Published in final edited form as:
Acad Med. 2014 October ; 89(10): 1398–1407. doi:10.1097/ACM.0000000000000400.

The Emerging Physician-Scientist Workforce: Demographic, Experiential, and Attitudinal Predictors of MD-PhD Program Enrollment

Dr. Donna B. Jeffe, PhD,
Professor of medicine, Washington University School of Medicine, and director, Health Behavior, Communication, and Outreach Core, Alvin J. Siteman Cancer Center, Barnes-Jewish Hospital and Washington University School of Medicine, St. Louis, Missouri

Dorothy A. Andriole, MD,
Assistant dean for medical education and associate professor of surgery, Washington University School of Medicine, St. Louis, Missouri

Dr. Heather D. Wathington, PhD, and
Assistant professor, Curry School of Education, University of Virginia, Charlottesville, Virginia

Dr. Robert H. Tai, EdD
Associate professor, Curry School of Education, University of Virginia, Charlottesville, Virginia

Abstract

Purpose—MD-PhD scientists are a very successful, but small and fairly homogenous group of biomedical researchers. The authors conducted a retrospective cohort study to identify predictors of MD-PhD program enrollment to inform the development of evidence-based strategies to increase the size and diversity of the biomedical research workforce.

Method—Using de-identified data from all 2001–2006 Pre-Medical College Admission Test Questionnaire (PMQ) respondents, the authors developed multivariate logistic regression models to identify the demographic, experiential, and attitudinal variables associated with MD-PhD program enrollment at matriculation compared with all other MD program enrollment at matriculation and with not enrolling in medical school by August 2012.

Results—Of 207,436 PMQ respondents with complete data for all variables of interest, 2,575 (1.2%) were MD-PhD program enrollees, 80,856 (39.0%) were other MD program enrollees, and 124,005 (59.8%) were non-medical school matriculants. Respondents who were black (vs. white), high school and college laboratory research apprenticeship participants, and highly endorsed the importance of research/finding cures as reasons to study medicine were more likely to be MD-

Correspondence should be addressed to: Dr. Jeffe, Department of Medicine, Washington University School of Medicine, 660 S. Euclid Ave., Campus Box 8005, St. Louis, MO 63110; telephone: (314) 286-1914; djeffe@dom.wustl.edu.

Other disclosures: None reported.

Ethical approval: The institutional review board at Washington University School of Medicine approved this study as non-human subjects research.

Disclaimer: The conclusions of the authors are not necessarily those of the Association of American Medical Colleges, National Institutes of Health, or their respective staff members.

PhD program enrollees, whereas respondents who highly endorsed the status of medicine as a reason to study medicine were less likely to be MD-PhD program enrollees than either other MD program enrollees or non-medical school matriculants.

Conclusions—MD-PhD program directors appear to be successful in enrolling students whose attitudes and interests align with MD-PhD program goals. Continued efforts are needed to promote MD-PhD workforce diversity and the value of both high school and college research apprenticeships for students considering careers as physician-scientists.

Since the inception of the National Institute of General Medical Sciences (NIGMS) Medical Scientist Training Program (MSTP) in 1964 with programs at three medical schools,[1] the number of MD-PhD programs, both MSTP-funded and non-MSTP-funded, has steadily increased. In 2011, MD-PhD dual-degree programs were offered at 111 of the 131 medical schools in the United States.[2] In the 2012–2013 fiscal year, there were 43 MSTP-funded programs,[3] and about two-thirds of MD-PhD graduates of U.S. medical schools accredited by the Liaison Committee on Medical Education (LCME) were graduates of schools with MSTP-funded MD-PhD programs.[4] Longitudinal studies of MD-PhD programs have demonstrated that many MD-PhD graduates pursue biomedical research careers.[1,5]

The number of students enrolled in MD-PhD programs has steadily increased over the past decade,[6] and MD-PhD graduates comprised 3.2% (547/16,838) of all LCME-accredited U.S. medical school graduates in 2009.[7] The Biomedical Workforce Working Group of the National Institutes of Health (NIH) Advisory Council to the Director estimated that, based on National Science Foundation Survey of Earned Doctorates data, about 9,000 individuals graduated with biomedical sciences doctoral degrees in the United States in 2009.[8] Of those, 6.1% (547) graduated with an MD-PhD.[7] Thus, MD-PhD program graduates in the United States still comprise only a small proportion of all MD-degree graduates and of all biomedical PhD-degree graduates.

MD-PhD dual-degree holders (MD-PhDs), including some individuals who obtained their MD and PhD degrees from separate programs (i.e., not MD-PhD dual-degree programs), have been overrepresented among grant applicants and among successful applicants for NIH individual research awards.[9,10] MD-PhDs also are relatively overrepresented in academic medicine and have particularly favorable career trajectories in this setting.[11,12] As MD-PhDs comprise a particularly successful group of biomedical researchers, identifying the characteristics associated with MD-PhD program enrollment may help address current concerns about the size and composition of the biomedical research workforce.[13,14] Thus, we sought to identify demographic, academic preparation, research experience, and attitudinal variables associated with MD-PhD program enrollment at medical school matriculation. We hypothesized that, among students who considered careers in medicine, as evidenced by their completion of the Association of American Medical Colleges' (AAMCs') Pre-Medical College Admission Test (MCAT) Questionnaire (PMQ),[15] those students who enrolled in MD-PhD dual-degree programs would have demonstrated a longstanding commitment to biomedical research through their participation in research opportunities at multiple points along the educational continuum. Since MSTP-funded MD-PhD programs seek to recruit a demographically diverse group of trainees,[16] as do LCME-accredited U.S.

medical schools in general,[17–19] we also hypothesized that the representation of women and of students from racial/ethnic groups historically underrepresented in the biomedical research workforce (e.g., blacks, Hispanics, and Native Americans/Alaskan Natives) enrolled in MD-PhD programs would be relatively high compared to their representation among PMQ respondents who did not enroll in medical school but similar to their representation among students who entered other MD-degree programs.

