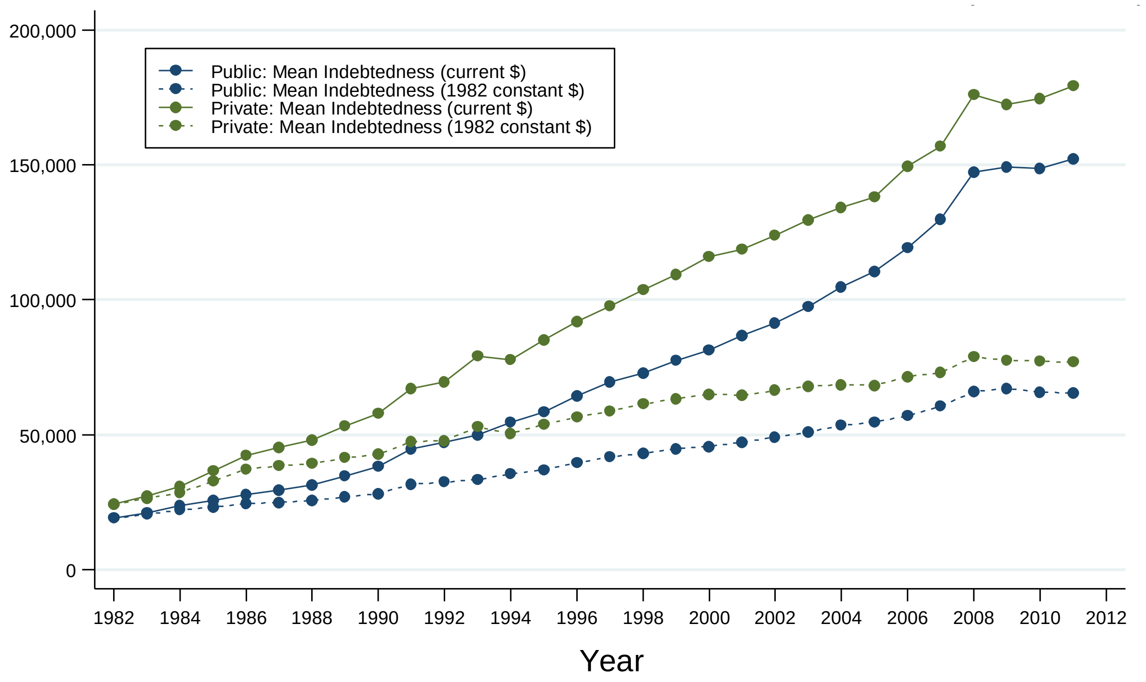
[1] The average level of debt does not preclude the existence of a portion of the population that is not subject to this burden, and debt may not be a factor in every decision whether or not to pursue a research career. But it is very likely that educational debt acts as a limiting factor on the size of the potential population of physician scientists.

demographic characteristics. In a study limited to MD-PhD graduates, Jeffe and Andriole (2011) found that the relationship between indebtedness and faculty positions remained significant after other variables were considered. Fang (2004), on the other hand, found that there was a relationship between debt and faculty appointments only for 1992 and 1993 medical school graduates, and he found no relationship for earlier graduates (with lower average debt levels).

Figure 6.1: Average Debt of Medical School Graduates in Current and Constant Dollars (1982-2011)



Chapter 7 : NIH Loan Repayment Program

The rising level of debt incurred by graduating medical students has been considered a major disincentive to the pursuit of a research career (Thier et al., 1980). Burdened with the obligation to repay large student loans, it was assumed that new physicians would be discouraged from the greater risk and lower salaries associated with the pursuit of research careers.

The NIH Loan Replacement Program (LRP) offers repayment of up to $35,000 per year of eligible educational debt in exchange for a two-year commitment to conduct qualified research. Awardees may apply for additional one- or two-year renewal contracts (NIH, 2009). Following a recommendation of the NIH Director's Panel on Clinical Research (1997), the LRP was significantly expanded in 2000 and 2001 to offset some of the financial barriers facing early career health professionals considering careers in the biomedical and behavioral sciences. Eligibility was extended to pediatric researchers, extramural scientists in clinical research, health disparities researchers, and clinical researchers from disadvantaged backgrounds.

It is too early to measure the contributions of the expanded LRP to successful research careers, but, to date, the programs have been able to provide assistance to several thousand qualified candidates. Since 2004, the extramural LRP has made approximately 1,600 awards per year. A smaller intramural LRP has made about 85 awards per year since 2008.

In its first two years of operation, 48.2 percent of the extramural LRP went to MDs. This percentage has declined, and in 2011, 42.9 percent had MD degrees. Between eight and nine percent of the awards went to individuals with MD-PhD degrees.

In the intramural LRP, awardees were more likely to have medical degrees. From 2008 through 2011, over 80 percent of the award recipients had either an MD, or both MD and PhD degrees, with only minor fluctuations from year to year.

Figure 7.1a: Number of Extramural Loan Repayment Awards, by Degree (2004-2011)

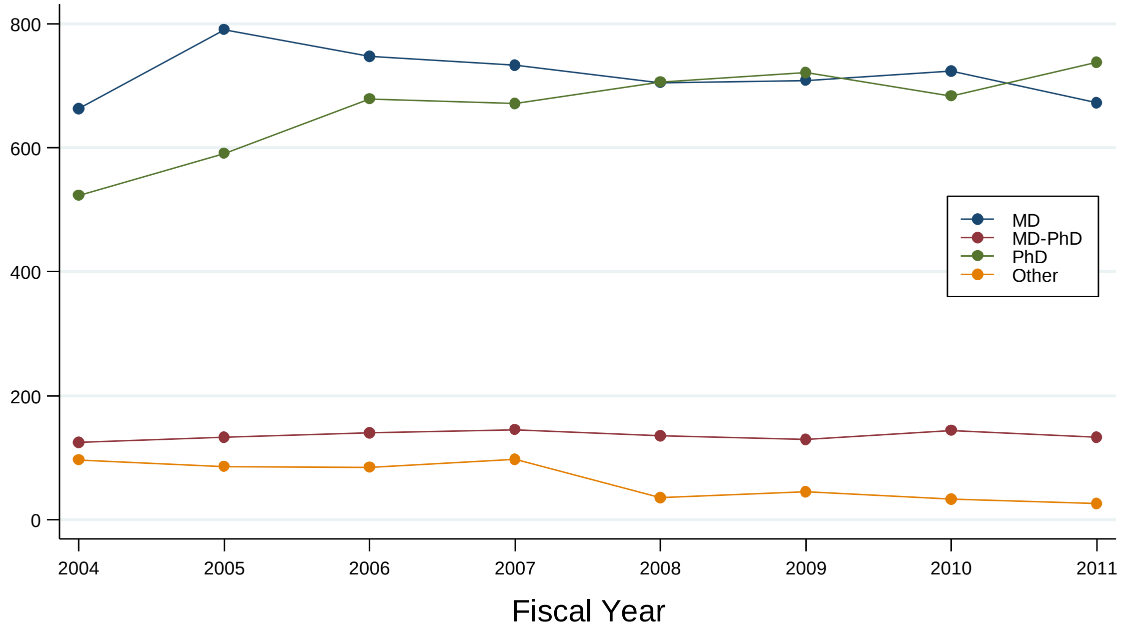


Figure 7.1b: Number of Intramural Loan Repayment Awards, by Degree (2004-2011)

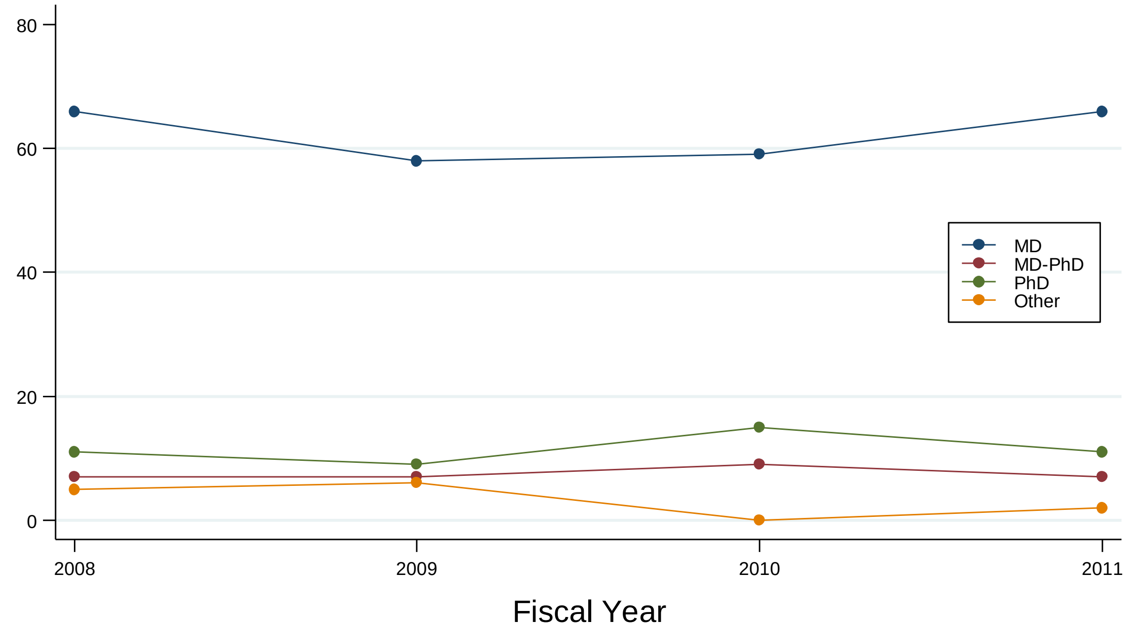


Figure 7.2a: Distribution of Extramural Loan Repayment Awards, by Degree (2004-2011)

