Are MD–PhD Programs Meeting Their Goals? An Analysis of Career Choices Made by Graduates of 24 MD–PhD Programs

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Abstract

Purpose
MD–PhD training programs provide an integrated approach for training physician–scientists. The goal of this study was to characterize the career path taken by MD–PhD program alumni during the past 40 years and identify trends that affect their success.

Method
In 2007–early 2008, 24 programs enrolling 43% of current trainees and representing half of the National Institutes of Health-funded MD–PhD training programs submitted anonymous data on 5,969 current and former trainees.

Results
The average program enrolled 90 trainees, required 8.0 years to complete, and had an attrition rate of 10%. Nearly all (95%) of those who graduated entered residencies. Most (81%) were employed in academia, research institutes, or industry; 16% were in private practice. Of those in academia, 82% were doing research and at least 61% had identifiable research funding. Whereas two-thirds devoted more than 50% effort to research, only 39% devoted more than 75% effort. Many with laboratory-based PhDs reported doing clinical, as well as basic and translational, research. Emerging trends include decreasing numbers of graduates who forego residencies or hold primary appointments in nonclinical departments, increasing time to graduation, and expanding residency choices that include disciplines historically associated with clinical practice rather than research.

Conclusions
Most MD–PhD program graduates follow career paths generally consistent with their training as physician–scientists. However, the range of their professional options is broad. Further thought should be given to designing their training to anticipate their career choices and maximize their likelihood of success as investigators.

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The concept of the MD–PhD program as an integrated approach to training physician–scientists dates back to the late 1950s. Although a long tradition exists of physicians becoming investigators as well as clinicians, MD–PhD programs were established with the realization that the standard four-year medical school curriculum is neither intended nor sufficient to train physician–investigators who are as proficient in the lab as they are in the clinic. As the term is now commonly applied, a *physician–scientist* or, more broadly, a *physician–investigator*, is a physician who is committed to the quest for new knowledge and new approaches to disease diagnosis, treatment, and prevention, and who devotes far more of his or her time to these activities than to routine clinical care. It was expected from the start that most graduates of MD–PhD programs would be employed by academic medical centers, universities, and research institutes such as the National Institutes of Health (NIH). It was also expected that links would exist between program graduates' medical training, clinical activities, and research interests and that each of these would inform the others in ways that could not be experienced by scientists who were not trained as physicians.[1]

MD–PhD programs are not the only available approach for training future physician–scientists, but they have, in many respects, become the most visible.[2–4] In an MD–PhD curriculum, students complete the requirements for both the MD and the PhD, usually by starting with the first two years of medical education and then focusing on graduate school before returning to complete the medical degree. Although initially available at only a few universities, MD–PhD programs are now offered at most U.S. and a few Canadian medical schools. These programs vary considerably in size and resources. Since 1964, NIH support has been available through institutional Medical Scientist Training Program (MSTP) grants from the National Institute of General Medical Sciences (NIGMS)[4] and competitively awarded individual fellowships that are offered by some of the NIH institutes. In addition to assisting with program costs, NIH funding has helped standardize training approaches and provides a regular source of external review as programs compete to obtain and continue their MSTP status.

Because MD–PhD programs commonly provide full tuition and stipend support to their trainees, they collectively represent a large investment of institutional, federal, and societal resources. Therefore, it is reasonable to ask whether they are meeting their goals. This was last done in the 1990s.[4–6] Recent debates at national conferences and in the literature about the best ways and times to train physicians to be investigators[7] led us to believe it is time to evaluate MD–PhD programs again. To our knowledge, the present study, which analyzes the data provided to us by 24 MD–PhD programs in 2007 and early 2008, represents the most exhaustive look to date at the career paths of MD–PhD program alumni. The participating programs collectively enroll approximately 40% of the estimated

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5,000 MD–PhD students currently in training and together represent nearly half of the 42 programs that were receiving NIGMS MSTP grants at the time the data were collected. The data that were provided allow us to address issues raised in recent editorials calling for an evaluation of MD–PhD training programs,[7,8] as well as concerns that physician–investigators are a vanishing species.[1]

Method

We sent a request for data to the directors and administrators of 25 MD–PhD programs, which we selected from among participants at the 2007 national conference of MD–PhD programs. We tried to achieve as much diversity as possible in program size and location. This was not a prospective study; rather, we asked the program leaders to provide as much data as possible from the inception of their program through the end of academic year (AY) 2007 (the 12 months ending in June 2007). Current students were defined as those enrolled at the time that the survey was completed, which was during AY2008. Twenty-four programs agreed to participate*; one program was unable to comply within the designated time frame. Twenty of the participating programs were among the 42 programs receiving NIGMS MSTP grants. Our decision to overrepresent NIGMS-funded programs arose in part because they tend to be the larger programs and in part because they are required to track their graduates and report on their activities every five years. In other words, they were more likely than other programs to have the necessary data on hand.

Each program submitted basic information, including the number of trainees in AY2008, the number of students entering the program in AY1998–2007, the number of students resigning without one or both degrees from AY1998 to AY2007, the percentage of trainees in AY2008 who were women, the average number of years to complete both degrees for graduates in AY1998–2007, and the discipline in which the PhD was awarded.