Method

The institutional review board at Washington University School of Medicine determined this study to be non-human subjects research, as all data provided to the researchers were completely de-identified. We created a database with individually linked records for all first-time PMQ respondents from 2001–2006. Since 2013, this questionnaire has been administered after the MCAT and renamed the Post-MCAT Questionnaire. The PMQ is administered on a confidential and voluntary basis to MCAT examinees to better understand their experiences and future career plans.[15] As some MCAT examinees might matriculate in medical school (in both MD-PhD and other MD degree programs) many years after they first take the MCAT, we limited our examination of PMQ respondents to those who initially took the MCAT prior to 2007. Thus, with follow-up data through August 2012, we had a minimum follow-up period of five years for all PMQ respondents in our sample. The AAMC provided us with examinees' initial MCAT scores as well as data for selected items from the PMQ, Student Record System (SRS), and Data Warehouse (see below for a description of the variables).

Predictor variables

We categorized self-identified race/ethnicity (black, Hispanic, Native American/Alaska Native, Asian/Pacific Islander, white, or other/multiple races/no response) and gender (female vs. male) based on data from the SRS and PMQ.

We computed a composite score for each student's MCAT as the sum of the Verbal Reasoning, Biological Sciences, and Physical Sciences subscores. We then created a five-category variable (quintiles) based on the composite MCAT scores of all MCAT examinees in our database.

The AAMC provided the Carnegie Classification of the undergraduate institution[20] that each PMQ respondent reported attending. We created a six-category Carnegie Classification variable for analysis: (1) research universities with very high research activity, (2) research universities with high research activity and doctoral/research universities, (3) masters colleges and universities, (4) BA/BS colleges, (5) all other undergraduate institutions (including all other Carnegie Classifications of non-research oriented undergraduate institutions), and (6) institution of enrollment not specified.

We included responses to the PMQ items for participation in a high school summer laboratory research apprenticeship (yes vs. no) and for participation in a college laboratory research apprenticeship (yes vs. no) as well as responses to the item, "Please indicate the area of medicine in which you are most interested" (public health, patient management, or biomedical research).

The PMQ included 15 items about the importance of various factors in a student's decision to study medicine; response options ranged from 1 = not at all important to 4 = very important. We used an iterative process of exploratory principal components analysis with varimax rotation for data reduction, dropping items that loaded ≥ .400 on more than one factor or that loaded < .600 on any one factor. Multi-item factors that emerged were used for analysis.

We obtained data for institutional MSTP funding during the study period using NIGMS rosters of MSTP-funded institutions,[3] which are updated annually. Using these NIGMS data and data from the NIH Research Portfolio Online Reporting Tools (RePORTER),[21] we categorized all LCME-accredited U.S. medical schools as having received MSTP funding for some or all years of the study period or as never having received MSTP funding during the study period. We reviewed the MSTP-funding records for the preceding 20 years (1993–2012) and classified the 47 LCME-accredited U.S. medical schools that had received MSTP funding for some or all of these years as MSTP-funded schools; schools that had never received MSTP funding during this period were classified as non-MSTP-funded schools. The AAMC then linked these institutional MSTP-funding data with each matriculant's record and provided the de-identified data to us (without school identifiers).

Outcome measure

Based on SRS records, we created a binary variable for medical school matriculation by August 2012 (yes vs. no). We then created a three-category outcome variable for all PMQ respondents in our database: (1) MD-PhD program enrollment at matriculation; (2) other MD program enrollment at matriculation; and (3) non-medical school matriculation (no record of medical school matriculation).

Statistical analysis

We report descriptive statistics for each independent variable and the outcome variable. In separate multivariate logistic regression models, we identified variables independently associated with MD-PhD program enrollment compared to other MD program enrollment and to non-medical school matriculation, reporting adjusted odds ratios (aOR) and 95% confidence intervals (CI) from each regression model. We performed all tests using SPSS version 20.0.0.1 (IBM SPSS Inc., Chicago, IL). Two-sided $P < .05$ was considered significant.

Results

From 2001 to 2006, 262,813 individuals completed the PMQ prior to taking the MCAT for the first time. We excluded 141 individuals (0.1%) whose records indicated that they had initially enrolled in medical school prior to the 2002–2003 academic year. Of the remaining 262,672 PMQ respondents, 3,196 (1.2%) had enrolled in MD-PhD programs; 96,776 (36.8%) had matriculated in medical school but not as MD-PhD program enrollees, and 162,700 (61.9%) had not matriculated in medical school by August 2012. Our final study sample of 207,436 PMQ respondents with complete data for all measures of interest (79.0% of 262,672) included 2,575 (80.6% of 3,196) who had enrolled in MD-PhD programs; 80,856 (83.5% of 96,776) who had matriculated in medical school but not in MD-PhD programs, and 124,005 (76.2% of 162,700) who had not enrolled in medical school by August 2012.

Three factors emerged from our principal components analysis of 15 attitudinal items measuring the importance of reasons for studying medicine; five items that loaded > .400 on two factors were dropped. Thus, we computed the mean of items loading on each factor to create three variables for subsequent analysis, measuring the importance of: (1) status, (2) altruism, and (3) research/finding cures as reasons to study medicine. Factor loadings and the internal consistency of items on each factor (Cronbach's alpha) are shown in Table 1.

As shown in Table 2, women comprised 54.2% (112,351/207,436) of the study sample, but only 40.3% (1,038/2,575) of MD-PhD program enrollees, which was less than among other MD program enrollees (40,424/80,856; 50.0%) and among non-medical school matriculants (70,889/124,005; 57.2%). We observed similar findings for each of black, Hispanic, and Native American/Alaska Native students.