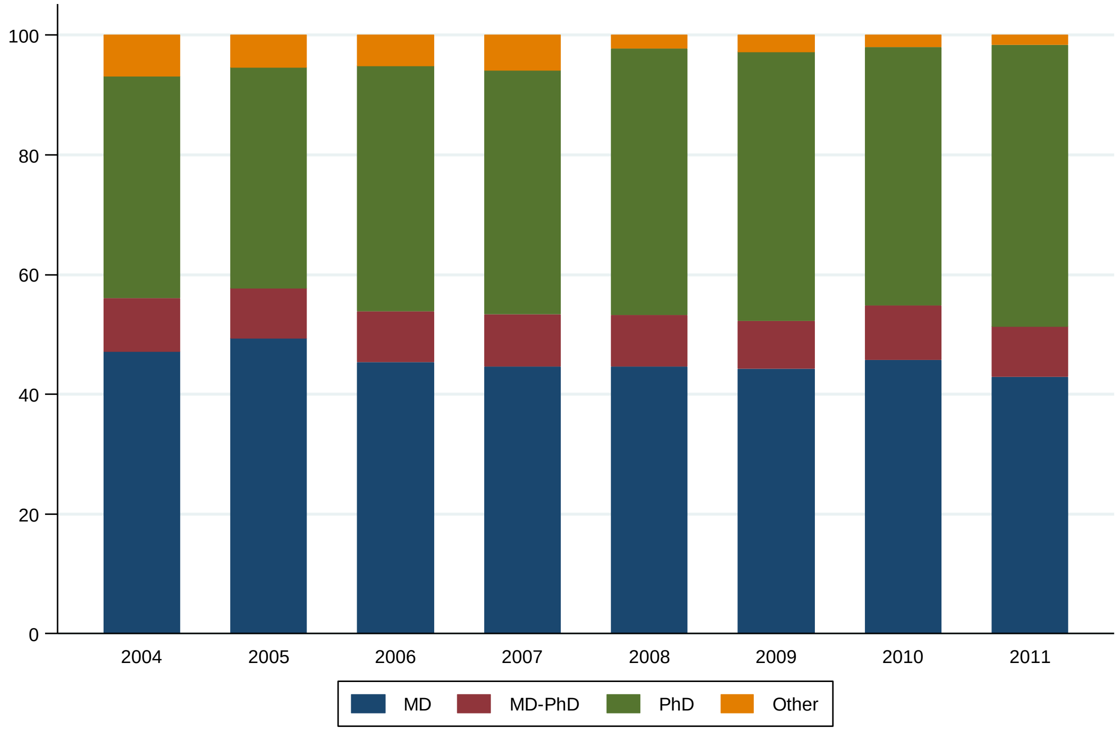
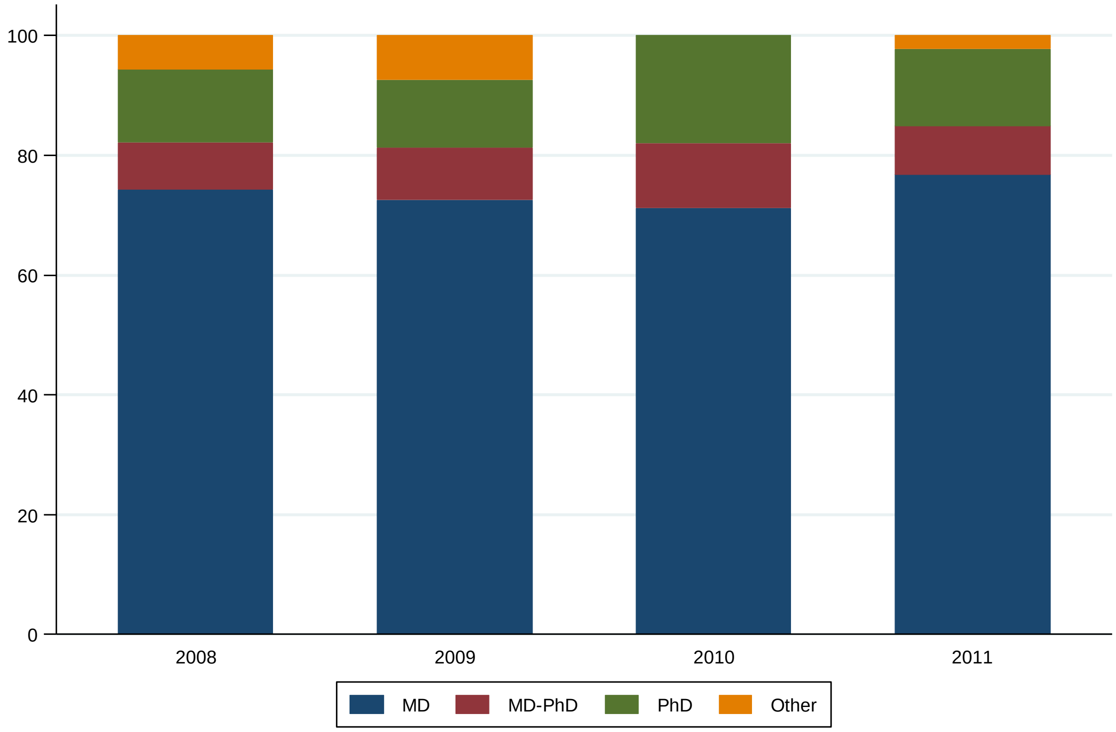


Figure 7.2b: Distribution of Intramural Loan Repayment Awards, by Degree (2008-2011)



Chapter 8 : NIH Career Development Awards

NIH has a series of development awards designed to assist early career scientists. These "K series" awards have a variety of specific aims, and their utilization and requirements vary across individual NIH Institutes and Centers (ICs). The primary purpose of the NIH Mentored Clinical Scientist Research Career Development Awards (K08) program is "to prepare qualified individuals for careers that have a significant impact on the health-related research needs of the Nation." K08 awards, in existence since the early 1970s, provide support and "protected time" to individuals with a clinical doctorate degree for an intensive, supervised research career development experience. Following a recommendation made by the NIH Director's Panel on Clinical Research (1997), K23 awards (NIH Mentored Patient-Oriented Research Career Development Awards) were established in 1999 to provide protected time for individuals with a clinical doctorate who are interested in pursuing a career in patient-oriented research. Trends in the number of applicants provide an indication of the desirability of this career path; trends in the number of awards and award rates indicate how much support is available to encourage this decision.

K08

The number of K08 Career Development Award applications rose steadily over most of the program's history, indicating a growing interest in research careers among clinicians. When the K08 program was initiated in the 1970s, it was very small, with less than 25 applicants and fewer than 15 awards in each of the first four years of operation. The program grew, and the number of applications increased. Even after the introduction of the K23 program in 2002, the number of

K08 applications continued to rise. In 2005, there were 676 K08 applications. After 2005, when NIH funding for research was no longer increasing, the number of applications fell, and by 2011 there were only 425.

In general, the number of K08 awards grew in direct proportion to the number of applications. The number of awards grew from 164 in 1993 to a high of 311 in 1998. After 1998, the number of awards declined, and by 2005 only 266 K08 awards were made. Success rates fell below 40 percent for the first time since 1989. This may have been due, in part, to the rising cost of the K series awards, which include funding for salaries and research expenses. The average cost of a K08 award rose from $95,000 in 1998 to $134,000 in 2005.

K23

K23 grants are also career development awards designed to provide protected time for individuals with clinical doctorates, but they have a more specific focus than the K08 awards and are limited to those pursing patient-oriented research. As was the case for the K08 awards, the rising number of K23 applications indicates a strong interest in patient-oriented research. The number of K23 applications rose from 421 in 2002 to 679 in 2005 before declining in each of the next four years. In 2009, there were 517 applications. Applications rose in the two most recent years, and in 2011, there were 599 applications.

While the number of K23 applications fluctuated over the 2002-2011 period, the number of K23 awards remained constant at approximately 200 per year. As a result, there was substantial variation in success rates, ranging from a low of 27.0 percent to a high of 46.6 percent.

Figure 8.1: Applications and Awards for NIH Mentored Clinical Scientist Research Career Development Awards (K08) (1972-2011)

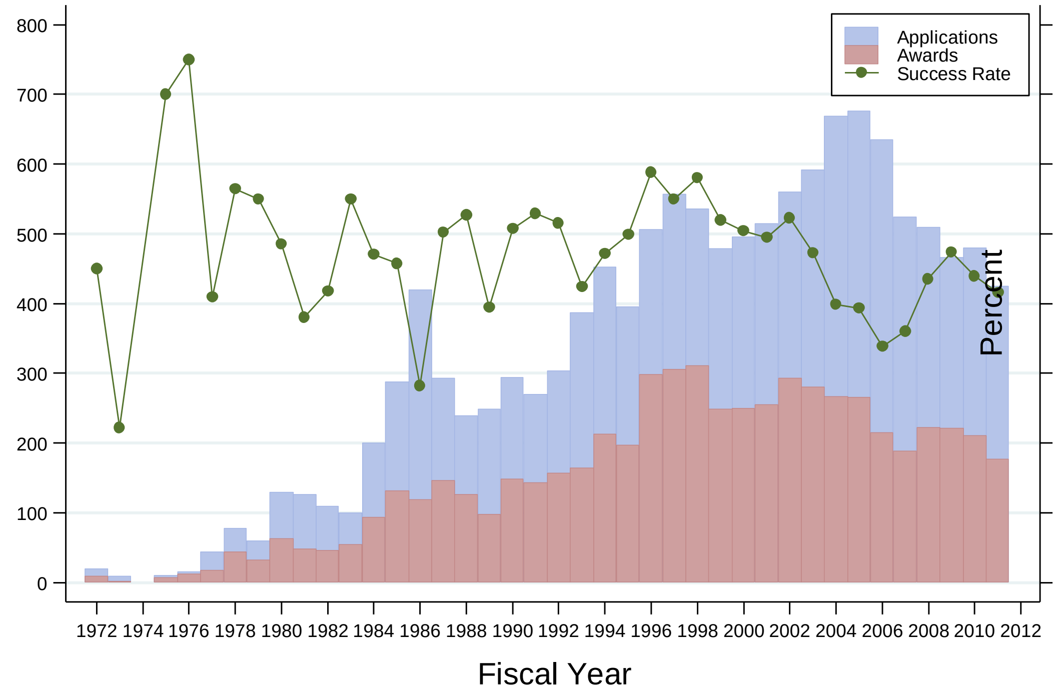
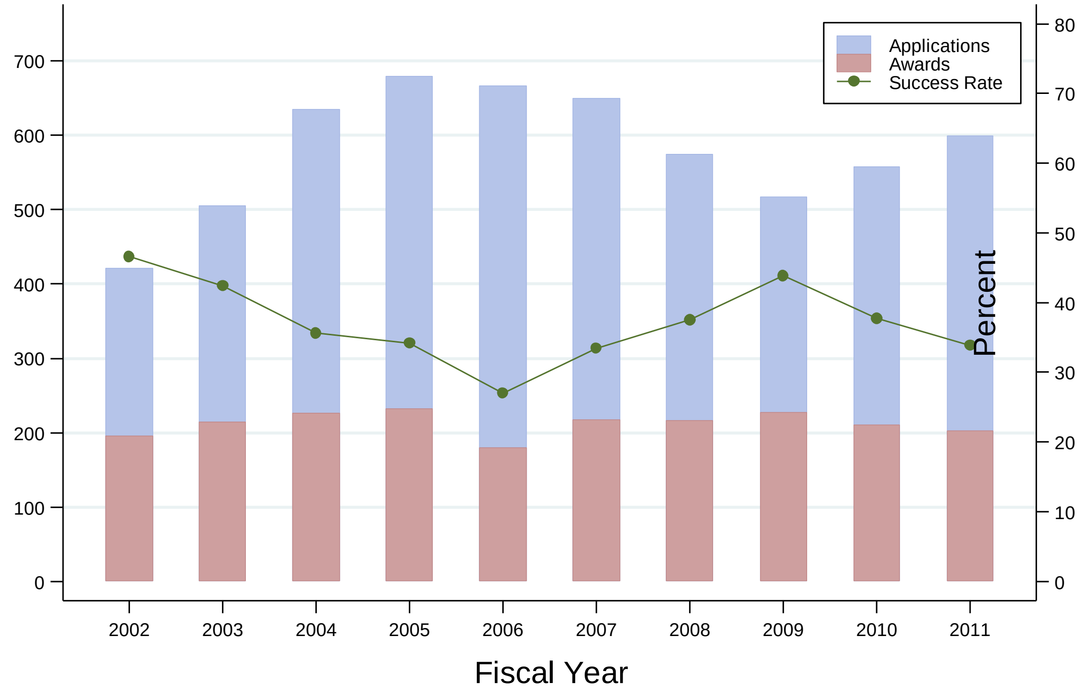


Figure 8.2: Applications and Awards for NIH Mentored Patient-Oriented Research Career Development Awards (K23) (2002-2011)



Chapter 9 : Transitions from Career Development Awards

The purpose of K08, K23, and other career development awards is to prepare clinician scientists for productive research careers. One important measure of their effectiveness is the percentage of career development award recipients who receive subsequent funding from NIH. NIH is the major sponsor of biomedical research in the U.S., and in most medical school and university settings, external grant support is a requirement for an independent research career.

