MD–PhD Program Graduates' Engagement in Research: Results of a National Study

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Abstract

Purpose
To determine if specialty, among other professional development and demographic variables, predicted MD–PhD program graduates' research engagement.

Method
The authors merged the 2015 Association of American Medical Colleges (AAMC) National MD–PhD Program Outcomes Survey database with selected data from the AAMC Student Records System, Graduation Questionnaire, and Graduate Medical Education (GME) Track Resident Survey. At the person level, they tested variables of interest for independent associations with MD–PhD graduates' research engagement using chi-square, Pearson correlations, and analysis of variance tests and logistic and linear regressions.

Results
Of 3,297 MD–PhD graduates from 1991–2010 who were no longer in GME training in 2015, 78.0% (2,572/3,297) reported research engagement. In models controlling for several variables, a neurology (vs internal medicine; adjusted odds ratio [AOR]: 2.48; 95% confidence interval [CI]: 1.60–3.86) or pathology (vs internal medicine; AOR: 1.89; 95% CI: 1.33–2.68) specialty, full-time faculty/research scientist career intention at graduation (vs all other career intentions; AOR: 3.04; 95% CI: 2.16–4.28), and ≥ 1 year of GME research (vs no GME research year[s]; AOR: 2.45; 95% CI: 1.96–3.06) predicted a greater likelihood of research engagement. Among graduates engaged in research, the mean percentage of research time was 49.9% (standard deviation 30.1%). Participation in ≥ 1 year of GME research (beta [β] coefficient: 7.99, $P < .001$) predicted a higher percentage of research time, whereas a radiation oncology (β: −28.70), diagnostic radiology (β: −32.92), or surgery (β: −29.61) specialty, among others, predicted a lower percentage of research time (each $P < .001$ vs internal medicine).

Conclusions
Most MD–PhD graduates were engaged in research, but the extent of their engagement varied substantially among specialties. Across specialties, participation in research during GME may be one factor that sustains MD–PhD graduates' subsequent early- to midcareer research engagement.

At its inception in 1964, the National Institutes of Health (NIH) National Institute of General Medical Sciences (NIGMS) Medical Scientist Training Program (MSTP) provided support for 4 MD–PhD joint-degree programs.[1] In 1998, 32 programs had MSTP support, and the NIGMS released a national outcomes study of MD–PhD joint-degree program graduates (hereafter referred to as MD–PhD graduates), both MSTP and non-MSTP supported, who completed their dual-degree programs through 1990.[1] In 1995, most were working in academic settings and involved in research; outcomes were not examined by specialty, sex, or race/ethnicity.[1]

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Acad Med. 2021;96:540–548.
First published online May 19, 2020
doi: 10.1097/ACM.0000000000003516

In the 2019–2020 academic year, there were 95 U.S. Liaison Committee on Medical Education (LCME)-accredited medical schools offering MD–PhD programs with at least one matriculant.[2] Annual numbers of MD–PhD graduates, and their gender and racial/ethnic diversity, have increased substantially since 1990,[3–5] and more recent MD–PhD graduates have pursued a broad range of specialties.[6–8] In this study, we examined the career paths of MD–PhD graduates who graduated in 1991–2010 to determine if there were differences by specialty, gender, and race/ethnicity in research engagement that could inform both MD–PhD program directors' efforts to support trainees aspiring to research careers in various specialties and residency program directors' and department chairs' efforts to optimize graduate medical education (GME) and career development support for an increasingly diverse MD–PhD workforce across all specialties.

Method

We examined the following variables as potential predictors of research engagement, based on the literature[6–13]: items from the Association of American Medical Colleges (AAMC) Student Records System (SRS),[14] Graduation Questionnaire (GQ),[15] GME Track Resident Survey,[16,17] and National MD–PhD Program Outcomes Survey database,[18] and items from the LCME Part I-A Annual Financial Questionnaire (administered by the AAMC on behalf of the LCME). We focused our study on MD–PhD graduates who graduated in 1991 (the NIGMS study included graduates through 1990[1]) through 2010 (to allow enough time for graduates to have advanced through their GME training by the time they were surveyed in 2015, described below).

Student Records System

Based on SRS data for MD–PhD graduates in 1991–2010 included in the National MD–PhD Program Outcomes Survey database, we created a dichotomous variable for sex ("men" and "women") and a 4-category variable for graduation (calendar) year period ("1991–1995," "1996–2000," "2001–2005," and "2006–2010"). To compare our sample with all MD–PhD graduates nationally, we used SRS data on the sex and race/ethnicity of all U.S. MD–PhD graduates in 1991–2010 and created a dichotomous variable for sex and a 4-category race/ethnicity variable (described below).