Also shown in Table 2, compared with other MD program enrollees and non-medical school matriculants, greater percentages of MD-PhD program enrollees scored ≥ 31 on the MCAT, participated in both high school and college laboratory research apprenticeships, and reported that biomedical research was the most interesting area of medicine. MD-PhD program enrollees also reported greater importance of research/finding cures in their decision to study medicine compared with each of the other two groups.

As shown in Table 3, respondents who reported black (vs. white) race/ethnicity, participating in high school and college laboratory research apprenticeships, greater importance of research/finding cures as a reason for studying medicine, and who attended BA/BS colleges (vs. research universities with very high research activity) were each more likely to be MD-PhD program enrollees at matriculation compared with other MD program enrollees. In contrast, respondents who reported Asian/Pacific Islander and other (each vs. white) race/ethnicity, that public health aspects of disease and patient management were the most interesting aspects of medicine (each vs. biomedical research), greater importance of the status of the medical profession and of altruism as reasons for studying medicine, and had composite MCAT scores < 31 were each less likely to be MD-PhD program enrollees at matriculation compared with other MD program enrollees. Respondents who reported black and Hispanic (each vs. white) race/ethnicity, participating in high school summer and college laboratory research apprenticeships, greater importance of research/finding cures as a reason for studying medicine, and who attended BA/BS colleges (vs. research universities with very high research activity) were each more likely to be MD-PhD program enrollees at matriculation compared with non-medical school matriculants. In contrast, respondents who reported Asian/Pacific Islander and other (each vs. white) race/ethnicity, that public health aspects of disease and patient management were the most interesting aspects of medicine (each vs. biomedical research), greater importance of the status of the medical profession as a reason for studying medicine, had composite MCAT scores < 31, and attended Master's colleges/universities (vs. research universities with very high research activity) were each less likely to be MD-PhD program enrollees at matriculation compared with non-medical school matriculants.

Table 4 shows the characteristics of MD-PhD program enrollees, grouped by their medical school's MSTP-funding status. Compared with MD-PhD program enrollees in non-MSTP-funded schools, greater percentages of MD-PhD program enrollees in MSTP-funded schools were men, participated in high school summer and college laboratory research apprenticeships, reported on the PMQ that the most interesting area of medicine is biomedical research, had higher MCAT scores, and attended undergraduate institutions with the Carnegie Classification of research universities with very high research activity. Although greater percentages of MD-PhD program enrollees in MSTP-funded schools versus those in non-MSTP-funded schools were black, Hispanic, and Native American/Alaska Native, the association between institutional MSTP-funding status and race/ethnicity was not statistically significant.

Discussion

MD-PhD program enrollees differed in numerous regards from all other PMQ respondents in our sample. As hypothesized, students who enrolled in MD-PhD programs at medical school matriculation had a strong commitment to research, according to both experiential and attitudinal variables in our models. Given recent efforts to increase the diversity of medical school matriculants in general,[17–19] and of MSTP-funded MD-PhD program enrollees in particular,[16] we also hypothesized that the representation of women and historically underrepresented minorities (URM) in MD-PhD programs would be similar to their representation in other MD programs and relatively high compared with their representation among non-medical school matriculants. This hypothesis was not supported, suggesting that continued efforts to increase diversity among MD-PhD enrollees are warranted. We discuss our results in the context of: (1) the roles of formal high school and college laboratory research apprenticeships in participants' career goals and graduate education, (2) academic preparation for students who may aspire to physician-scientist careers, (3) enrollment of students strongly committed to biomedical research in MD-PhD programs, and (4) the gender and racial/ethnic diversity of the emerging MD-PhD workforce.

High school and college laboratory research apprenticeships

Participants in both high school summer and college laboratory research apprenticeships were more likely to be MD-PhD program enrollees (compared with other MD program enrollees and with non-medical school matriculants), which speaks to the positive impact that participating in research programs at multiple points along the educational continuum has on promoting students' pursuit of research-related careers. Previous research has shown that college research programs may play an important role in a student's decision to pursue doctoral studies in the biomedical sciences.[22] A National Research Council report noted that most T34 Undergraduate Student Training in Academic Research Program (U*STAR) and T34 Career Opportunities in Research Education and Training (COR) undergraduate research program participants expected that such programs would help them decide between attending medical or graduate school.[23] Historically, a substantial percentage of college graduates who participated in some undergraduate programs designed to promote URM students' entry into PhD programs (e.g., the Minority Access to Research Careers program) ultimately pursued careers in medicine.[24]

Our results indicate that large numbers of students seriously consider pursuing careers in medicine after participating in college laboratory research apprenticeships and that such participation played a significant, positive role in their continued involvement in a biomedical research career path--many enrolled in MD-PhD rather than other MD degree programs. We speculate that, if any participants in the current NIH **Bu**ilding **I**nfrastructure **L**eading to **D**iversity (**BUILD**) initiative[25] ultimately decide to pursue careers in medicine, they also will be more likely to matriculate as MD-PhD program enrollees than as other MD program enrollees.

Academic preparation

As expected based on available data,[26] students with MCAT scores < 31 were less likely to be MD-PhD program enrollees than other MD program enrollees or non-medical school matriculants. Our findings underscore the critical independent role of strong academic support and preparation, in addition to research opportunities at multiple points along the educational continuum, in promoting greater biomedical research workforce diversity.

Although only 7.2% of all students in our cohort attended BA/BS colleges, these students were more likely to be MD-PhD program enrollees than other MD program enrollees and non-medical school matriculants. We speculate that students in these educational settings might be particularly well-mentored, better prepared academically, or have other unmeasured characteristics when they start college, which could influence their likelihood of enrolling in an MD-PhD program at medical school matriculation.

MD-PhD program enrollees' commitment to biomedical research

Our observations suggest that MD-PhD program directors are successful in enrolling students with attitudes and career interests that align with the research-focused goals of MD-PhD programs. Enrolling such students is important for MD-PhD program directors, since enrollees who plan substantive career involvement in research are less likely to discontinue their MD-PhD training prior to completing the dual-degree requirements than are students who enter their programs planning less substantive career involvement in research.[27] Our observed differences among MD-PhD program enrollees by their medical school's MSTP-funding status might reflect differences in the goals and missions of MSTP-funded and non-MSTP-funded MD-PhD programs as well as differences in the applicant pools for each (for which we lacked data).