K08

Since the inception of the program, the majority of the K08 award recipients have subsequently received major research grants from NIH (NIH, 2007). During the twenty year period from 1980 through 1999, an average of 55.8 percent of the K08 award recipients went on to receive additional research funding from NIH. Just under one-fourth (24.5 percent) unsuccessfully applied for NIH support, and 19.7 percent never applied for subsequent NIH research funding.

More recently, the percentage of K08 awardees with subsequent NIH funding began to drop. In 2000, the percentage fell below 50 percent for the first time since 1983.

A considerable period of time is needed to complete the K award, finish specialty and subspecialty training, find a research position, and apply for NIH grant funding. NIH was only able to provide data through 2007, and outcomes for K awardees in 2000 and beyond must be considered incomplete. For K awardees in the early 2000s, the number of NIH grant applications and awards will likely increase with the passage of time.

K23

The newer K23 program displayed the same pattern of successful transition found in the K08 program. Exactly one-half of the 1999 K23 grantees received subsequent research support from NIH. As was the case for K08 transition, the data were collected in 2007, and there is no information for more recent K23 awardees. The outcomes for those who received their awards after 2000 are incomplete due to career contingencies (time needed to complete specialty training), and the lower success rates in these years cannot be meaningfully interpreted.

Figure 9.1: Transition from K08 Awards (1980-2007)

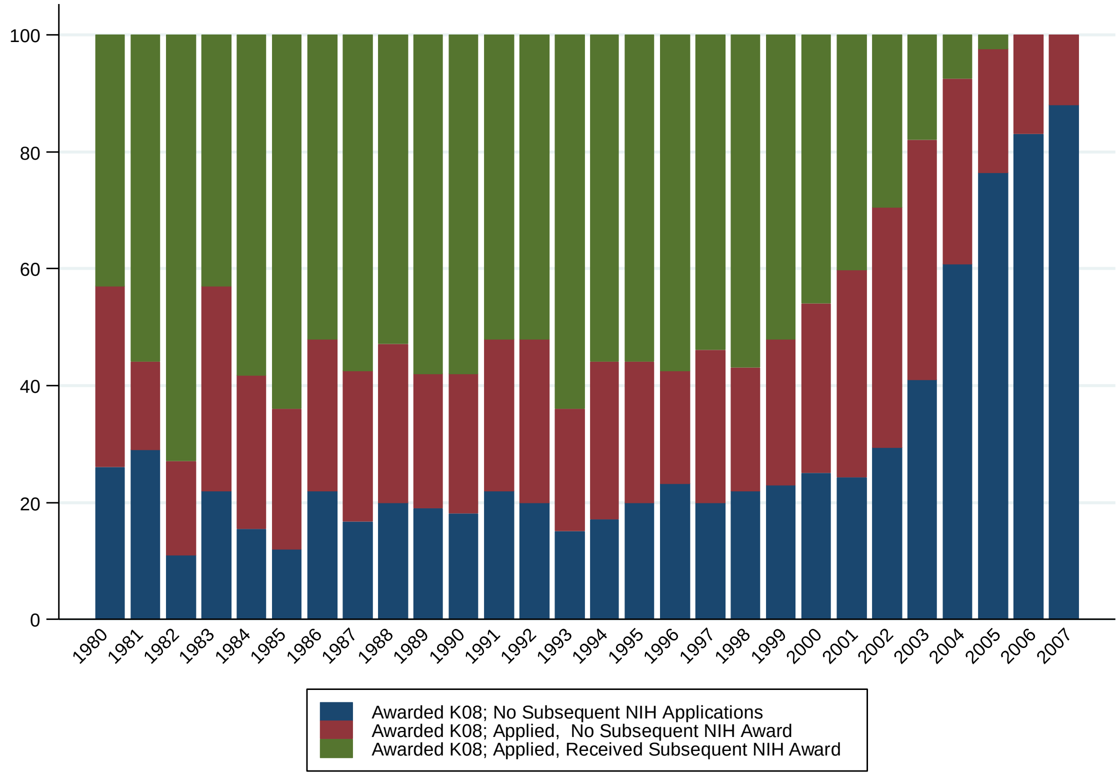
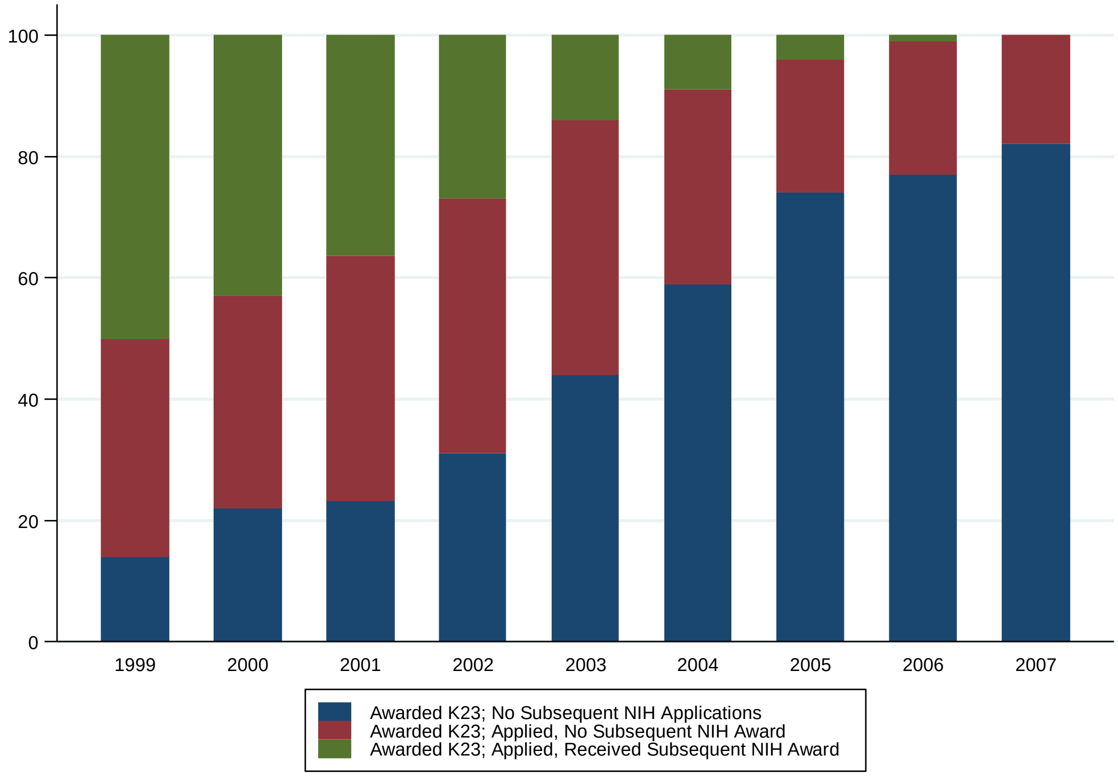


Figure 9.2: Transition from K23 Awards (1999-2007)



Chapter 10 : Medical School Faculty Positions

The total number of medical school faculty members has grown by more than seven fold since 1967, rising from 20,266 to 153,223 in 2011. [1] Expansion was greatest in the late 1970s, early 1990s, early 2000s (when the NIH budget was growing rapidly), and 2008-2011 (when several new medical schools opened).

Clinical Departments

Medical school faculty positions have increased over the past three decades, driven principally by the addition of MD faculty in clinical departments. Most of the faculty members in medical schools (over 70 percent) hold MD degrees, and they hold an even larger share of the medical school faculty positions in clinical departments. The percentage of MDs in clinical departments, however, declined 4.3 percentage points, from 80.1 percent in 1981 to 75.8 percent in 2011. The fraction with MD-PhD degrees rose by 2.9 percentage points over the same time period from 4.8 percent to 7.7 percent, compensating partially, but not completely, for the decline in MD-only faculty.

Basic Science Departments

The number of MDs holding medical school faculty positions in basic science departments declined over the past three decades, falling from 2,590 in 1981 to 1,741 in 2011. Again, the decline in MD faculty has been partially offset by an increase in MD-PhD basic science faculty over the same time period. MD-PhD faculty in basic science departments rose from 729 in 1981

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[1] The totals for "All Faculty Positions" include individuals with unreported degrees as well as degrees other than MD, PhD, and MD-PhD.

to 1,370 by 2011. Basic science faculty with PhD degrees, however, also nearly doubled since 1981, and, as a result, the percentage of basic science faculty with MD or MD-PhD degrees declined from 30.0 percent to 18.7 percent. Debt burden may partially explain why the only growing component of the academic physician scientist population is the MD-PhD segment, since many dual degree students received tuition support and stipends from the NIH’s Medical Scientist Training Program and other similar programs while in medical school.

The loss of physician scientists in basic science departments has not been linear. The total number of physician scientists (MD and MD-PhD) in these departments declined gradually from 1981 through the mid-1990s. When NIH research funding grew during the late 1990s and early 2000s, the number of physicians in basic science departments rose as well. Research funding shortfalls in the past few years, however, may be taking a toll on physician scientists in basic science departments. After 2007—when the grants awarded in 2003 (the last year of double digit budget increases for NIH) ended—the number of physician scientists in basic science departments began to decline. The number of physician scientists in basic science departments dropped from 3,730 in 2007 to 3,111 in 2011, and their relative share of the faculty positions fell from 21.7 percent to 18.7 percent.