Program directors and administrators also provided information about alumni, including all graduates from program inception when possible. Program leaders obtained this information from a combination of alumni questionnaires, alumni Web sites, and searches of public databases such as the NIH Computer Retrieval of Information on Scientific Projects database. The identities of individual trainees and alumni were not available to us, and therefore we were not able to obtain additional primary data ourselves.

Statistical analysis

We calculated values in Figure 1 for r^2, the square of the Pearson correlation coefficient, using functions built into Microsoft Excel 2008 (Microsoft Corporation, Redmond, Washington).

Results

Twenty-four MD–PhD programs provided information about 5,969 individuals, including 2,023 current trainees, 1,143 recent graduates who were still in residencies or postdoctoral fellowships, and 2,803 older alumni who had completed all phases of postgraduate training. This represents 43% of the 4720 trainees enrolled in 2008 (www.aamc.org/data/facts/enrollmentgraduate/start.htm) and may represent a similar proportion of alumni, although the total number of graduates is currently unknown. Because some of the programs were unable to supply answers to all of the survey questions, in the following presentation of the results we have indicated the number of programs and/or alumni that answered each question.

Program characteristics and trainees

The 24 programs that participated in the survey ranged in size in AY2008 from 31 to 184 trainees; the average was 90 trainees. Thirty-seven percent of trainees in AY2008 were women, but this proportion varied considerably (range 20%–60%). The unweighted average time to complete both degrees for graduates in AY1998–2007 was 8.0 ± 0.4 years (mean ± 1 SD; 7.8 years when weighted by program size, range 7.2–8.5 years). On average, 10% of the 2,562 students who enrolled from AY1998 to AY2007 withdrew without completing both degrees (range 3%–34%, 1 SD = 7%). We found no relationship between program size and either the time to degree or the attrition rate from the same program (Figures 1A and 1B). Although we were not provided information about students' reasons for withdrawing, our personal experience as program directors and administrators suggests that most of those who withdraw from MD–PhD programs complete medical school. Fewer complete graduate school alone or drop out completely. Despite a recent report that women are less likely than men to complete MD–PhD programs,[9] we found no relationship between the attrition rate from individual programs and the percentage of trainees enrolled in the programs who were women (Figure 1C).

Information on PhD disciplines was provided for 1,957 trainees enrolled in AY2008, including 306 first- and second-year students who had not yet declared a discipline (a common practice in many of the programs). Of the 1,651 students who had declared a discipline, 1,422 (86%) were enrolled in PhD programs within the broad arc of biomedical disciplines. Another 151 (9%) were in engineering. The others were working in diverse disciplines including health policy, epidemiology, public health, anthropology, sociology, chemistry, mathematics, philosophy, marine biology, population health, psychology, and the history and sociology of science.

Positions of program alumni

Twenty-two programs provided information about then-current or last known positions of 2,413 alumni who had completed all phases of postgraduate training. Our results show that 80% of graduates were employed full-time in academic centers (1,625, or 67%),

* The 24 programs that participated are located at the Albert Einstein College of Medicine of Yeshiva University; Baylor College of Medicine; Case Western Reserve University School of Medicine; Emory University School of Medicine; Harvard Medical School; Johns Hopkins University School of Medicine; Medical College of Wisconsin; Northwestern University Feinberg School of Medicine; University of California, San Diego, School of Medicine; University of California, San Francisco, School of Medicine; University of Colorado Denver School of Medicine; University of Iowa Roy J. and Lucille A. Carver College of Medicine; University of Maryland School of Medicine; University of Medicine and Dentistry of New Jersey–Robert Wood Johnson Medical School; University of Michigan Medical School; University of Pennsylvania School of Medicine; University of Pittsburgh School of Medicine; University of Rochester School of Medicine and Dentistry; University of Texas Medical School at Houston; University of Texas Southwestern Medical Center at Dallas Southwestern Medical School; University of Wisconsin School of Medicine and Public Health; Vanderbilt University School of Medicine; Washington University in St. Louis School of Medicine; and Weill Cornell Medical College of Cornell University.