Gender and racial/ethnic diversity of the emerging MD-PhD workforce

Women and individuals from some racial/ethnic groups (including blacks, Hispanics, and Native Americans/Alaska Natives) have been historically underrepresented among MD-PhD program enrollees. On average, the percentage of female PhD students in all biomedical fields (except biomedical engineering and bioengineering) exceeds or approaches 50%,[23] and, in recent years, the percentage of women among all medical school matriculants has approached gender parity (47%). Although the percentage of women among active MD-PhD program enrollees increased from 31% in 2002 to 38% in 2013,[6,28] the percentage of female MD-PhD matriculants started to decline from 41% in 2006 to 36% in 2012.[29] Thus, women remain relatively underrepresented in MD-PhD programs compared to their respresentation among all medical school matriculants[7] and among all biomedical sciences PhD program enrollees.[23]

We observed that women were neither more nor less likely to enroll in MD-PhD programs compared with other MD programs or with not enrolling in medical school in models that controlled for academic preparation, research interests, and research experiences, which were independently associated with MD-PhD program enrollment. Further investigation is warranted to determine whether the underrepresentation of women among MD-PhD program enrollees is mediated by other factors, such as women’s concerns about the challenges of combining successful physician-scientist careers with childbearing and family life, lack of encouragement for women to pursue the MD-PhD program pathway to a physician-scientist career, and lack of compelling role models for doing so.[30]

Individuals from historically URM groups, including blacks, Hispanics, and Native Americans/Alaska Natives, remain underrepresented among NIH-supported trainees and among all science and engineering faculty nationally compared to their representation in the U.S. population at large.[16] The associations we observed between race/ethnicity and MD-PhD program enrollment differed somewhat for each of the three URM groups that we examined. Black students were significantly more likely than white students to enroll in MD-PhD programs compared with other MD degree programs and with not enrolling in medical school (see Table 3). Although the numbers of MD-PhD program graduates have increased at U.S. medical schools over the past decade, from 327 in 2002 to 564 in 2011,[7] the numbers of black MD-PhD program graduates and the proportion of black graduates among all MD-PhD program graduates both have remained low over the past 10 years, from 4.0% (13/327) in 2002 to 4.6% (26/564) in 2011.[7] The significant positive association we observed between black race/ethnicity and MD-PhD program enrollment suggests that programmatic efforts to promote the enrollment of URM students in MD-PhD programs (a particular focus for those MD-PhD programs that receive NIGMS funding[16]) may have had some success among black students.

Although low, the percentage of Hispanic MD-PhD program graduates has increased from 3.1% (10/327) in 2002 to 5.5% (31/564) in 2011.[7] Hispanic students were neither more nor less likely than white students to enroll in MD-PhD programs compared with other MD programs, but they were twice as likely to enroll in MD-PhD programs as they were to not matriculate in medical school. Finally, Native Americans/Alaska Natives were neither more nor less likely than white students to enroll in MD-PhD programs compared with other MD programs, and the percentage of Native American/Alaska Native MD-PhD program graduates remains low, increasing only from 0.6% (2/327) in 2002 to 1.1% (6/564) in 2011.[7] Continued efforts are warranted to identify and address possible barriers to the recruitment of Native American/Alaska Native students to MD-PhD programs; the Society for the

Advancement of Hispanics/Chicanos and Native Americans in Science (SACNAS)[31] may be particularly well-positioned to make substantive contributions to such efforts, since its mission is to promote success among Hispanic and Native American scientists. Notably, the observed percentages of black, Hispanic, and Native American/Alaska Native students enrolled in MD-PhD programs were still quite low compared with their representation in the population of U.S. medical students enrolled in LCME-accredited medical schools after 2001.[7]

Additional research is needed to examine gender and race/ethnicity in association with MD-PhD program graduates' career paths. Previous work indicates that there is a progressive loss of female MD-PhD grant applicants and a lower percentage of female than male grant applicants who are successful in obtaining some (e.g., K01 and R01-equivalent), but not all, types of awards.[9] The probability of being awarded R01 funding for new proposals differs by race/ethnicity, with black applicants being less successful than white applicants (including both MD and MD-PhD applicants).[32] Further research is warranted to fill the gap in knowledge about the physician-scientist career paths of female and URM MD-PhD program graduates specifically.

Strengths and limitations

Our study had several strengths, including the use of data from and about a national cohort of all PMQ respondents from 2001–2006 and the receipt of primary source data from the AAMC for the outcome of interest, with a minimum of five years of follow-up available for all PMQ respondents. This database was sufficiently large to permit disaggregation of data by race/ethnicity among students from groups historically underrepresented in the biomedical research workforce and to use multivariable models to identify independent associations between our outcome and predictors of interest.

Our study also has some limitations. After completing the PMQ, students in the non-medical school matriculant group in our study sample could have pursued a variety of educational paths, about which we lacked data. Future research in this area includes determining the educational and/or employment outcomes for those students who did not matriculate in LCME-accredited U.S. medical schools by August 2012. We also lacked information about the particular types of high school and college laboratory research apprenticeships in which students in our sample may have participated. College-level programs in particular vary widely in design, intent, and scope.[23,33,34] Thus, associations between participation in specific types of college-level research apprenticeships and MD-PhD program enrollment may differ from the associations we observed in this national cohort.

Nonetheless, our results may be of interest to federal agencies that sponsor an extensive array of high school-[31] and college-level[35,36] programs intended to promote interest in biomedical research careers among diverse populations of students. Our results also may be of interest to medical schools and other organizations that provide support to MD-PhD programs[3,37] and to MD-PhD program enrollees,[38] as well as to MD-PhD program directors as they work together to recruit, enroll, and support an emerging physician-scientist workforce that is well-prepared to address national biomedical research workforce needs.