Figure 10.1: Expansion of Full-Time Medical School Faculty, by Degree Type (1968-2011)

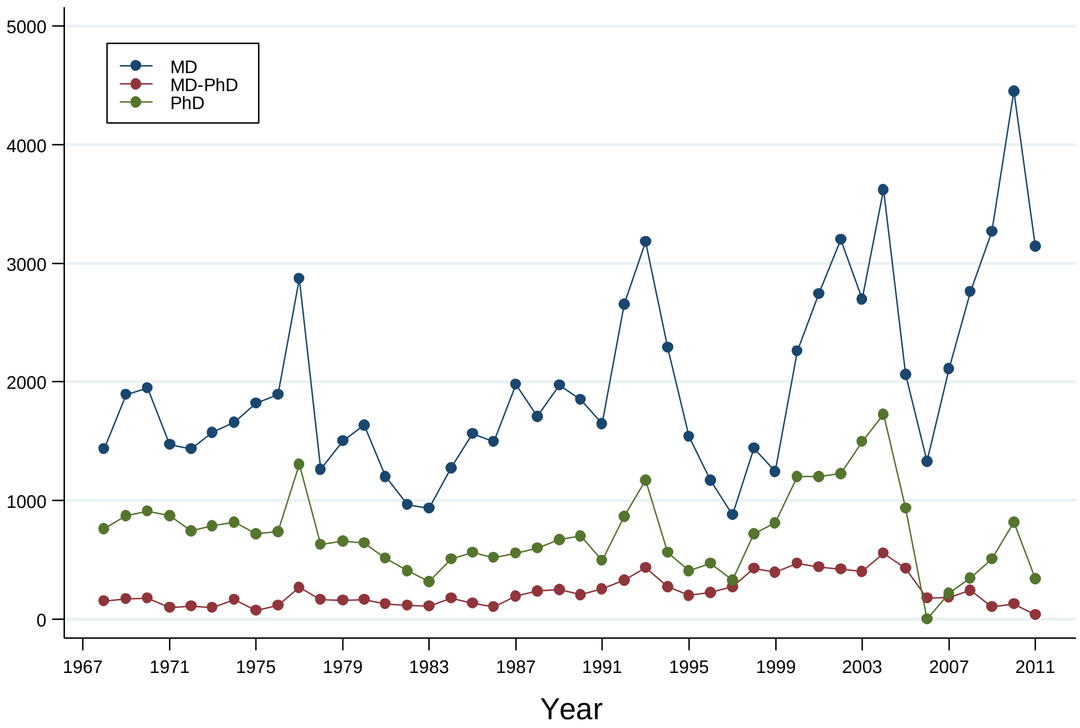


Figure 10.2a: Medical School Faculty Members in Clinical Departments, by Degree (1981-2011)

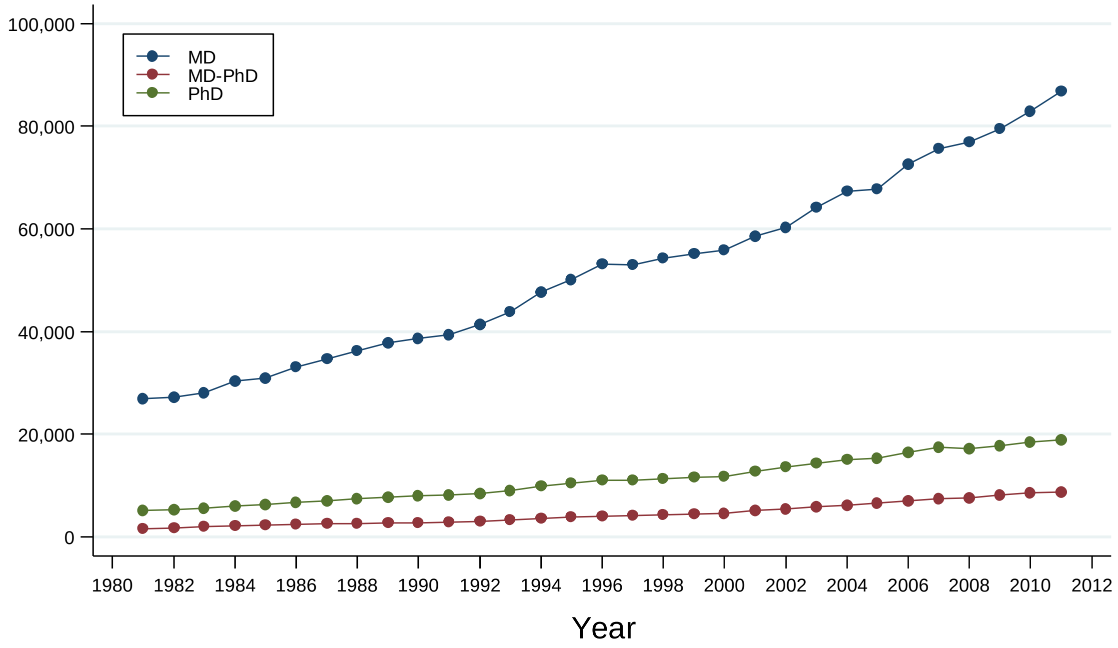


Figure 10.2b: Medical School Faculty Members in Basic Departments, by Degree (1981-2011)

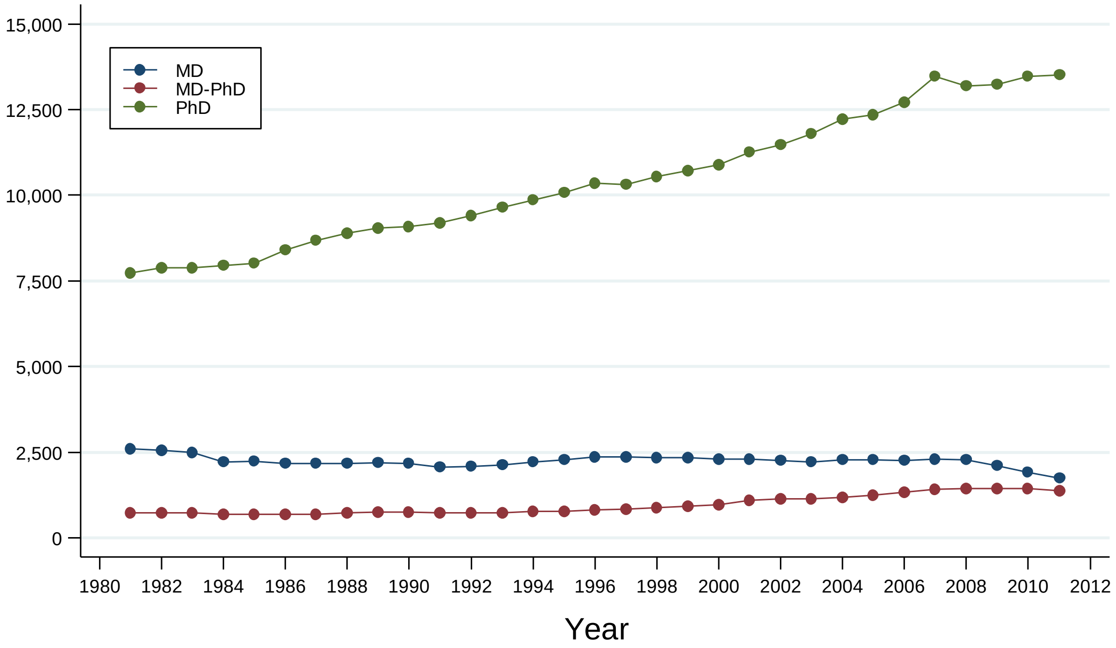


Figure 10.3a: Percentage Distribution by Degree of Medical School Faculty Members in Clinical Departments (1981-2011)

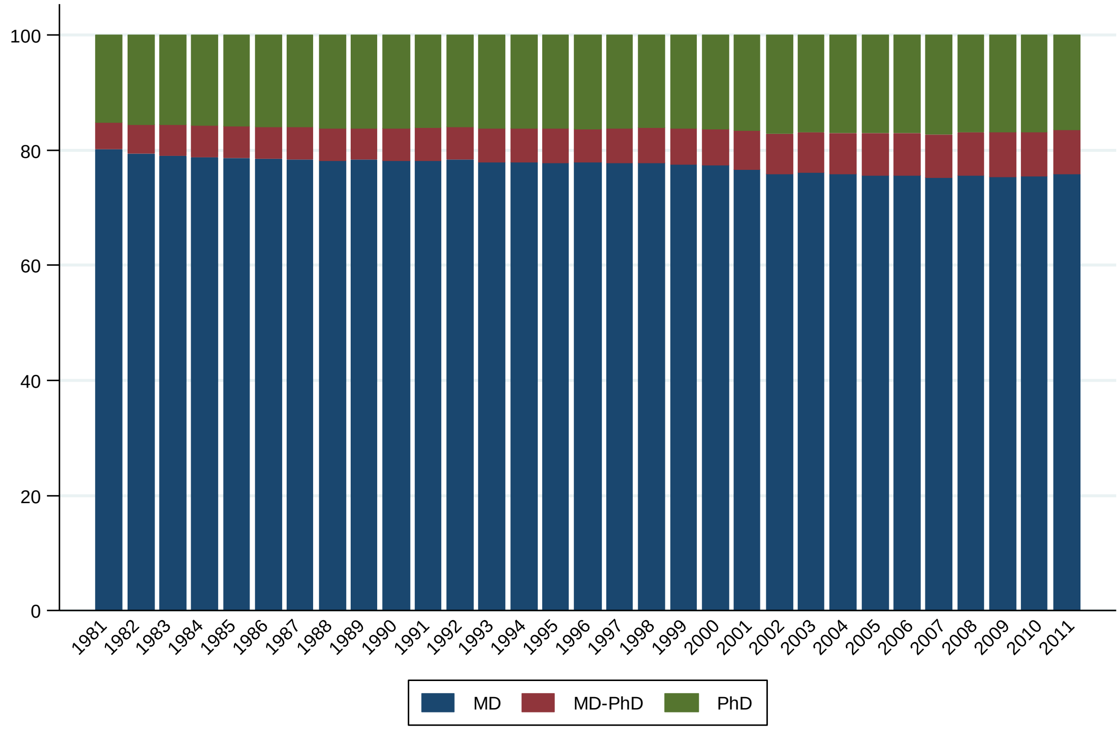
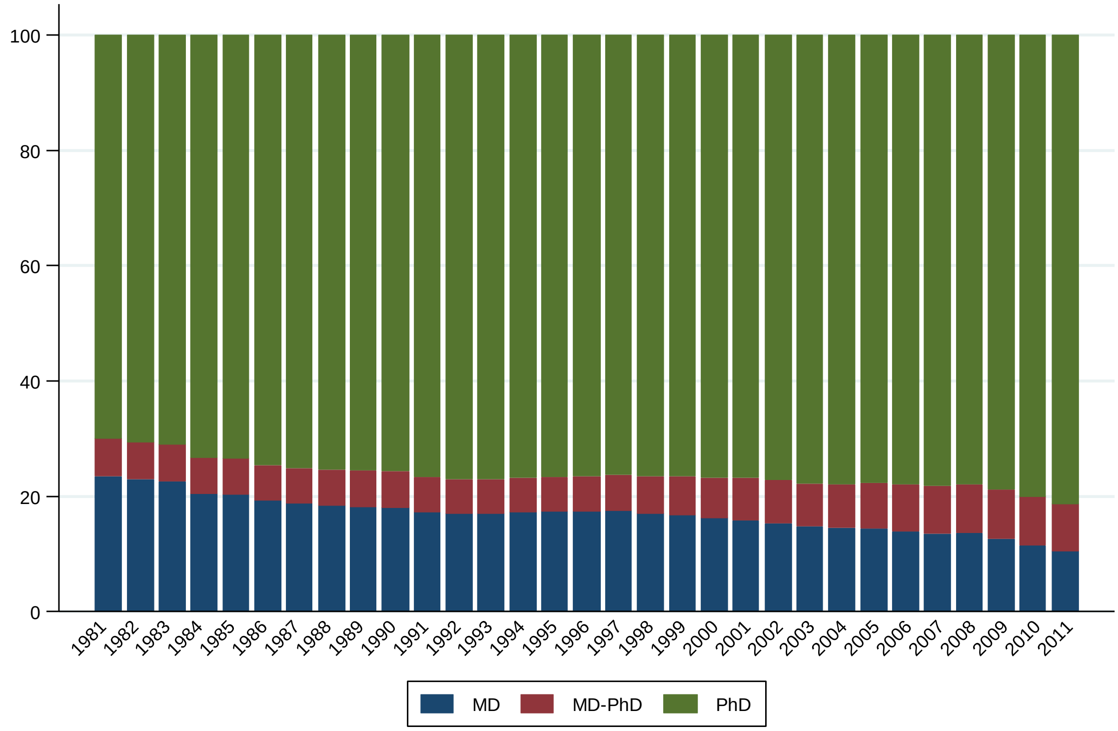