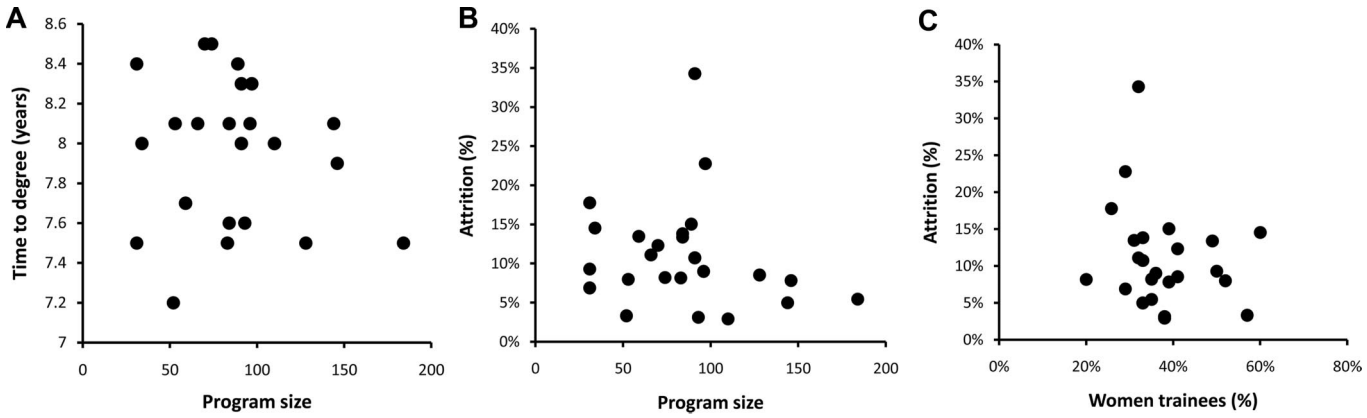

Figure 1 Relationships among MD–PhD program size, time to degree, attrition rates, and the percentage of trainees who are women. (A) The relationship between program size in academic year (AY) 2008 and time to degree for students entering in AY1998–2007 using data from 23 MD–PhD programs ($r^2 = 0.018$). (B) The relationship between program size in AY2008 and attrition rate over the period from AY1998 to AY2007 using data from 24 programs ($r^2 = 0.034$). (C) The proportion of trainees in AY2008 who are women and the attrition rate over the period from 1998 to 2007 using data from 24 programs ($r^2 = 0.043$).

research institutes such as the NIH (105, or 4%), or in industry (189, or 8%), each of which is an outcome consistent with the goals of MD–PhD training. Of the remainder, 386 (16%) were in private practice.

Because of concerns about possible ascertainment bias arising from the greater ease in tracking individuals employed in universities and research institutes, we also analyzed the data focusing solely on the 16 programs able to provide information on at least 98% (n = 1,927) of their alumni. The numbers we obtained are essentially identical to those derived from the larger data set: 68% employed in academia, 4% in research institutes, 8% in industry, and 16% in private practice.

Information about primary appointments was provided to us for 1,621 alumni of 22 programs working in academia (Table 1). Collectively, internal medicine, pediatrics, pathology, and neurology accounted for 975 (60%) of the alumni in academia, but most alumni (1,428, or 88%) held primary appointments in clinical departments. Many also had secondary appointments in basic science departments.

Research activities of program alumni

At least 921 (82%) of 1,118 alumni (of 17 programs) in academia indicated that they were doing research; 141 (13%) reported that they were not, and no data were available for 56 (5%). However, considerable variation existed in the amount of time that 814 alumni of 16 programs were willing or able to devote to research: Nearly two-thirds (521, or 64%) reported committing at least half of their time to research activities, but only 39% (317) devoted at least three-quarters of their time; 19% (155) reported spending one-quarter or less (Figure 2A).

Table 1

Primary Department of MD–PhD Program Alumni in Academia*

Department	MD–PhD program alumni No. (%)
Internal medicine	427 (26.3)
Pediatrics	203 (12.5)
Pathology	192 (11.8)
Neurology	153 (9.4)
Surgery	116 (7.2)
Psychiatry	85 (5.2)
Ophthalmology	61 (3.8)
Anesthesiology	50 (3.1)
Radiology	43 (2.7)
Dermatology	43 (2.7)
Radiation oncology	24 (1.5)
Obstetrics–gynecology	19 (1.2)
Emergency medicine	7 (0.4)
Physical medicine and rehabilitation	5 (0.3)
Nonclinical	175 (10.8)
Unknown	18 (1.1)
Total	1,621 (100.0)

* Summary of data provided by 22 MD–PhD programs on 1,621 alumni, each of whom had completed postgraduate training and was employed full-time in academia at the time that the survey data were collected in 2007–2008. "Surgery" includes all of the related disciplines. "Nonclinical" includes, but is not limited to, basic science departments.

Interestingly, even though the vast majority of trainees completed their PhD studies in basic biomedical or engineering disciplines, 736 alumni of 14 programs gave a variety of answers to a question about the kinds of research that they do. The choices provided were basic, translational, clinical, and health services. More than one answer was allowed, and more than one was commonly given. Although relatively few program graduates were engaged in health services research at the time of the survey, nearly equal numbers reported doing basic, translational, and clinical research (Figure 2B).

Information about research funding was available for 1,120 alumni of 17 programs who were in academia. Of these, at least 685 (61%) had funding; 154 (14%) said that they did not. Of the 281 (25%) for whom no data were available, nearly half (131, or 12%) reported research activities and may have had research support that was not reported, which means that the correct proportion of those in academia who have research funding may be as much as 73% (61% plus 12%). Note that many of the individuals working at institutes or in industry would also be expected to be doing research, but they were not included in this analysis, so the overall percentage of alumni doing research may be even higher than suggested by our analysis of those in academia.