Acknowledgments

The authors thank their colleagues, Paul Jolly, PhD, and Lindsay Roskovensky, at the Association of American Medical Colleges, Washington, DC, for their support of these research efforts through the provision of data and assistance with coding. They also thank Peter C. Preusch, PhD, at the National Institute of General Medical Sciences (NIGMS) for information regarding institutional Medical Scientist Training Program funding as well as James Struthers and Yan Yan, MD, PhD, at Washington University School of Medicine, for data management services and statistical consults, respectively.

Funding/Support: This study was funded in part by grants from NIGMS (R01 GM094535-03 and 2R01 GM085350-04) and the National Cancer Institute (NCI) Cancer Center Support grant to the Siteman Cancer Center (P30 CA091842-07) for use of the Health Behavior, Communication, and Outreach Core's data management services. The NIGMS and NCI were not involved in the design or conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review or approval of the manuscript.

References

1. National Institute of General Medical Sciences. MSTP study: the careers and professional activities of graduates of the NIGMS medical scientist training program. Bethesda, MD: National Institutes of Health; Sep. 1998 http://publications.nigms.nih.gov/reports/mstpstudy/ [Accessed May 7, 2014]
2. Barzansky B, Etzel SI. Medical schools in the United States, 2010–2011. JAMA. 2011; 306:1007–1014. [PubMed: 21900145]
3. National Institute of General Medical Sciences. Medical Scientist Training Program (MSTP) institutions. Bethesda, MD: National Institutes of Health; http://www.nigms.nih.gov/Training/InstPredoc/PredocInst-MSTP.htm [Accessed May 7, 2014]
4. Jeffe DB, Andriole DA. A national cohort study of MD-PhD graduates of medical schools with and without funding from the National Institute of General Medical Sciences' Medical Scientist Training Program. Acad Med. 2011; 86:953–961. [PubMed: 21694566]
5. Brass LF, Akabas MH, Burnley LD, Engman DM, Wiley CA, Andersen OS. Are MD-PhD programs meeting their goals? An analysis of career choices made by graduates of 24 MD-PhD programs. Acad Med. 2010; 85:692–701. [PubMed: 20186033]
6. Association of American Medical Colleges. [Accessed May 9, 2014] Table 36. Total MD-PhD enrollment by US medical school and sex. https://www.aamc.org/data/facts/enrollmentgraduate/161898/tot-mdphd_enroll-school-sex.html
7. Association of American Medical Colleges. Diversity in Medical Education: Facts & Figures 2012. Washington, DC: Association of American Medical Colleges; 2012. https://members.aamc.org/eweb/upload/Diversity%20in%20Medical%20Education%20Facts%20and%20Figures%202012.pdf [Accessed May 9, 2014]
8. NIH Research Portfolio Online Reporting Tools. [Accessed May 7, 2014] ACD Biomedical Workforce Working Group Data. Graduate: graduate training snapshot. http://report.nih.gov/investigators_and_trainees/ACD_BWF/Phd_Graduate.aspx
9. Ley TJ, Hamilton BH. Sociology. The gender gap in NIH grant applications. Science. 2008; 322:1472–1474. [PubMed: 19056961]
10. Haak, L.; Schnell, J. National Institutes of Health Individual Mentored Career Development Awards Program. Bethesda, MD: National Institutes of Health; Aug 29. 2011 http://grants.nih.gov/training/K_Awards_Evaluation_FinalReport_20110901.pdf [Accessed May 7, 2014]
11. Association of American Medical Colleges. [Accessed May 7, 2014] Table 7. Distribution of U.S. medical school faculty by rank and degree. AAMC Faculty Roster. Dec 31. 2012 https://www.aamc.org/download/325974/data/12table7.pdf
12. Liu, CQ.; Alexander, H. Analysis in Brief. Washington, DC: Association of American Medical Colleges; May. 2010 Promotion rates for first-time assistant and associate professors appointed from 1967 to 1997. https://www.aamc.org/download/121130/data/aibvol9_no7.pdf [Accessed May 7, 2014]
13. National Institutes of Health. [Accessed May 7, 2014] Biomedical Research Workforce working group report. Jun 14. 2012 http://acd.od.nih.gov/Biomedical_research_wgreport.pdf