Figure 10.3b: Percentage Distribution by Degree of Medical School Faculty Members in Basic Departments (1981-2011)



Chapter 11 : Age at First Medical School Appointment

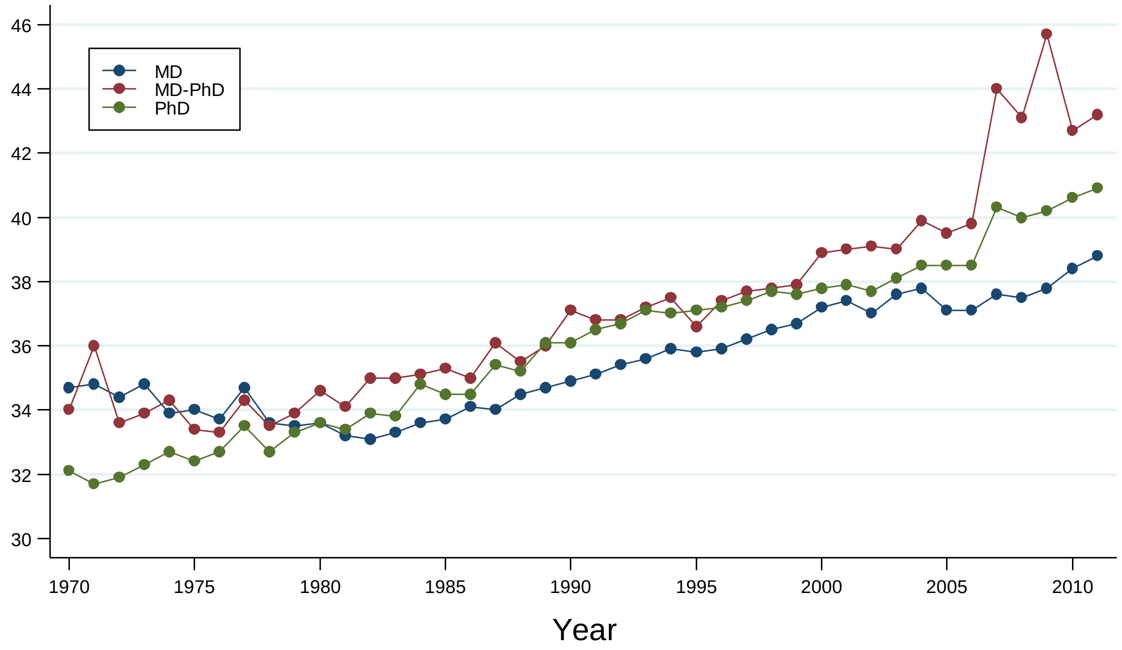
The amount of time needed to prepare for a career in biomedical research is an important consideration for those contemplating the pursuit of this vocation. The training is costly and the time out of the full-time labor force results in lost income. A prolonged apprenticeship also reduces the length of an independent research career for those who follow in this career path.

Data on age at first medical school faculty appointment are available from the AAMC. For MDs, the average age at first medical school faculty appointment has risen by four years since 1970. In the 12-year period from 1970 through 1982, the average age at first medical school appointment for MDs was 34.0 years. Beginning in 1983, however, the average age at first medical school appointment for MDs began to increase, reaching 38.8 years in 2011.

The phenomenon of rising average age at first medical school faculty appointment is not limited to those with MD degrees. Over time, the average age at first medical school appointment rose for PhDs as well. It was 32.1 years in the 1970s, but by 2011, the average age of PhD scientists at their first medical school appointment had reached 40.9 years.

With the increase in average age at first medical school appointment for MD and for PhDs, it should come as no surprise that the increase was greatest for those with both MD and PhD degrees. The average age at first medical school appointment for MD-PhDs averaged 34.1 years during the 1970s and early 1980s. By 2011, the average age at first medical school appointment for MD-PhDs was 43.2 years. This reflects an increase of 8.2 years over the comparable figure for 1982. Since MD-PhDs are a growing fraction to the clinically trained research workforce, this increased length of apprenticeship and delayed onset of faculty careers should be of great concern to policymakers.

Figure 11: Average Age at First Medical School Appointment, by Degree (1970-2011)



Chapter 12 : First-Time R01-Equivalent Applications and Awards

NIH provides funding for many types of research project grants (RPGs), including P01 program project grants for teams of investigators; R01 grants to support discrete, multiyear projects in an investigator's area of expertise; R21 exploratory-developmental grants; and R03 funding for small, pilot projects. Typically, a large, multi-year grant like an R01 grant is necessary for an individual to initiate a sustained program of independent research and make a substantial contribution to biomedical science. In 2011, the average R01-equivalent[1] grant had a budget of $408,600 (including indirect cost). At many institutions, one or more R01-equivalent grants are necessary for tenure and promotion.

R01 awards are made to experienced investigators to continue work on an existing project ("competitive renewals") or to begin research on a new topic. Approximately one-fifth of the R01 awards are "first-time" R01s, grants made to scientists and engineers who had not previously received R01 funding. The first-time R01-equivalent award is a highly sensitive leading indicator of change in the composition of the research workforce.

The number of first-time R01 awards has been remarkably stable over the past three decades. While there are yearly fluctuations, in most years, the number of first-time R01 awards was close to the thirty-year average of 1,574. During the years of double-digit budget growth for NIH, however, the average number of first-time R01 awards increased, exceeding 1,700 in 2003.

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[1] In addition to the R01 mechanism, NIH has used other mechanisms to provide multiyear support for discrete projects including R29 FIRST awards for early career investigators and R37 MERIT awards for highly productive scientists. These grants, along with the Director's Pioneer Awards (DP1), are collectively referred to as "R01-equivalent" grants.

The number of first-time R01 awards to MDs was highest in the late 1980s. In 1988, 345 first-time R01 awards went to MDs. This number declined by one-third over the next decade, and in 1996, there were only 228. In the 1998-2003 period of rapid budget growth for NIH, the situation improved, and in 2000, there were 299 first-time R01 awards to MDs. But when research grant funds became tighter after 2004, the number of first-time R01-equivalent awards to MDs fell.

First-time R01 awards to MD-PhDs grew steadily from 89 in 1982 to a high of 235 in 2004. In general, the rising number of first-time R01-equivalent awards to MD-PhDs offset most of the decline in these awards to MDs. Combining both groups, the number of awards to medically trained investigators in 2011 was 425, a level comparable to that for the years immediately before and after the 1998-2003 “doubling” of the NIH budget.

In the three decades since 1982, the average first-time R01 success rates for MDs (19.7 percent), MD-PhDs (23.0 percent), and PhDs (20.7 percent) were very similar, with MD-PhDs holding a slight advantage. With nearly equal success rates, the percentage of first-time R01 awards going to MDs, MD-PhDs, and PhDs was largely a function of the number of applications from each group. From 1985 through 1995, there were approximately 1,500 first-time R01 applications from MDs. In most subsequent years, there were approximately 1,300 of these R01 applications. In contrast, the number of first-time R01 applications submitted by MD-PhDs rose steadily over the past three decades, from 400 in the early 1980s to over 1,100 in the three most recent years. For PhDs, the number of first-time R01 applications also grew steadily over the past three decades, rising from just over 5,000 in the mid-1980s to more than 7,000 at the present time.

Due to the increase in the number of first-time R01 applications from PhDs and MD-PhDs, the overall share of first-time R01 awards going to MDs has declined since the late 1980s. The greatest gains were for MD-PhDs, whose share of the first-time R01 awards in 2011 was nearly double their share for 1986 (6.1 percent).