Trends over time

As noted above, our data show that most MD–PhD graduates enter academia and

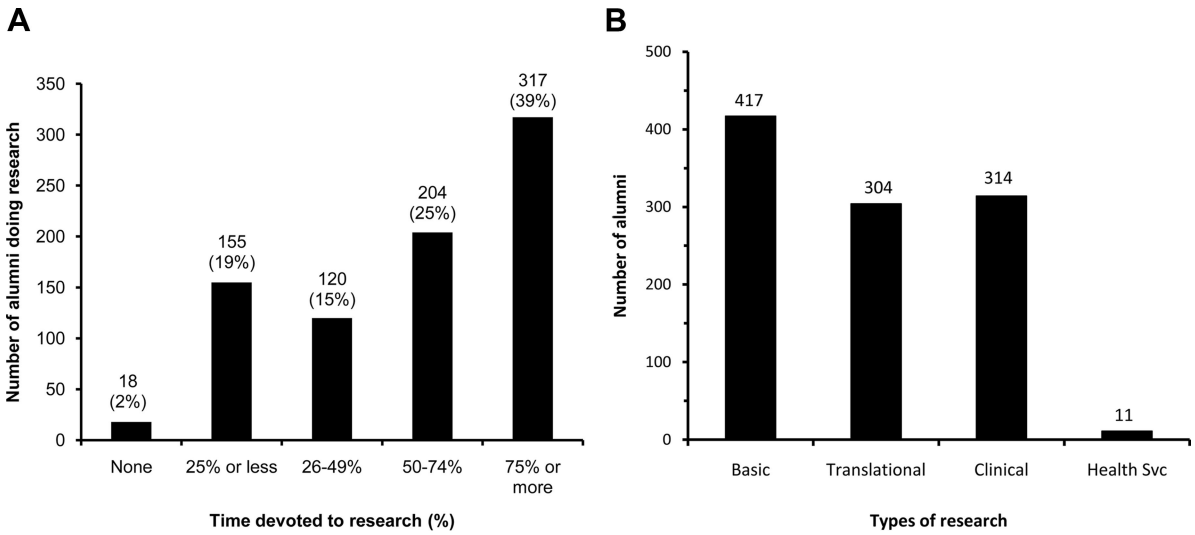

Figure 2 MD–PhD program graduates' responses to questions about their recent research activities. (A) How much time do you devote to research? Responses from 814 alumni of 16 programs who are now in academia. (B) Which kinds of research do you do? Data from 736 alumni of 14 programs; more than one answer was allowed.

have their primary appointment in a clinical department. The choices that senior students make for their next step after graduation strongly affect where they are likely to end up and may affect the likelihood that they will choose and succeed in a research-oriented career. Table 2 summarizes the choices made by 939 recent graduates of 21 programs. Of these, 892 (95%) chose to continue their clinical training. Only 47 (5%) elected to do a postdoctoral fellowship without postgraduate clinical training. Among those opting for a residency, internal medicine was the most popular choice (270, or 29%), and, collectively, internal medicine plus pediatrics, pathology, and neurology accounted for 518 (55%) recent graduates. The next most popular choice was surgery (107, or 11%), a category that combines all of the surgery-related disciplines.

Irrespective of their choice of residency, the vast majority of the alumni included in Table 2 completed their PhD training in a biomedical laboratory discipline. It is interesting to compare the residency choices of the whole group with the choices made by the small number (21) of recent graduates in the survey who did their PhD training in anthropology, demography, English, epidemiology, health policy, history of science, or public health. In this group, internal medicine was overwhelmingly the most popular choice, with 62% (13) choosing it compared with 29% (Table 2) in the total pool of recent graduates.

For an analysis of changes over time, we divided the data on program alumni into arbitrary cohorts of approximately 10 years based on graduation year. Several trends were evident. The percentage of graduates choosing to forgo a residency in favor of a postdoctoral fellowship, which has never been a common choice, has declined to 4% to 5% (Figure 3A).

Table 2

Residency Choice of Recent MD–PhD Alumni Still in Training*

Department	MD–PhD alumni in training No. (%)
Internal medicine	270 (28.8)
Surgery	107 (11.4)
Pediatrics	98 (10.4)
Pathology	79 (8.4)
Neurology	71 (7.6)
Radiology	61 (6.5)
Psychiatry	54 (5.8)
Dermatology	51 (5.4)
Radiation oncology	32 (3.4)
Ophthalmology	33 (3.5)
Anesthesiology	19 (2.0)
Obstetrics–gynecology	10 (1.1)
Emergency medicine	7 (0.7)
Postdoctoral training without residency	47 (5.0)
Total	939 (100.0)

* Summary of data provided by 21 MD–PhD programs on 939 recent graduates who were still in postgraduate training at the time that the survey data were collected in 2007–2008.

There has also been a decline in the number of graduates choosing residencies in internal medicine, neurology, pathology, and pediatrics—disciplines that have historically provided a protected environment for the development of physician–scientist careers—and an increase in those selecting dermatology, ophthalmology, radiation oncology, and surgery (Figure 3B). Others have noted similar trends in residency choice by all medical school graduates.[9–11]

Is choice of residency field predictive of whether MD–PhD program graduates will stay on track to become investigators or enter private practice? In Table 3, we present the outcomes data for 1,862 alumni of 22 programs who had completed all phases of postgraduate training, asking retrospectively whether those who chose clinical training in a particular field eventually ended up in private practice. There was considerable variability: 8% of pathology graduates ended up in private practice compared with 62% of those who completed family medicine residencies. Overall, 14% (165 of 1,220) of graduates who chose residencies in internal medicine, neurology, pediatrics, or pathology ended up in private practice, compared with 36% (120 of 338) of graduates who chose dermatology, ophthalmology, or surgery (three of the four areas noted above as showing an increase in popularity).