Graduation Questionnaire

Based on GQ total education debt responses, we created a 5-category debt variable (adjusted for inflation): "none," "$1–$24,999," "$25,000–$79,999," "≥ $80,000," and "missing" (for missing GQ responses). Based on GQ career intention responses, we created a 3-category career intention variable: "research-related career setting" (including "basic science teaching/research," "clinical teaching/research," and "other: nonuniversity research scientist"), "clinical practice/other/undecided" (including all clinical practice choices and "other: state or federal agency," "other: medical/health care administration, without practice," "other," and "other: undecided"), and "missing" (missing GQ responses).

GME Track Resident Survey

Included in the AAMC's GME Track Resident Survey are national GME census data for Accreditation Council for Graduate Medical Education-accredited training programs (residency and fellowship) and trainees; program directors voluntarily submit these data annually.[16,17] Before 2000, the AAMC and the American Medical Association administered separate GME surveys; since 2000, they have jointly administered the National GME Census using the AAMC's GME Track Resident Survey.[16] We used program directors' responses to the item "The resident is doing a year of research while in the program" to create a 3-category variable for participation in ≥ 1 year(s) of research during GME ("≥ 1 year of GME research," including "yes" [GME record with at least one "yes" response for this item], "no" [GME record without at least one "yes" response for this item], and "missing" [no GME record]).

National MD–PhD Program Outcomes Survey database

The National MD–PhD Program Outcomes Survey database has been described in detail.[18,19] Based on race/ethnicity data in this database, we created a 4-category race/ethnicity variable: "white," "Asian," "underrepresented in medicine" (URM, including black or African American; Hispanic, Latino, or of Spanish origin; Pacific Islander or American Indian/Alaska Native; and regardless of whether they also selected another non-URM race/ethnicity), and "other/unknown" (including non-U.S. citizens and non-URM multiple races/ethnicities).

The Outcomes Survey was administered in 2015 to MD–PhD graduates who graduated before 2015 from 80 participating U.S. MD–PhD programs[18]; the survey instrument has been published.[18] We used responses to the employment status item to select and include in our study only those respondents employed full-time at survey completion. Based on responses to the postgraduate training specialty item (asked only of those respondents who indicated they were not currently in postgraduate training), we created a 13-category specialty variable: "internal medicine," "anesthesiology," "dermatology," "neurology" (including neurology and pediatric neurology), "ophthalmology," "pathology," "pediatrics," "psychiatry," "diagnostic radiology," "radiation oncology," "surgery" (including all surgical specialties and subspecialties), "all other specialties" (specialties with smaller numbers that precluded separate categories, including emergency medicine, family medicine, obstetrics and gynecology, and preventive medicine, among others), and "no designated specialty" (including "no postgraduate training" responses). Write-in responses for "combined specialties" and "other" that aligned with the specialty categories above were assigned to those categories; responses not aligned were assigned to the "all other specialties" category.

Based on responses to the item "Which of the following best describes your current position?," we created a 5-category current employment setting variable: "academia-fulltime," "academia-parttime," "NIH/research institute/pharmaceutical and biotech industry," "nonacademic clinical," and "other/unknown" (including all other responses to this item and missing).

Respondents not in postgraduate training were eligible to answer an item about the percentage of their current total professional time (100%) spent engaged in research. Based on responses to this item, we created a dichotomous research engagement variable ("engaged in research" included all responses greater than 0%, "not engaged in research" included all responses of 0%).

LCME Part I-A Annual Financial Questionnaire

Based on each medical school's direct federal grants and contracts expenditures for organized research in fiscal year 2000 (as a midpoint between 1991 and 2010), as reported by all 125 U.S. LCME-accredited medical schools in 2000 on the LCME Part I-A Annual Financial Questionnaire, we assigned a "federal research expenditures" (FREs) rank (1 = lowest reported FREs to 125 = highest reported FREs) to each graduate's medical school.

Data analysis

Using a person-level AAMC research identifier (unique to each individual), all data from the aforementioned datasets were merged to create a database of linked, deidentified data for analysis (i.e., deidentified, person-level data, with a single record of data for each graduate). We used chi-square, Pearson correlations, and analysis of variance tests to examine the significance of bivariate associations. We used a logistic regression to identify independent predictors of research engagement among all graduates and a linear regression to identify independent predictors of percentage of research time among graduates engaged in research. Two-sided P values < .05 were considered significant. All analyses were performed using Stata 15 (StataCorp, College Station, Texas). The Human Subjects Protection Program staff at the AAMC reviewed this study and determined that it was exempt from further institutional review board review because it did not involve human subjects.