Figure 12.1a: NIH Competing First-Time R01 Equivalent Applications, by Degree (1982-2011)

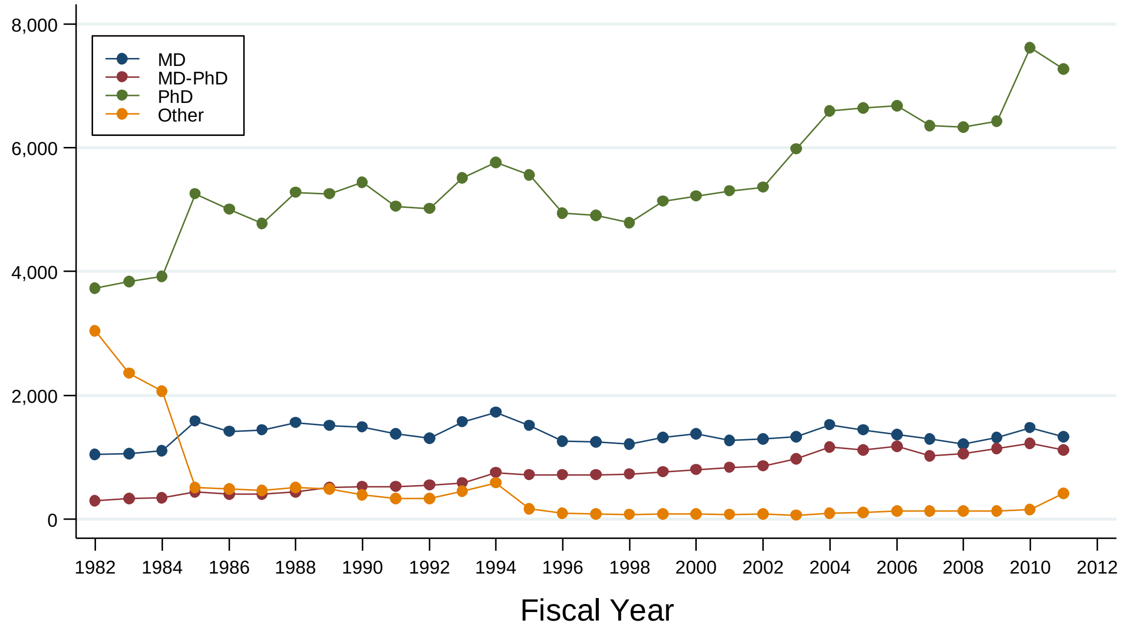


Figure 12.1b: NIH Competing First-Time R01 Equivalent Awards, by Degree (1982-2011)

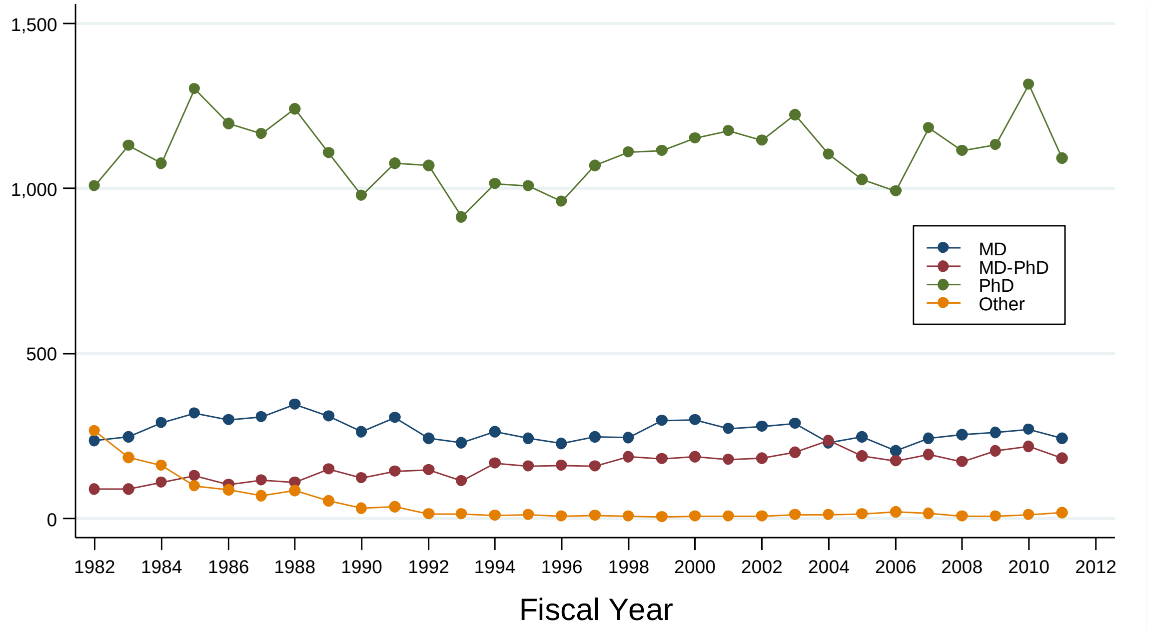


Figure 12.1c: NIH Competing First-Time R01 Success Rates, by Degree (1982-2011)

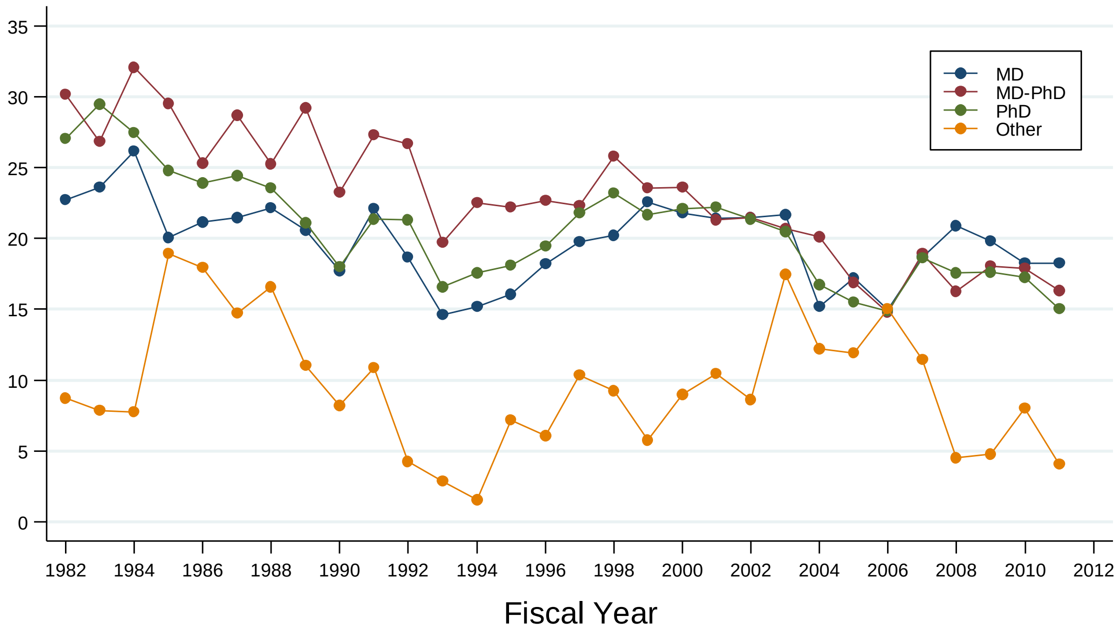


Figure 12.2a: Distribution of NIH Competing First-Time R01 Equivalent Applications by Degree (1982-2011)

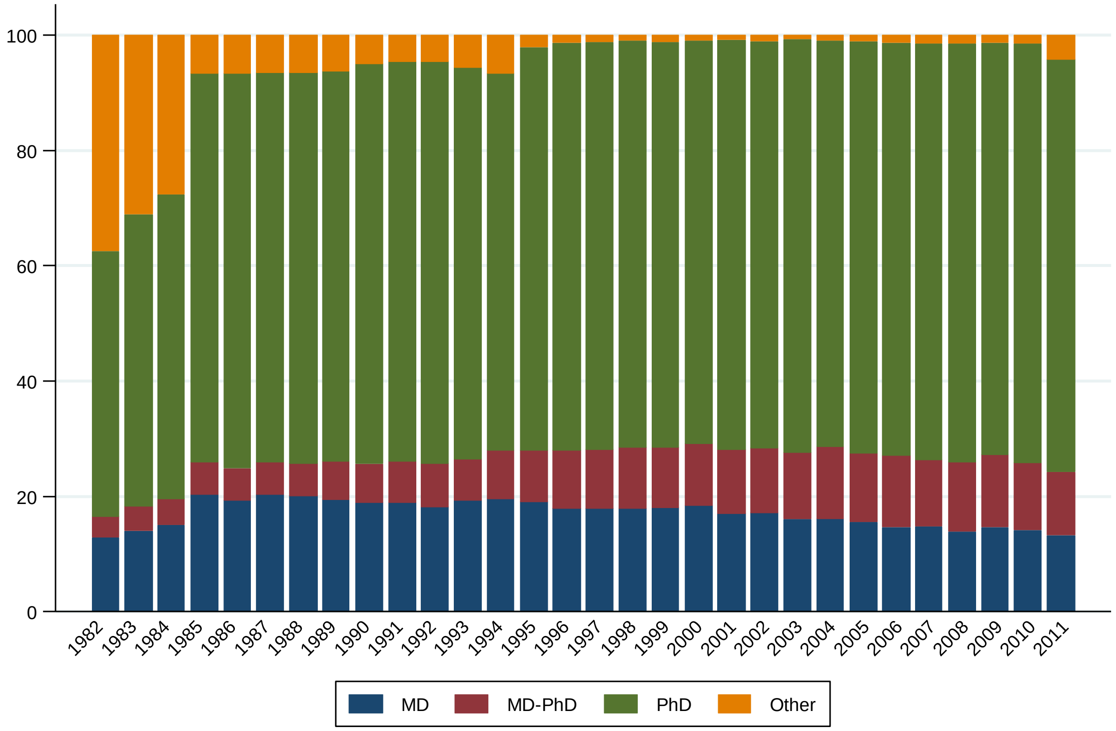
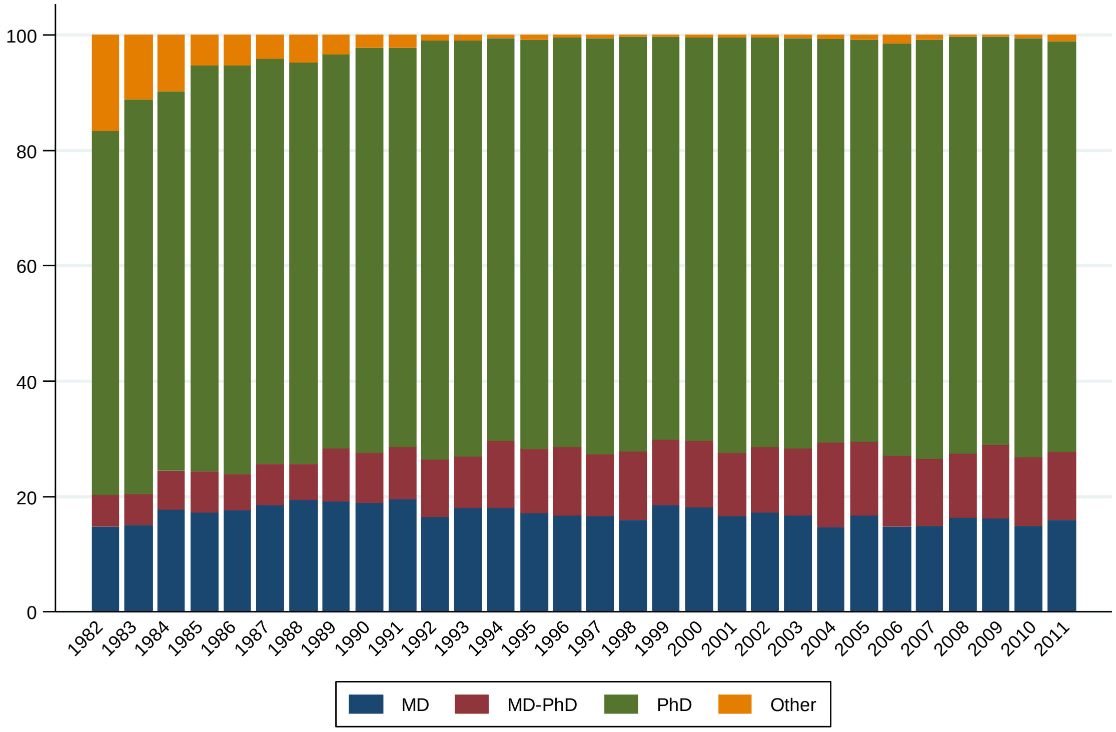


Figure 12.2b: Distribution of NIH Competing First-Time R01 Equivalent Awards by Degree (1982-2011)



Chapter 13 : Average Age at First R01-Equivalent Grant

In recent years, the number of R01-equivalent grant applications increased faster than the growth in NIH research grant funding. Intensified competition for NIH R01-equivalent awards has not only reduced the likelihood of success, but it has also extended the amount of time that early career scientists spend seeking funding for an independent laboratory (National Research Council, 2005).