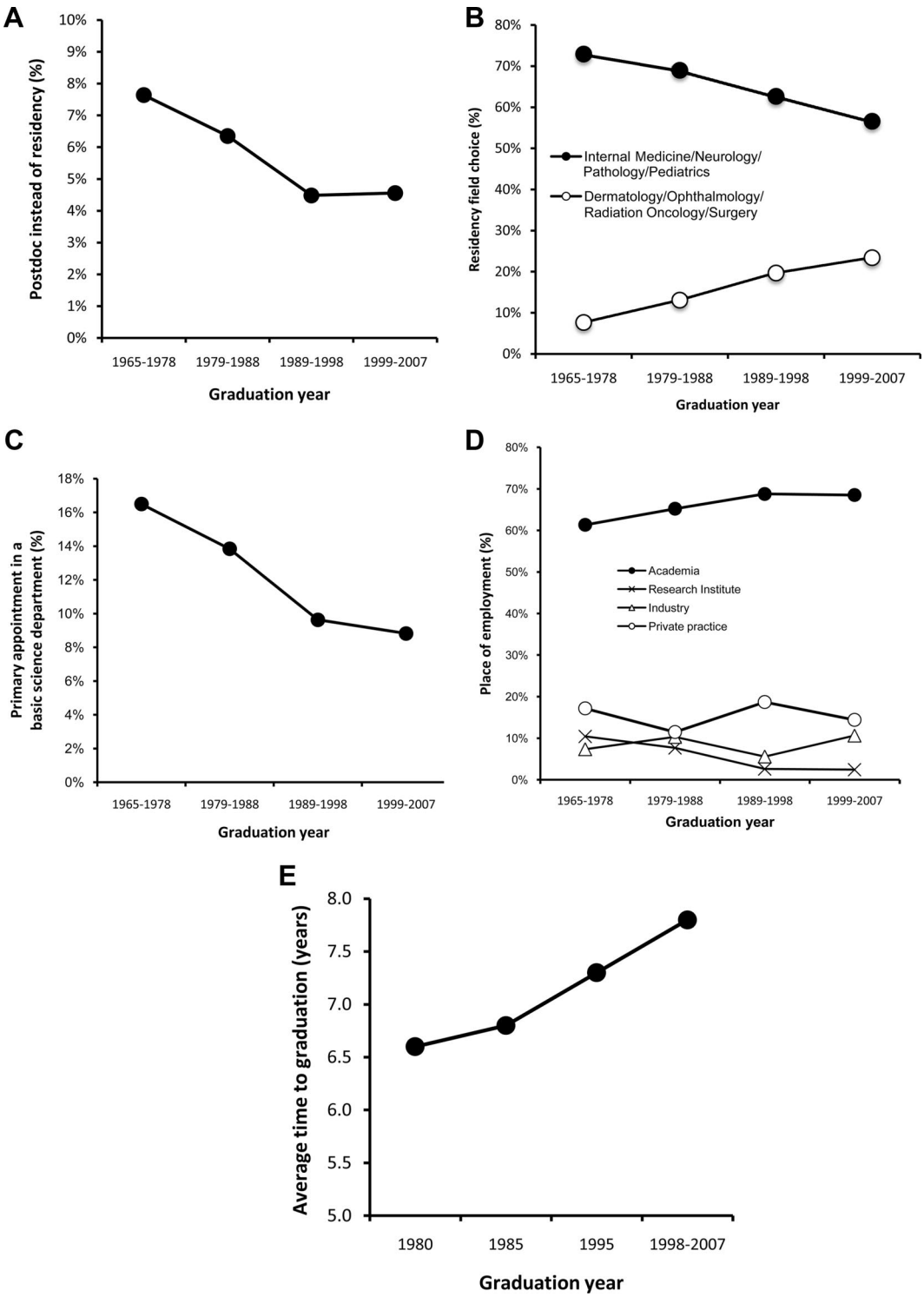

Figure 3 Emerging trends in choices made by MD–PhD program alumni and in the length of time required to graduate from MD–PhD programs. (A) Trends in the choice to do a postdoctoral research fellowship and forego doing a residency. Analysis drawn from data on 3,172 alumni from 23 programs divided into cohorts: 1965–1978 (n = 144), 1979–1988 (n = 551), 1989–1998 (n = 1,160), and 1999–2007 (1,317). (B) Trends in choosing a residency in internal medicine, neurology, pathology, or pediatrics compared with choosing a residency in dermatology, ophthalmology, radiation oncology, or surgery. Analysis drawn from data on 3,172 alumni from 23 programs divided into cohorts as shown in (A). (C) Trends in having a primary appointment in a basic science department. Analysis drawn from data provided by 22 programs divided into cohorts: 1965–1978 (n = 97), 1979–1988 (n = 383), 1989–1998 (n = 820), and 1999–2007 (n = 306). (D) Trends in choosing a career in academia, a research institute, industry, or private practice. Analysis drawn from data provided by 22 programs divided into cohorts: 1965–1978 (n = 163), 1979–1988 (n = 601), 1989–1998 (n = 1,198), and 1999–2007 (n = 306). (E) Average time to graduation. Trainees who graduated between 1998 and 2007 from the programs included in the present study required an average of 7.8 years (weighted) to complete both degrees. The data from studies completed in 1980, 1985, and 1995 are from the National Institute of General Medical Sciences.[4]

Table 3
Residency Choice as a Predictor of Eventually Choosing Private Practice*

Department	MD–PhD program alumni		
	Total no.	No. in private practice	% in private practice
Family medicine	13	8	62
Emergency medicine	13	6	46
Dermatology	70	31	44
Ophthalmology	101	44	44
Radiology	69	28	41
Obstetrics–gynecology	26	8	31
Surgery	167	45	27
Anesthesiology	57	13	23
Physical medicine and rehabilitation	5	1	20
Internal medicine	578	93	16
Radiation oncology	27	4	15
Neurology	173	23	13
Pediatrics	243	32	13
Psychiatry	94	11	12
Pathology	226	17	8

* Summary of data provided by 22 MD–PhD programs on 1,862 alumni, each of whom had completed postgraduate training at the time of this study in 2007–2008. Note that overall, 16% of the alumni who had completed training were in private practice at the time that the survey data were collected. The columns indicate the total number of alumni who completed a residency in each department and the number of those who subsequently entered private practice. The percentage for each department is the number who entered private practice divided by the total number who completed a residency in that department.