14. National Institutes of Health, Working Group on Diversity in the Biomedical Research Workforce. [Accessed May 7, 2014] Draft Report of the Advisory Committee to the Director Working Group on Diversity in the Biomedical Research Workforce. Jun 13. 2012 http://acd.od.nih.gov/Diversity%20in%20the%20Biomedical%20Research%20Workforce%20Report.pdf
15. Association of American Medical Colleges. [Accessed May 7, 2014] Post-MCAT Questionnaire (PMQ). Frequently Asked Questions (FAQ). https://www.aamc.org/data/pmq/faq/
16. National Institute of General Medical Sciences. [Accessed May 7, 2014] Investing in the future: National Institute of General Medical Sciences Strategic Plan for Biomedical and Behavioral Research Training. 2011. http://publications.nigms.nih.gov/trainingstrategicplan/Strategic_Training_Plan.pdf
17. Liaison Committee on Medical Education; American Medical Association. [Accessed May 7, 2014] MS-8. 2013. http://www.lcme.org/connections/connections_2013-2014/MS-8_2013-2014.htm
18. Liaison Committee on Medical Education; American Medical Association. [Accessed May 7, 2014] IS-16. 2013. http://www.lcme.org/connections/connections_2013-2014/IS-16_2013-2014.htm
19. Addams, AN.; Bletzinger, RB.; Sondheimer, HM.; White, SE.; Johnson, LM. Roadmap to Diversity: Integrating Holistic Review Practices into Medical School Admission Processes. Washington, DC: Association of American Medical Colleges; 2010. https://members.aamc.org/eweb/upload/Roadmap%20to%20Diversity%20Integrating%20Holistic%20Review.pdf [Accessed May 7, 2014]
20. Carnegie Foundation for the Advancement of Teaching. [Accessed May 7, 2014] Carnegie Classifications: Classification Description. http://classifications.carnegiefoundation.org/descriptions/basic.php
21. NIH Research Portfolio Online Reporting Tools (RePORT). [Accessed May 7, 2014] http://www.projectreporter.nih.gov/
22. Villarejo M, Barlow AE, Kogan D, Veazey BD, Sweeney JK. Encouraging minority undergraduates to choose science careers: career paths survey results. CBE Life Sci Educ. 2008; 7:394–409. [PubMed: 19047426]
23. Lorden, JF.; Kuh, CV.; Voytuk, JA., editors. Research-doctorate programs in the biomedical sciences: selected findings from the NRC Assessment. Washington, DC: The National Academies Press; 2011. http://grants.nih.gov/training/biomedical_sciences.pdf [Accessed May 9, 2014]
24. National Research Council. Assessment of NIH minority research and training programs: Phase 3. Washington, DC: The National Academies Press; 2005. http://books.nap.edu/catalog/11329.html [Accessed May 7, 2014]
25. National Institutes of Health. [Accessed May 7, 2014] Enhancing the diversity of the NIH-funded workforce. Building Infrastructure Leading to Diversity (BUILD). https://commonfund.nih.gov/diversity/Initiatives.aspx
26. Association of American Medical Colleges. [Accessed May 7, 2014] Table 35. MCAT scores and GPAs for MD/PhD applicants and matriculants to US medical schools, 2008–2010. 2010. https://www.aamc.org/download/161878/data/table45-mdphd-mcatgpa-2011.pdf
27. Jeffe DB, Andriole DA, Wathington HD, Tai RH. Educational outcomes for students enrolled in MD-PhD programs at medical school matriculation, 1995–2000: A national cohort study. Acad Med. 2014; 89:84–93. [PubMed: 24280845]
28. Association of American Medical Colleges. [Accessed May 7, 2014] Table 36. Total Active MD/PhD enrollment by US medical school and sex. 2002–2006. https://www.aamc.org/download/161882/data/table36a-mdphd-enroll-sch-sex-0206.pdf
29. Association of American Medical Colleges. [Accessed May 9, 2014] Table 32: MD-PhD Applicants, Acceptees, Matriculants, and Graduates of US Medical Schools by Sex. 2001–2012. https://www.aamc.org/download/321542/data/2012factstable32.pdf
30. Andrews NC. The other physician-scientist problem: where have all the young girls gone? Nat Med. 2002; 8:439–441. [PubMed: 11984578]
31. Society for the Advancement of Hispanics/Chicanos and Native Americans in Science (SACNAS). [Accessed May 9, 2014] https://sacnas.org/

NIH-PA Author Manuscript

NIH-PA Author Manuscript

32. Ginther DK, Haak LL, Schaffer WT, Kington R. Are race, ethnicity, and medical school affiliation associated with NIH RO1 type l award probability for physician investigators? Acad Med. 2012; 87:1516–1524. [PubMed: 23018334]
33. McGee R Jr, Saran S, Krulwich TA. Diversity in the biomedical research workforce: developing talent. Mt Sinai J Med. 2012; 79:397–411. [PubMed: 22678863]
34. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. Washington, DC: The National Academies Press; 2011.
35. National Institute of General Medical Sciences. [Accessed May 7, 2014] Programs by academic stage. http://www.nigms.nih.gov/Training/TrainingCareerAwards.htm
36. National Science Foundation. [Accessed May 7, 2014] Funding. Specialized information for undergraduate students. http://www.nsf.gov/funding/education.jsp?fund_type=1
37. National Institutes of Health. NIH MD/PhD partnership training program. Bethesda, MD: National Institutes of Health; http://mdphd.gpp.nih.gov/ [Accessed May 7, 2014]
38. Association of American Medical Colleges. [Accessed May 7, 2014] Potential funding sources for MD-PhD students. https://www.aamc.org/students/linkableblob/62756-3/data/fundingformdphd-data.pdf

Table 1

Principal Components Analysis of Pre-Medical College Admission Test Questionnaire (PMQ) Items Measuring Importance of Factors in Respondent's Decision to Study Medicine, 2001–2006

PMQ items	Factor 1: Status (Cronbach's alpha = .77)	Factor 2: Altruism (Cronbach's alpha = .73)	Factor 3: Research/finding cures (Cronbach's alpha = .63)
1. Profession provides opportunity to satisfy personal desire for authority	**.632**	−.155	.202
2. Profession represents achievement higher than any other profession	**.710**	−.002	.165
3. Physicians receive immediate status and prestige	**.811**	−.135	.113
4. Profession offers the possibility of a high income	**.797**	−.010	−.077
5. Physicians are rarely unemployed	**.651**	.199	−.130
6. Profession offers the opportunity to serve community needs	−.067	**.815**	.122
7. Coworkers share desire to help people	−.005	**.718**	.094
8. Profession offers opportunity to make a difference in people's lives	−.008	**.845**	.020
9. Profession provides chance to pursue interest in research	−.001	.041	**.855**
10. Profession offers opportunity to discover a great cure	.162	.202	**.790**

Note: PMQ respondents were asked, "Please rate the importance of each of the following factors in your decision to study medicine." Factor loadings in bold indicate items included in computation of mean score for that factor.