This prolonged apprenticeship is costly to individuals and the research enterprise in several ways. The extra time spent in training means greater expense for students, educational institutions, and research sponsors. For many prospective scientists and engineers, the additional preparation time and expense create a disincentive to pursue a career in research. Beside the loss of potential scientists, there are other costs for the larger society. Higher training costs mean less funding available for conducting research, and the delayed onset of a research career shortens the expected work-life of a researcher. Taken together, all of these factors slow the advancement of science.

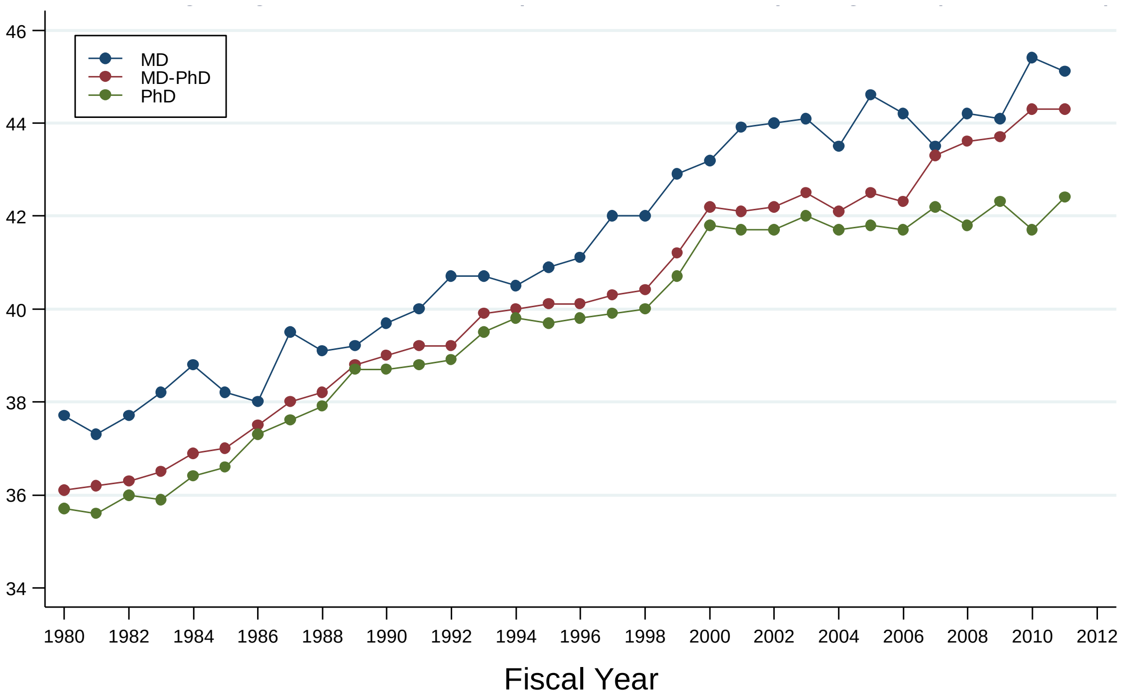
Since most academic institutions require a faculty appointment before an individual can submit an NIH research grant application, it should come as no surprise that the trends in age at first R01-equivant grant closely mirror those of faculty appointments (see chapter 11). The average age at first R01-equivalent award has risen steadily for all types of applicants, but the gap between physicians and non-physicians has widened substantially since the late 1980s. In 1980, the average age at which an MD was awarded his or her first R01-equivant grant was 37.7 years.

By 2011, the average age was 45.1, an increase of 7.4 years. Since the average age at first medical school appointment increased by five years during the same time period, something additional —beyond delayed achievement of faculty positions—was driving the increased time to first R01-equivalent grant.

The age at which PhD scientist received their first R01-equivalent award also increased during this time period, rising from 35.7 years in 1982 to 42.4 years in 2011. This increase of 6.7 years for PhDs was lower than that for MDs. While most of the increase in age at first award is general across all segments of the applicant population, additional factors seem to be affecting physician scientists.

In 2011, the average age at which MD-PhD scientists received their first R01-equivant award was 44.3 years. This is two years beyond the average for PhD scientists, but nearly a year ***less*** than the average for those with an MD degree only. This represents an interesting departure from the pattern found for faculty appointments. MD-PhDs were, on average, two years older than their PhD counterparts at first medical school appointment and four years older than their MD colleagues. The difference between average age at first faculty appointment and average age at first R01-equivalent grant was 6.3 years for MDs, 3.5 years for PhDs, and only 1.1 years for MD-PhDs. Thus, while it took MD-PhDs longer to obtain their first medical school faculty appointment, they seem to be best positioned for success in the competition for NIH research grants once they achieve faculty status.

Figure 13: Average Age at First R01-Equivalent Grant, by Degree (1980-2011)



Chapter 14 : Membership on NIH Grant Review Panels

Each year, NIH awards approximately 10,000 research grants. The agency uses a sophisticated review process to help identify the most meritorious proposals from among the 50,000 applications submitted annually. At the heart of the system are panels of scientists who evaluate proposals in their areas of expertise. NIH strives to ensure that these individuals are qualified and have the relevant expertise for the decisions that they are called upon to make. Their qualifications are essential to ensuring the peer review system's effectiveness, fairness, and legitimacy.

It has been hypothesized that the shortage of physicians in biomedical research stems, in part, from a lack of appreciation of clinical research and from difficulties encountered in the peer review process. Williams et al. (1997) found that clinical research proposals had lower priority scores and funding rates when they were evaluated in study sections with relatively few clinical applications.

Others have expressed concern that the number of reviewers with clinical training has an effect on the types of research funded. Data on the educational background of the members of Integrated Review Groups (IRGs), formed by the NIH Center for Scientific Review (CSR), was obtained to determine if physicians are disproportionately underrepresented in the review process. In a typical year, IRGs evaluate 87 percent of the applications submitted to NIH (National Institutes of Health, 2012).[1]

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[1] The remaining grant applications are evaluated by panels established by the NIH Institutes and Centers to evaluate applications submitted in response to Requests for Proposals on specific topics

The number of applications reviewed by NIH has grown from 16,744 in 1980 to 49,529 in 2011, and the number of CSR IRG members has grown from 862 to 3,703 during the same time period. In 1980, 278 IRG members had MD degrees and 45 had MD and PhD degrees. They comprised 32.3 and 5.2 percent, respectively, of the IRG members.

Over the next three decades, the number of reviewers in each degree category increased, but the percentage distribution shifted due to differential rates of growth. In 2011, reviewers with a medical background (MD or MD-PhD) were a smaller proportion of the reviewer population than they were in 1980. Most of the change took place prior to 1995. The percentage of IRG members with medical backgrounds declined steadily from 37.5 percent in 1980 to 25.3 percent in 1994. The percentage rose to 27.7 in 1997[2] and has fluctuated between 26.6 percent and 27.7 percent over the past 15 years. Since 1997, however, a decline in the percentage of MDs was balanced by a commensurate increase in the percentage of MD-PhDs.

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[2] NIH was unable to provide data for 1996.

Figure 14.1: Membership on CSR Integrated Review Groups, by Degree (1980-2011)