An additional trend that emerged shows a steady decline in the proportion of graduates working in academia whose primary appointment is in a basic science department (Figure 3C). Overall, however, the proportion of graduates choosing careers in academia, research institutes, or industry has changed little over almost 50 years (Figure 3D).

Finally, we asked whether there has been a change in the time required to complete both degrees over the years that MD–PhD programs have been in existence. As noted above, the unweighted average time for graduates in AY1998–2007 was nearly 8 years, which represents a substantial increase from the 6.6 years noted in 1980[4] (Figure 3E).

Discussion

MD–PhD programs have expanded greatly in size and have become nearly ubiquitous since their beginnings about 50 years ago at a handful of medical schools. However, the number of applicants to these programs each year remains a small fraction of those applying to medical school, and the number of MD–PhD graduates remains a small fraction of total medical school graduates. In 2007, there were only 1,721 applicants to MD–PhD programs, which represents about 4% of total medical school candidates. Of these 1,721 individuals, 536 matriculated.[12]

As program numbers increased, some schools and groups of schools made efforts to analyze the careers of their graduates.[5,6,13,14] In 1998, NIGMS made available some of the outcomes data that had been reported by MSTP-funded institutions as part of their training grant renewals.[4] The results of these studies showed, much as we have found, that the majority of MD–PhD graduates are in academia. However, none of the previous studies are recent, and none of them address recent trends. Although an all-encompassing prospective database about MD–PhD program graduates would be useful, none currently exists.

In an effort to obtain a snapshot within a reasonable length of time, we asked the 24 participating programs to provide information that they had already collected. As a result, not all programs could answer all questions about all alumni, a recognized limitation of the data. Nonetheless, a number of the results that we obtained are in good agreement with those from the earlier studies cited above. Given the size of the sample, our conclusions are likely to be applicable to MD–PhD programs as a whole and especially to those programs with NIGMS MSTP funding, nearly half (20 of 42) of which were included in our survey. To what extent this heavy reliance on data from programs with MSTP grants has affected the results will remain unclear until a fully inclusive MD–PhD program graduates database—such as the one under consideration by the Association of American Medical Colleges (AAMC)—is launched. Until then, important questions about comparative outcomes between programs that receive MSTP support and those that do not will have to wait.

Nevertheless, we can draw several clear conclusions from the data that are available. The first is that most MD–PhD program graduates (80%) are in careers generally consistent with the goal of MD–PhD training, which is to train physicians who are committed to the quest for new knowledge and new approaches to disease diagnosis, prevention, and treatment. This number is essentially the same as the 81% of 2000–2006 MD–PhD graduates who reported in the AAMC graduation survey that they planned substantial career involvement in research.[9] Approximately 67% are in academia, a number that is also remarkably similar to what has been reported previously.[4,6,13,14]

A second conclusion is that most (82%) of the program graduates at academic medical centers are doing research and have funding to support their efforts. Presumably at least as many of the graduates at research institutes such as the NIH are doing research as well. The data, however, also clearly show that the range of career choices among MD–PhD program graduates is very broad with respect to both research interests and time spent on research. This diversity is not currently reflected in the curriculum design and admissions policies of MD–PhD programs, which typically focus on the recruitment and training of bench scientists. The unstated assumption is that if MD–PhD graduates start in laboratory-based research, that is what they will continue to do—an assumption that is challenged by the number of

graduates who have decided to do translational and clinical research. The skill set needed to conduct well-designed research in humans is simply not addressed in most graduate school training programs.

Although there are no standard criteria to identify a physician–scientist, given the complexity of modern research many of us advise our students and prospective students that they will need to spend 75% to 80% of their time on research-related activities, leaving the remaining time for clinical care, teaching, and other activities that will hopefully integrate well with their research interests. However, our study data show that if the designation *physician–scientist* is limited to those who spend at least 75% of their time on research-related activities, then many MD–PhD graduates fit this definition, but many do not (Figure 2A).

A third conclusion is that recent concerns that the dropout rate from MD–PhD programs is very high and that many of those who stay in the program until the end enter private practice are not justified by the data. We found that most MD–PhD students complete the program, and most alumni are *not* in private practice. The average attrition rate of students who entered programs in AY1998–2007 was 10%, very similar to the 12% reported by Fang and Meyer[15] for MSTP-funded trainees who matriculated between 1980 and 1988, but considerably lower than the 29% that was reported in 2008 by Andriole and colleagues.[9] The attrition rate varied from 3% to 34% among the schools in this study, a variation that deserves closer scrutiny to establish cause. Our study does not directly address gender differences regarding attrition—whether women are less likely than men to persist in a physician–scientist career.[9,16,17] Gender was not included in the information supplied on each trainee. At the program level, however, we did not find a correlation between the percentage of trainees who are women and the attrition rate from the program.