Table 2

Descriptive Statistics of the Study Sample According to Pre-Medical College Admission Test Questionnaire Respondent Group, 2001–2006

Variable	No. (%)	MD-PhD program enrollees	Other MD program enrollees	*P* value[a]	Non-medical school matriculants	*P* value[b]
Total	207,436	2,575	80,856		124,005	
Gender				< .001		< .001
Men	95,085 (45.8)	1,537 (59.7)	40,432 (50.0)		53,116 (42.8)	
Women	112,351 (54.2)	1,038 (40.3)	40,424 (50.0)		70,889 (57.2)	
Race/ethnicity				< .001		< .001
White	123,017 (59.3)	1,642 (63.8)	50,877 (62.9)		70,498 (56.9)	
Black	16,868 (8.1)	137 (5.3)	5,938 (7.3)		10,793 (8.7)	
Hispanic	16,330 (7.9)	141 (5.5)	6,570 (8.1)		9,619 (7.8)	
Asian/Pacific Islander	41,227 (19.9)	546 (21.2)	14,810 (18.3)		25,871 (20.9)	
Native American/Alaska Native	720 (0.3)	2 (0.1)	281 (0.3)		437 (0.4)	
Other/multiple races/no response	9,274 (4.5)	107 (4.2)	2,380 (2.9)		6,787 (5.5)	
High school summer laboratory research apprenticeship				< .001		< .001
No	185,858 (89.6)	1,983 (77.0)	71,764 (88.8)		112,111 (90.4)	
Yes	21,578 (10.4)	592 (23.0)	9,092 (11.2)		11,894 (9.6)	
College laboratory research apprenticeship				< .001		< .001
No	134,695 (64.9)	631 (24.5)	47,299 (58.5)		86,765 (70.0)	
Yes	72,741 (35.1)	1,944 (75.5)	33,557 (41.5)		37,240 (30.0)	
Most interesting area of medicine				< .001		< .001
Public health aspects of disease	23,117 (11.1)	168 (6.5)	7,917 (9.8)		15,032 (12.1)	
Patient management	167,892 (80.9)	888 (34.5)	67,346 (83.3)		99,658 (80.4)	
Biomedical research	16,427 (7.9)	1,519 (59.0)	5,593 (6.9)		9,315 (7.5)	
MCAT scores, quintiles				< .001		< .001
< 19	37,732 (18.2)	8 (0.3)	2,354 (2.9)		35,370 (28.5)	
19–23	45,814 (22.1)	57 (2.2)	8,837 (10.9)		36,920 (29.8)	
24–26	35,559 (17.1)	139 (5.4)	12,902 (16.0)		22,518 (18.2)	
27–30	45,157 (21.8)	509 (19.8)	25,792 (31.9)		18,856 (15.2)	

Variable	No. (%)	MD-PhD program enrollees	Other MD program enrollees	*P* value[a]	Non-medical school matriculants	*P* value[b]
≥ 31	43,174 (20.8)	1,862 (72.3)	30,971 (38.3)		10,341 (8.3)	
College Carnegie Classification				< .001		< .001
Research universities with very high research activity	87,670 (42.3)	1,651 (64.1)	45,308 (56.0)		40,709 (32.8)	
Not specified	31,062 (15.0)	103 (4.0)	2,973 (3.7)		27,985 (22.6)	
Other institutions	6,565 (3.2)	27 (1.0)	1,734 (2.1)		4,804 (3.9)	
BA/BS colleges	19,038 (9.2)	331 (12.9)	9,572 (11.8)		9,135 (7.4)	
Master's colleges and universities	30,143 (14.5)	188 (7.3)	8,895 (11.0)		21,060 (17.0)	
Research universities with high research activity or doctoral/research universities	32,958 (15.9)	275 (10.7)	12,374 (15.3)		20,309 (16.4)	
Importance of factors in decision to study medicine	Mean (SD)	Mean (SD)	Mean (SD)		Mean (SD)	
Research/finding cures	2.9 (0.8)	3.5 (0.6)	2.7 (0.8)	< .001	2.9 (0.8)	< .001
Status	2.2 (0.7)	2.1 (0.7)	2.2 (0.7)	< .001	2.2 (0.7)	< .001
Altruism	3.7 (0.4)	3.6 (0.5)	3.7 (0.4)		3.7 (0.4)	

Abbreviations: MCAT indicates Medical College Admission Test; BA/BS, baccalaureate arts and sciences; SD, standard deviation.

[a] Tests of significance were chi-square tests (for categorical variables) and one-way analysis of variance (for continuous variables) comparing MD-PhD program enrollees with other MD program enrollees.

[b] Tests of significance were chi-square tests (for categorical variables) and one-way analysis of variance (for continuous variables) comparing MD-PhD program enrollees with non-medical school matriculants.

Table 3

Multivariate Logistic Regression Models Comparing MD-PhD Program Enrollees (n = 2,575) to Other MD Program Enrollees (n = 80,856) and to Non-Medical School Matriculants (n = 124,005), Adjusting for All Variables in Each Model

Variable	MD-PhD program enrollees vs. other MD program enrollees aOR (95% CI)	*P* value	MD-PhD program enrollees vs. non-medical school matriculants aOR (95% CI)	*P* value
Gender				
Men	1.00 (ref)		1.00 (ref)	
Women	0.93 (0.85–1.01)	.095	1.08 (0.98–1.19)	.144
Race/ethnicity				
White	1.00 (ref)		1.00 (ref)	
Black	1.45 (1.19–1.78)	< .001	5.63 (4.24–6.77)	< .001
Hispanic	0.99 (0.81–1.20)	.899	2.12 (1.71–2.64)	< .001
Asian/Pacific Islander	0.87 (0.78–0.97)	.014	0.85 (0.75–0.97)	.012
Native American/Alaska Native	0.43 (0.10–1.81)	.251	1.16 (0.26–5.20)	.849
Other/multiple races/no response	1.26 (1.01–1.58)	.044	0.67 (0.53–0.84)	.001
High school summer laboratory research apprenticeship				
No	1.00 (ref)		1.00 (ref)	
Yes	1.31 (1.18–1.46)	< .001	1.42 (1.25–1.61)	< .001
College laboratory research apprenticeship				
No	1.00 (ref)		1.00 (ref)	
Yes	2.27 (2.06–2.51)	< .001	3.02 (2.72–3.36)	< .001
Most interesting areas of medicine:				
Biomedical research	1.00 (ref)		1.00 (ref)	
Public health aspects of disease	0.21 (0.18–0.25)	< .001	0.36 (0.29–0.43)	< .001
Patient management	0.14 (0.13–0.16)	< .001	0.29 (0.26–0.33)	< .001
Importance of factors in decision to study medicine				
Research/finding cures[a]	2.46 (2.28–2.65)	< .001	2.28 (2.11–2.48)	< .001
Status[b]	0.65 (0.61–0.70)	< .001	0.75 (0.70–0.81)	< .001
Altruism[c]	0.66 (0.61–0.72)	< .001	0.98 (0.88–1.08)	.629