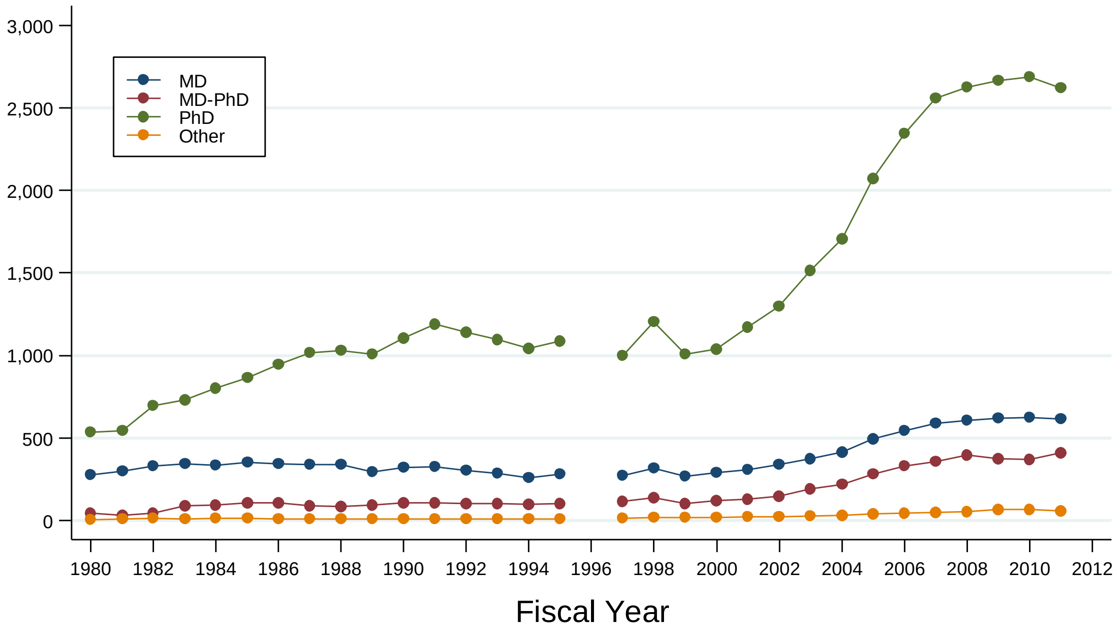
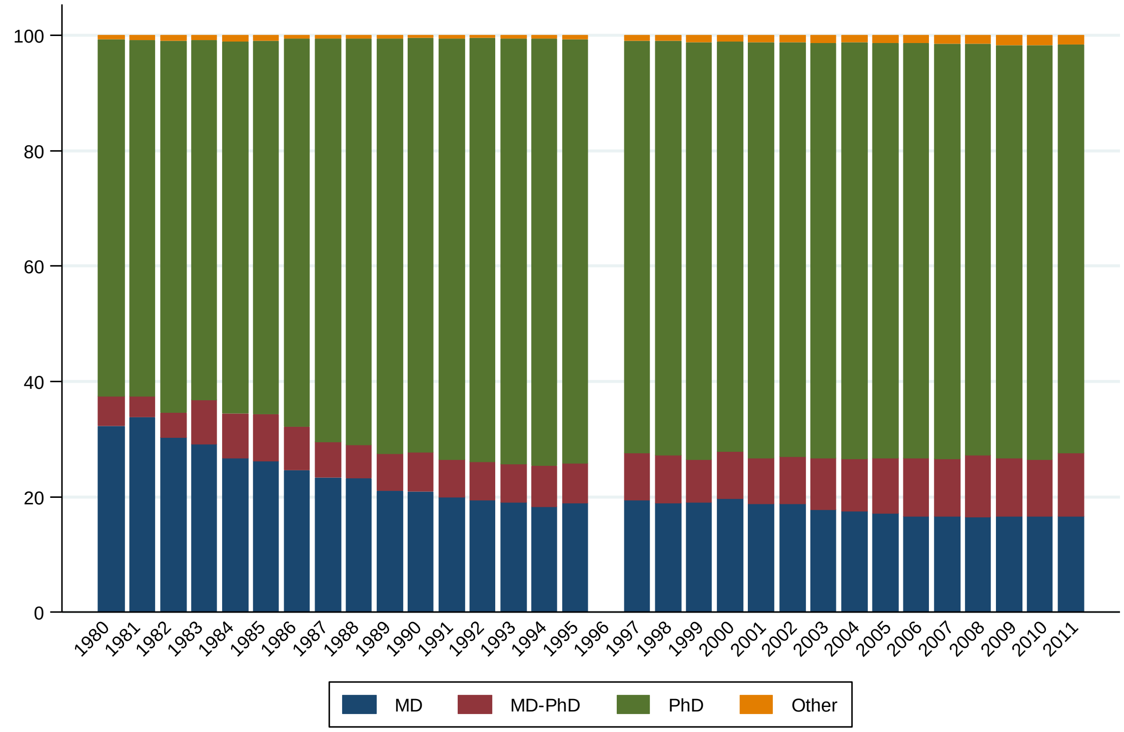


Figure 14.2: Distribution of Memberships on CSR Integrated Review Groups, by Degree (1980-2011)



Chapter 15 : Human Subjects Research

While physician scientists make important contributions to all types of biomedical research, their role in clinical research has been a special concern of policymakers (Wyngaarden, 1979). Some have even suggested that the relationship between clinical research and the number of physician scientists is bidirectional; not only does the shortage of physician scientists limit the volume of clinical research, but the obstacles to clinical research put clinical researchers at a career disadvantage (NIH Director's Panel on Clinical Research, 1997) and may discourage many physicians from pursuing research careers.

Clinical research typically refers to studies of therapies for actual patients and controls. Most research databases, however, do not categorize projects in this way. Many investigators have examined projects designated "human subjects research" on the Public Health Service grant application as a proxy for clinical research.[1]

We were able to find information on NIH "human subjects research awards" for 2003 through 2012 in a published NIH report (Rockey, 2013). This report identified the percentage of RPG awards that involved human subjects (projects reviewed and approved by an Institutional Review

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[1] The Department of Health and Human Services regulations "Protection of Human Subjects" (45 CFR 46, administered by the Office of Human Research Protection) define a *human subject* as a living individual about whom an *investigator* conducting *research obtains*: data through *intervention* or *interaction* with the individual; or *identifiable private information.* According to SF424, Application Guide for NIH and Other PHS Agencies, "NIH defines a clinical trial as a prospective biomedical or behavioral research study of human subjects that is designed to answer specific questions about biomedical or behavioral interventions (drugs, treatments, devices, or new ways of using known drugs, treatments, or devices)." In their analysis of NIH R01 awards, Kotchen et al (2004) stratified the human subjects research from a single review cycle into seven categories: mechanisms of disease, clinical trials/interventions, development of new technologies, epidemiology studies, behavioral studies, health services/outcomes, and de-identified human tissue. In their study, approximately 50 percent of the human subjects applications were classified as mechanisms of disease or clinical trials.

Board), and animal subjects (projects approved by an Institutional Animal Care and Use Committee), both human and animal subjects, and no human or animal subjects.

NIH Research Project Grants (RPGs) with MDs as principal investigator (PI) are twice as likely to involve human subjects as those headed by PhD scientists (Figure 15 and Table 15). In 2003, 46.1 percent of the MD's projects involved human subjects only. The comparable fraction was 22.8 percent for PhDs. While the category "human subjects research" is a broad one, and cannot be taken as synonymous with "clinical research," this general pattern—which has been consistent over the past decade—lends strong support to the view that physician scientists make a unique contribution to the field of biomedical research.

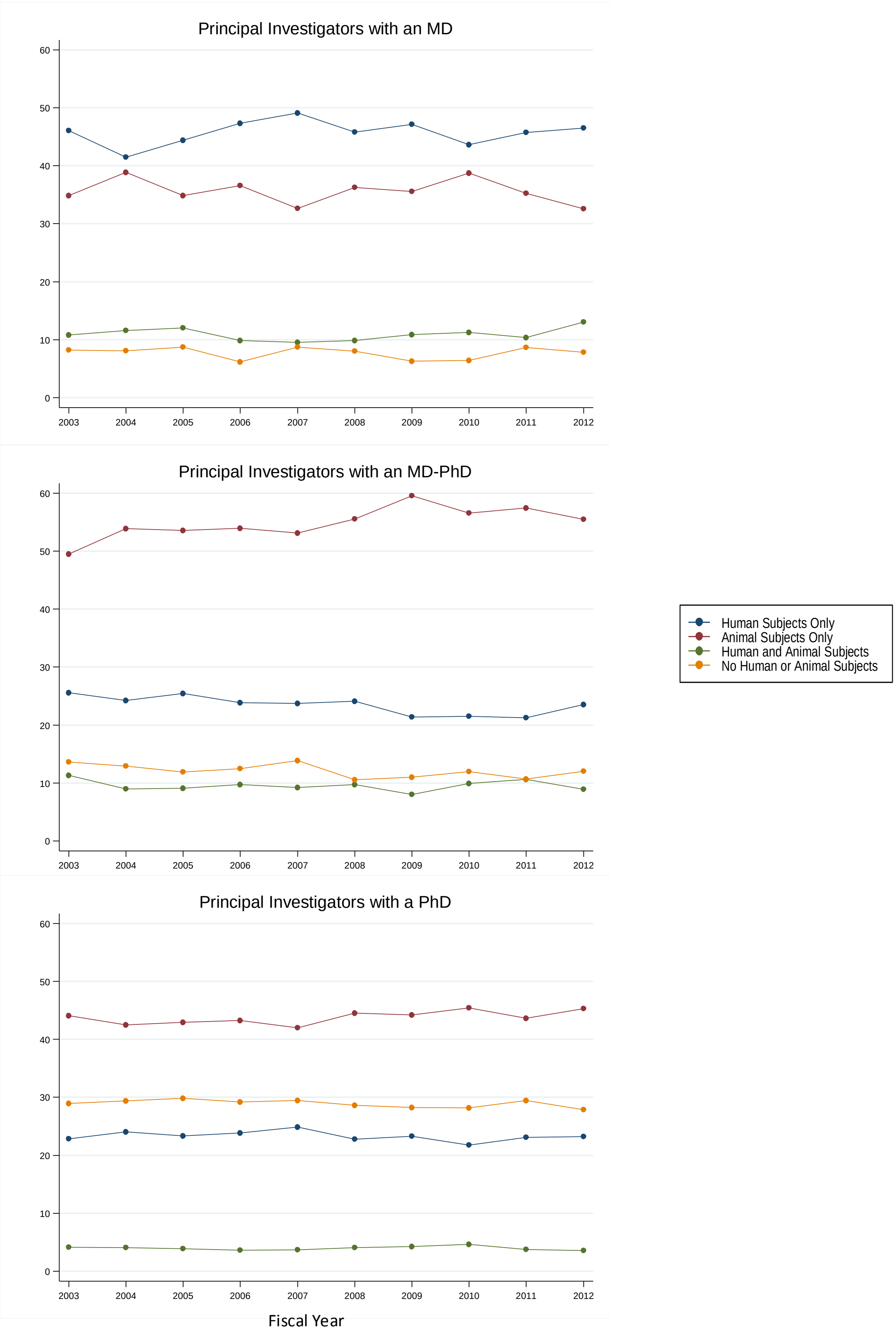
RPGs headed by MD-PhDs involved human subjects less frequently than those directed by MDs. In 2003 25.6 percent of the RPGs with an MD-PhD as PI involved human-only subjects, a fraction much closer to the rate for PhDs than for MDs. Over the course of the decade, the average of percentage of projects involving human subjects only was virtually identical for MD-PhDs and PhDs.

When grants involving *both* human subjects and animal subjects are considered, grants awarded to physician scientists also differ from those awarded to PhDs. In 2003, 10.9 percent of the NIH RPGs headed by a PI with an MD degree involved both human and animal subjects. Only 4.2 percent of the projects headed by PhDs involved both human and animal subjects. Again, these distributions were fairly stable across the decade.

Projects headed by MD-PhDs were similar to those headed by MDs in terms of the percentage using both human and animal subjects. The actual percentage fluctuated over the past decade, but, on average, 10 percent of the projects headed by MD-PhDs involved human and animal subjects, a rate just slightly below that for MD scientists.

For the broad category of human subjects research, educational background is highly correlated with the types of projects headed by MD, MD-PhD, and PhD scientists. This relationship has important policy implications. If the composition of the research workforce is changing, we can expect to see a change in the types of projects that are proposed and funded in the future. Since MD scientists are most frequently involved in human subjects research, their declining percentage in the research population could portend a declining in the volume of human subjects research.

Figure 15: Distribution of NIH Research Project Grant Awards Involving Human and Animal Subjects, by Principal Investigator’s Degree (2003-2012)



Chapter 16 : Acknowledgments

This study was made possible through funding from the Doris Duke Charitable Foundation and the Burroughs Wellcome Fund.

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