Overall, we found that 16% of the MD–PhD alumni who completed postgraduate training eventually entered private practice, a number that is larger than one might hope but is perhaps unsurprising given the challenges of predicting what a 21-year-old applicant will actually do when he or she is 30 to 40 years old. A retrospective analysis does suggest that some choices of a clinical field for residency are more likely than others to lead to a career in private practice (Table 3), but given the manner of data collection, we cannot determine whether graduates chose to enter private practice as a consequence of their residency choice or whether the choice of a residency was a consequence of a decision not to pursue a career in research. We note that graduates of three of the fields that have shown recent gains in popularity (dermatology, ophthalmology, and surgery) had higher-than-average rates of going into private practice. But it is equally important to note that at least some of the alumni who chose those fields eschewed private practice and reported performing funded research.

A final conclusion from the data is that MD–PhD program graduates pursue a broad range of types of research, perhaps reflecting their training in both science and medicine as well as their original goals when choosing to apply to MD–PhD programs. Our survey shows that instead of becoming basic scientists with only a distant memory of their medical training, many MD–PhD program graduates are conducting translational and patient-oriented research as well as basic research. In keeping with this trend, discussions at the annual meetings of program directors and administrators suggest that many MD–PhD programs are paying increased attention to the need for their students to be trained (or at least exposed) to the skills needed for translational and clinical research. Our survey did not address the question of whether MD–PhD trainees receive the formal training in the design and implementation of human studies that is increasingly being viewed as essential for clinical investigators. Although the training they receive in the scientific method will be helpful, if MD–PhD graduates are to be successful in this realm as well as in the laboratory, additional thought should be given to what they will need to know and when they should learn it. Timing is especially important given the need to resist making a lengthy training program even longer.

Alternative paths to research careers

If MD–PhD programs are to be viewed as an experiment in training physician–investigators, then what is the appropriate comparison group? Most medical students are not planning research careers, so using all medical students as a control group is not especially helpful. In considering a smaller group, the subset of physicians who apply for NIH grants, Dickler and colleagues[18] reported that MDs who become investigators are less successful than MD–PhDs and PhDs in obtaining a first NIH research project grant (R01) and, if funded once, are less likely to receive a subsequent R01. They are also more likely to do clinical rather than basic research. There has also been a decrease in MDs serving on NIH study sections.[19]

All of this makes perfect sense if successful MD–PhD program candidates are viewed as individuals who have gone through a rigorous vetting process that emphasizes early research experience and commitment as well as academic excellence. It does not mean that attending an MD–PhD program is the *only* way to become a physician–scientist. From our experience as program directors, we have found that MD–PhD programs are particularly well suited to individuals who decide early enough in their college careers that they have a commitment to discovery in medicine and are fortunate enough to receive guidance that includes information about physician–scientist training programs. There will always be a need for alternative pathways to capture the "late bloomers" because there are not currently (and likely never will be) enough MD–PhD program graduates to maintain the ranks of active physician–scientists. However, in general, avoiding an MD–PhD program is not a strategy that shortens the time to an independent career, even taking into account the rising time to graduation that we noted for such programs. The average age at first R01 was the same (43 years) for both MDs and MD–PhDs in 2007.[20] This suggests that if one intends to be a physician–scientist at the time of entry to medical school, skipping graduate school will not save time—presumably because an independent research career requires an extended period of mentored research training, whether it is completed during medical school or after residency.

Research careers require research training, which is not usually part of the medical school curriculum. One alternative path is offered by the Howard Hughes Medical Institute-sponsored NIH Cloister Program, which participants typically complete after their third year of medical school. Fang and Meyer[15] found that participants in the Cloister Program were more likely to hold research-oriented faculty positions at medical schools than were unsuccessful applicants to the program, but they were less likely to hold such positions than were the graduates of MSTP-funded programs. Other alternative pathways include obtaining mentored research training or even attending graduate school after completing postgraduate clinical training. Our anecdotal impression is that fewer are choosing these last two alternatives, at least as a means to move toward an independent laboratory-based research career. Currently, most of those whose goal is to focus exclusively on patient-oriented rather than basic research obtain the required clinical research training postresidency, usually in programs that lead to a master's degree rather than a PhD.

Trends over time

We observed several notable trends in the data on program alumni. The proportion of graduates that choose to forego residency training has always been relatively small. It seems to be declining further, as is the proportion of alumni working in academia with their primary appointment in a nonclinical department (Figure 3C). The decline in primary basic science appointments occurred during a period that saw a large growth in both the faculty size[21] and the research portfolios of clinical departments. One might speculate that clinical department chairs view MD–PhD investigators as a safer bet than investigators with a PhD but no MD—individuals with an MD–PhD can potentially generate clinical revenues; those with a PhD cannot. The increase in primary appointments in clinical departments may also speak to the commitment of MD–PhD graduates to pursue disease-related research that finds a more comfortable home in clinical departments. This would be consistent with the high percentage of alumni who report involvement in translational and clinical research (Figure 2B). A shift of physician–scientists to clinical departments was also noted in 2000 by Zemlo and colleagues.[19] Nonetheless, a recent survey of clinical department chairs still reported a large number of vacant positions for physician–investigators able to do clinical research.[22]

The distribution among clinical fields chosen by MD–PhD program graduates has also gradually changed over the past 50 years. Like Andriole and colleagues,[9] we found that the proportion choosing internal medicine, neurology, pathology, and pediatrics has declined, whereas those choosing fields such as dermatology, ophthalmology, radiation oncology, and surgery has increased (Figure 3B). In other words, more of the recent graduates of MD–PhD programs are choosing clinical training in disciplines outside those that have historically been the most willing to provide the large amounts of protected time required to do meaningful research. To the extent that residency choice is a predictor of which department MD–PhD program graduates eventually join, a review performed 20 years from now is likely to find that a far broader range of clinical departments have become the "home" for MD–PhD program alumni. If so, then the critical question is, what will they be doing in those departments?