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Variable	MD-PhD program enrollees vs. other MD program enrollees aOR (95% CI)	*P* value	MD-PhD program enrollees vs. non-medical school matriculants aOR (95% CI)	*P* value
MCAT scores, quintiles				
< 19	0.06 (0.03–0.12)	< .001	0.00 (0.00 0.00)	< .001
19–23	0.13 (0.10–0.17)	< .001	0.01 (0.00–0.01)	< .001
24–26	0.23 (0.19–0.28)	< .001	0.03 (0.03–0.04)	< .001
27–30	0.41 (0.37–0.46)	< .001	0.15 (0.13–0.16)	< .001
≥ 31	1.00 (ref)		1.00 (ref)	
College Carnegie Classification				
Not specified	1.12 (0.89–1.40)	.329	0.07 (0.06–0.08)	< .001
Other institutions	0.85 (0.56–1.28)	.436	0.66 (0.42–1.02)	.063
BA/BS colleges	1.18 (1.03–1.36)	.015	1.29 (1.10–1.50)	.001
Master's colleges and universities	0.99 (0.84–1.17)	.890	0.78 (0.65–0.94)	.008
Research universities with high research activity or doctoral/research universities	0.97 (0.84–1.12)	.702	0.96 (0.82–1.12)	.581
Research universities with very high research activity	1.00 (ref)		1.00 (ref)	

Note: aOR indicates adjusted odds ratio; CI, confidence interval; MCAT, Medical College Admission Test; BA/BS, baccalaureate arts and sciences. The Hosmer-Lemeshow goodness-of-fit test indicated that each model fit the data (each *P* > .05).

[a] aOR > 1.00 indicates greater likelihood of MD-PhD program enrollment with each increasing unit (1) of importance attributed to research/finding cures in one's decision to study medicine.

[b] aOR < 1.00 indicates lower likelihood of MD-PhD program enrollment with each increasing unit (1) of importance attributed to status in one's decision to study medicine.

[c] aOR < 1.00 indicates lower likelihood of MD-PhD program enrollment with each increasing unit (1) of importance attributed to altruism in one's decision to study medicine.

Table 4

Characteristics of MD-PhD Program Enrollees, Grouped by Their Medical School's Medical Scientist Training Program (MSTP)-funding Status

Variable	Total[a] No. (% of 2,574)	MSTP-funded No. (% of 1,998)	Non-MSTP funded No. (% of 576)	*P* value[b]
Gender				.012
Men	1,537 (59.7)	1,219 (61.0)	318 (55.2)	
Women	1,037 (40.3)	779 (39.0)	258 (44.8)	
Race/ethnicity				.103
White	1,642 (63.8)	1,258 (63.0)	384 (66.7)	
Black	137 (5.3)	109 (5.5)	28 (4.9)	
Hispanic	141 (5.5)	120 (6.0)	21 (3.6)	
Asian/Pacific Islander	545 (21.2)	419 (21.0)	126 (21.9)	
Native American/Alaska Native	2 (0.1)	2 (0.1)	0 (0.0)	
Other/multiple races/no response	107 (4.2)	90 (4.5)	17 (3.0)	
High school summer laboratory research apprenticeship				< .001
No	1,982 (77.0)	1,507 (75.4)	475 (82.5)	
Yes	592 (23.0)	491 (24.6)	101 (17.5)	
College laboratory research apprenticeship				< .001
No	631 (24.5)	454 (22.7)	177 (30.7)	
Yes	1,943 (75.5)	1,544 (77.3)	399 (69.3)	
Most interesting area of medicine				< .001
Public health aspects of disease	168 (6.5)	122 (6.1)	46 (8.0)	
Patient management	888 (34.5)	616 (30.8)	272 (47.2)	
Biomedical research	1,518 (59.0)	1,260 (63.1)	258 (44.8)	
MCAT scores, quintiles				< .001
< 19	8 (0.3)	3 (0.2)	5 (0.9)	
19–23	56 (2.2)	30 (1.5)	26 (4.5)	
24–26	139 (5.4)	67 (3.4)	72 (12.5)	
27–30	509 (19.8)	299 (15.0)	210 (36.5)	
≥ 31	1,862 (72.3)	1,599 (80.0)	263 (45.7)	

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Variable	Total[a] No. (% of 2,574)	MSTP-funded No. (% of 1,998)	Non-MSTP funded No. (% of 576)	*P* value[b]
College Carnegie Classification				< .001
Not specified	103 (4.0)	76 (3.8)	27 (4.7)	
Other institutions	27 (1.0)	9 (0.5)	18 (3.1)	
BA/BS colleges	331 12.9)	256 12.8)	75 (13.0)	
Master's colleges and universities	188 (7.3)	110 (5.5)	78 (13.5)	
Research universities with high research activity or doctoral/research universities	274 (10.6)	182 (9.1)	92 (16.0)	
Research universities with very high research activity	1,651 (64.1)	1,365 (68.3)	286 (49.7)	

Abbreviations: MCAT indicates Medical College Admission Test; BA/BS, baccalaureate arts and sciences.

[a]Institutional MSTP-funding data were missing for one person.

[b]Tests of significance were chi-square tests comparing MD-PhD program enrollees in MSTP-funded and non-MSTP-funded programs.