Results

Of all 10,591 MD–PhD graduates in the Outcomes Survey database, 6,588 graduated in 1991–2010, including 5,530 with valid email addresses who could respond to a survey. Of those 5,530 graduates who were invited to complete the Outcomes Survey in 2015, 4,122 (74.5%) did so. Overall, response rates differed by race/ethnicity (number of respondents/number of graduates invited to complete the survey [%]): white: 2,861/3,713 (77.1%); Asian: 797/1,171 (68.1%); URM: 308/433 (71.1%); and other/unknown: 156/213 (73.2%) ($P < .001$). They did not vary by sex ($P = .108$; data not shown).

The mean FREs rank for the medical schools of the 5,530 graduates invited to complete the Outcomes Survey was 98.9 (standard deviation [SD] 23.3). The FREs rank was slightly higher for the medical schools of the 4,122 respondents than for the schools of the 1,408 nonrespondents (100 [22.5] vs 96.7 [25.5], respectively; $P < .001$).

Of the 4,122 respondents, we excluded 666 who were "currently in postgraduate training" and 4 who were missing current postgraduate training status. Among the remaining 3,452 respondents, we excluded 141 who were not employed full-time and 14 who were missing research engagement data. Our final sample of 3,297 MD–PhD graduates (80.0% of all 4,122 survey respondents who graduated in 1991–2010) included 42.8% of all 7,699 U.S. MD–PhD graduates in 1991–2010.

As shown in Table 1, compared with their representation among all U.S. MD–PhD graduates, men and white graduates were somewhat overrepresented in our sample. Men comprised 72.1% (5,551/7,699) of U.S. MD–PhD graduates and 73.9% (2,438/3,297) of MD–PhD graduates in our sample; white graduates comprised 67.3% (5,179/7,699) of U.S. MD–PhD graduates and 70.7% (2,330/3,297) of MD–PhD graduates in our sample. The exclusion from our sample of those graduates still in training (or those missing data about current training status), those not employed full-time, and those missing research engagement data, who were otherwise eligible for inclusion based on Outcomes Survey data availability, contributed to the overrepresentation of men and of white graduates in our sample compared with their representation among all U.S. MD–PhD graduates.

Descriptive statistics for our sample are shown in Table 2, grouped by research engagement status. As shown, 78.0% (2,572/3,297) of MD–PhD graduates reported engagement in research. This percentage varied by sex, career intention, ≥ 1 year of GME research, specialty, graduation year, and current employment setting but not by race/ethnicity or debt at graduation. Also, this percentage varied by medical school FREs rank (data not shown). The overall mean (SD) rank of the medical schools of all 3,297 included graduates was 100.0 (22.3); the mean (SD) rank of the medical schools of the 2,572 graduates engaged in research was somewhat higher than that of the medical schools of the 725 graduates not engaged in research (101.1 [21.8] vs 96.2 [24.0], respectively; $P = .001$). Of the 2,572 graduates engaged in research, about 1 in 6 (437; 17.0%) was employed in a nonacademic setting (see Table 2).

Table 3 shows the results of a multivariable logistic regression model identifying the variables independently associated with research engagement. Graduates who reported full-time faculty/research scientist career intentions at graduation, who reported ≥ 1 year of GME research, who reported a neurology or pathology specialty (each vs internal medicine), or who attended higher FREs-ranked medical schools were more likely to be engaged in research; graduates who were women or in dermatology were less likely to be engaged in research. Race/ethnicity, debt at graduation, all other specialties (each vs internal medicine), and graduation year were not independently associated with research (vs no research) engagement.

Table 4 shows the mean (SD) percentage of time in research, by each variable of interest, for the 2,572 graduates engaged in research. Overall, the mean percentage of research time was 49.9%. This percentage was higher among men (50.9%); graduates of Asian (52.7%) and other/unknown (55.8%) race/ethnicity; those with no debt at graduation (50.3%) or missing debt data (52.4%); those who participated in ≥ 1 year of GME research (55.7%) or had no GME records (71.8%); those in internal medicine (60.7%), neurology (55.1%), pediatrics (57.5%), psychiatry (56.4%), or no designated specialty (63.1%); those who graduated in 2001–2005 (50.5%) or in 2006–2010 (53.4%); and those in academia-fulltime (51.0%) or nonacademic, research-related employment settings (74.3%). Also, percentage of time in research correlated with medical school FREs rank (Pearson correlation coefficient = .10; $P < .001$; data not shown in Table 4).