Although the reasons underlying this shift can be debated, the change may result in either a continued positive outcome (i.e., a wonderful opportunity to extend inquiry into new fields) or a very undesirable outcome (i.e., more investigators leaking out of the pipeline). It is too soon to tell, but, as we already noted, the data from this retrospective study clearly show that graduates of some residency fields have been far more likely than others to eventually become private practitioners (Table 3). Private practice fits nobody's definition of a desirable outcome for MD–PhD program alumni. In 2007, Ahn and colleagues[23] reported on the attitudes and career intentions of current trainees; Andriole and colleagues'[9] similar survey followed. These studies differ from ours in their focus on career intentions rather than actual career choices, but it is worrisome that, if true, their survey data raise questions about some trainees' commitment to research careers.[9,23,24] If MD–PhD programs continue to expand, admission of candidates who lack a strong commitment is clearly an area that requires continuing attention by individual program leaders, and efforts should be directed toward both the selection and the nurturing of trainees.

Finally, the time required to complete an MD–PhD program is increasing, a trend that bodes ill for reversing the ever-increasing age at first faculty appointment and first R01.[2] The average time to graduation has risen from 6.6 years[4] to 7.8 years (weighted by program size) since the early years of MD–PhD training programs, which is an 18% increase (Figure 3E). This trend may in part reflect the increasing demands of medical education. If so, some thought should be given to the education requirements of physician–scientists versus those who will become full-time clinicians. Some of the upward trend may also reflect increasing training requirements for PhD students[25] and a diminished willingness to cross-count credits for work done toward each degree. Data to substantiate these possibilities were not obtained for this study but need to be collected in the near future. Because graduates of MD–PhD program typically complete six or more years of postgraduate training, they have a long additional training period before their first faculty appointment. If an unacceptable total duration of training is to be avoided, more attention must be paid to the requirements at each phase of training that contribute to the whole. Too often, each step on this path to independence is overseen by a different organization or certification group, and these groups rarely communicate with each other. For this reason and others, it is easy to argue for much better vertical integration in the training of physician–scientists. A call to make this and other changes is part of a recent report from the Association of Professors of Medicine.[26]

Limitations of this study

This study is the largest of its kind to date. It is not, however, without limitations arising from the method used to collect the data, and we would like to point some of those out. The study includes data from only 24 programs, albeit ones that included 40% of the MD–PhD trainees in the United States at the time of the survey. The programs vary widely in size and location, but 20 of the participating programs had NIGMS MSTP grants at the time of data

collection, and, as already noted, results from the MSTP-supported programs may prove to be different in meaningful ways from the large number of programs that have not yet benefited from NIH support. These differences may prove to be quite important when assessing the performance of individual programs, but they may not change the aggregate analysis by much. MSTP-supported programs tend to be larger on average than those without MSTP support. The four smallest programs in this study enrolled only 31 to 34 trainees and had 36 to 71 alumni at the time of the study. In contrast, even the four smallest of the NIH-supported programs had more trainees (52–66) and more alumni (60–133).

It is also worth emphasizing that the data on MD–PhD alumni were provided to us by the programs and not directly by the alumni. Some programs did not include all alumni, and because this was not a prospective survey, not every question was asked by every program when they last surveyed their alumni. However, it is somewhat reassuring that essentially identical results were obtained when our analysis of outcomes was limited to just those programs that submitted data on more than 98% of their alumni.

Conclusions

In summary, this study shows that many MD–PhD program graduates are staying on the physician–investigator career track. It provides an interim response to a recent call[7] for evidence that MD–PhD programs accomplish their mission: Clearly, they can and do. However, looking beyond the very positive conclusions driven by the aggregate analysis, the data collected in this survey also show that the range of eventual professional "phenotypes" of program graduates is very broad. It is therefore entirely legitimate to ask whether all of these phenotypes are consistent with the currently espoused goals of MD–PhD training. Recognition of this point will hopefully prompt further debate. Whatever the outcome of those much-needed debates, continued attention will need to be paid to the selection of the most appropriate candidates, the mentoring and training of matriculants, and the care of program graduates as they traverse the challenging divide between graduation and independence.

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Correction

In the article by Shomaker[1] in the February issue of *Academic Medicine*, there was a mistake regarding the number of schools that have received full accreditation from the Caribbean Accreditation Authority for Education in Medicine and Other Health Professions (CAAM-HP). There was also a mistake regarding the accreditation status of Ross University and St. George's University medical schools as accorded by CAAM-HP.

To date, there is only one medical school that has received full accreditation from the CAAM-HP. The CAAM-HP accorded the status of *Accredited* to the medical programs of Ross University's and St. George's University's medical schools, not *Full Accreditation*. These schools were accredited for four years with conditions.

Full accreditation is granted without conditions for five to seven years, depending on the length of the program.

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