Table 5 shows the results of a multivariable linear regression model identifying the independent predictors of percentage of research time among the 2,572 graduates engaged in research. Asian race/ethnicity (beta [β] coefficient: 2.92), full-time faculty/research scientist career intention (β: 7.67), ≥ 1 year of GME research (β: 7.99), no GME record (β: 22.79), and higher medical

Table 1

Comparison of MD–PhD Joint-Degree Program Graduates in the Study Sample With All U.S. MD–PhD Graduates, 1991–2010

Characteristic	All U.S. MD–PhD graduates[a]	MD–PhD graduates in the Outcomes Survey database[a]	MD–PhD graduates who responded to the 2015 Outcomes Survey[a]	MD–PhD graduates in study sample[a]	P value[b]
Total no.	7,699	6,588	4,122	3,297	
Sex, no. (%)					< .002
Men	5,551 (72.1)	4,735 (71.9)	2,938 (71.3)	2,438 (73.9)	
Women	2,148 (27.9)	1,853 (28.1)	1,184 (28.7)	859 (26.1)	
Race/ethnicity, no. (%)					< .001
White	5,179 (67.3)	4,459 (67.7)	2,861 (69.4)	2,330 (70.7)	
URM	601 (7.8)	514 (7.8)	308 (7.5)	224 (6.8)	
Asian	1,597 (20.7)	1,375 (20.9)	797 (19.3)	637 (19.3)	
Other/unknown	322 (4.2)	240 (3.6)	156 (3.8)	106 (3.2)	

Abbreviation: URM, racial/ethnic groups underrepresented in medicine.
[a]Column numbers add up to the total within each variable category.
[b]Comparison of MD–PhD graduates in the study sample vs all U.S. MD–PhD graduates.

Table 2

Characteristics of the Study Sample, Grouped by Research Engagement Status, in a Study of MD–PhD Joint-Degree Program Graduates, 1991–2010

Characteristic	Total no. (N = 3,297)[a]	%[b]	No. engaged in research (n = 2,572)[a]	%[b]	No. not engaged in research (n = 725)[a]	%[b]	*P* value
Sex							.003
Men	2,438	73.9	1,933	79.3	505	20.7	
Women	859	26.1	639	74.4	220	25.6	
Race/ethnicity							.254
White	2,330	70.7	1,831	78.6	499	21.4	
URM	224	6.8	163	72.8	61	27.2	
Asian	637	19.3	496	77.9	141	22.1	
Other/unknown	106	3.2	82	77.4	24	22.6	
Debt at graduation							.561
None	883	26.8	692	78.4	191	21.6	
$1 to $24,999	554	16.8	428	77.3	126	22.7	
$25,000 to $79,999	574	17.4	451	78.6	123	21.4	
≥ $80,000	242	7.3	179	74.0	63	26.0	
Missing	1,044	31.7	822	78.7	222	21.3	
Career intention at graduation							< .001
Clinical practice/other/undecided	166	5.0	87	52.4	79	47.6	
Full-time faculty/research scientist	2,164	65.6	1,721	79.5	443	20.5	
Missing	967	29.3	764	79.0	203	21.0	
≥ 1 year of GME research							< .001
No	2,079	63.1	1,514	72.8	565	27.2	
Yes	1,068	32.4	930	87.1	138	12.9	
Missing	150	4.5	128	85.3	22	14.7	
Specialty							< .001
Internal medicine	741	22.5	605	81.6	136	18.4	
Anesthesiology	89	2.7	58	65.2	31	34.8	
Dermatology	133	4.0	72	54.1	61	45.9	
Neurology	247	7.5	217	87.9	30	12.1	
Ophthalmology	121	3.7	85	70.2	36	29.8	
Pathology	402	12.2	343	85.3	59	14.7	
Pediatrics	344	10.4	279	81.1	65	18.9	
Psychiatry	168	5.1	116	69.0	52	31.0	
Diagnostic radiology	149	4.5	105	70.5	44	29.5	
Radiation oncology	129	3.9	104	80.6	25	19.4	
Surgery	246	7.5	191	77.6	55	22.4	
Other	313	9.5	223	71.2	90	28.8	
No designated specialty	215	6.5	174	80.9	41	19.1	
Graduation year							.012
1991–1995	577	17.5	466	80.8	111	19.2	
1996–2000	813	24.7	636	78.2	177	21.8	
2001–2005	1,062	32.2	843	79.4	219	20.6	
2006–2010	845	25.6	627	74.2	218	25.8	
Current employment setting							< .001
Academia-fulltime	2,257	68.5	2,087	92.5	170	7.5	
Academia-parttime	67	2.0	48	71.6	19	28.4	
NIH/other research institutes/ pharmaceutical and biotech industry	266	8.1	226	85.0	40	15.0	
Nonacademic clinical	500	15.2	106	21.2	394	78.8	
Other/unknown[c]	207	6.3	105	50.7	102	49.3	

Abbreviations: URM, racial/ethnic groups underrepresented in medicine; GME, graduate medical education; NIH, National Institutes of Health.

[a]Column numbers add up to the total within each variable category.

[b]Column percentages add up to 100% within each row.

[c]Includes 2 respondents with missing data for current employment setting.

Table 3

Results of a Logistic Regression to Identify Predictors of Research Engagement (vs No Research Engagement Reference Group) in a Study of MD–PhD Joint-Degree Program Graduates, 1991–2010

Characteristic	AOR	*P* value	95% CI Lower	95% CI Upper
Sex				
Men	Reference			
Women	0.80	.021	0.66	0.97
Race/ethnicity				
White	Reference			
URM	0.75	.083	0.54	1.04
Asian	0.91	.404	0.72	1.14
Other/unknown	0.91	.696	0.56	1.48
Debt at graduation				
None	Reference			
$1 to $24,999	0.92	.570	0.71	1.21
$25,000 to $79,999	1.08	.557	0.83	1.42
≥ $80,000	0.97	.887	0.68	1.39
Missing	0.93	.779	0.55	1.57
Career intention at graduation				
Clinical practice/other/undecided	Reference			
Full-time faculty/research scientist	3.04	< .001	2.16	4.28
Missing	3.14	< .001	1.73	5.69
≥ 1 year of GME research				
No	Reference			
Yes	2.45	< .001	1.96	3.06
Missing	2.10	.013	1.17	3.79
Specialty				
Internal medicine	Reference			
Anesthesiology	0.63	.071	0.39	1.04
Dermatology	0.34	< .001	0.23	0.52
Neurology	2.48	< .001	1.60	3.86
Ophthalmology	0.81	.366	0.52	1.28
Pathology	1.89	< .001	1.33	2.68
Pediatrics	1.05	.781	0.75	1.48
Psychiatry	0.72	.104	0.49	1.07
Diagnostic radiology	0.75	.177	0.49	1.14
Radiation oncology	0.96	.881	0.59	1.57
Surgery	0.94	.762	0.65	1.37
Other	0.79	.152	0.57	1.09
No designated specialty	0.96	.852	0.59	1.55
Graduation year				
2006–2010	Reference			
1991–1995	1.06	.663	0.81	1.41
1996–2000	1.05	.685	0.82	1.34
2001–2005	1.22	.087	0.97	1.53
Medical school FREs rank, per unit increase	1.007	< .001	1.004	1.011

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; URM, racial/ethnic groups underrepresented in medicine; GME, graduate medical education; FREs, federal research expenditures.

school FREs rank (β: 0.18 per unit) each predicted a higher percentage of research time, whereas women (β: −4.70); anesthesiology (β: −20.23), dermatology (β: −15.30), ophthalmology (β: −14.27), pathology (β: −14.80), diagnostic radiology (β: −32.92), radiation oncology (β: −28.70), surgery (β: −29.61), “other specialties” (β: −10.89), and “no designated specialty” (β: −6.65), each vs internal medicine; and graduation before 2006 (β: −3.51 to −11.90) each predicted a lower percentage of research time. URM and other/unknown race/ethnicity; debt at graduation; and a neurology, pediatrics, or psychiatry specialty were not independently associated with percentage of research time.

Discussion

Physician–scientists play an important role in advancing medicine.[12] Despite numerous calls to action,[20–22] in 2014, an NIH working group forecast a decline in the number of physician–scientists.[12] Participation in MD–PhD joint-degree training programs, which combine medical training, graduate school, and research training, is one pathway for those interested in becoming physician–scientists. Our findings regarding MD–PhD program graduates’ careers in association with their specialty can inform both specialty-specific and cross-specialty efforts to support the continued development of these physician–scientists as contributors to the biomedical research enterprise.

Most MD–PhD graduates in our study reported at least some research engagement, but we observed differences in association with several variables. Our findings were most notable for specialty. We observed independent, negative associations between specialty and percentage of research time of the greatest magnitude for anesthesiology, diagnostic radiology, radiation oncology, and surgery. These are all specialties that are not among those (i.e., internal medicine, pediatrics, neurology, and pathology) that have historically provided substantial protected time for research.[6]

The wide range of MD–PhD graduates’ specialties likely partly reflects residency program directors’ priorities in trainee selection. In 2018, MD–PhD graduates comprised about 3% of all U.S. medical school graduates[5,23] and U.S. medical

Table 4

Percentage of Research Time (of 100% of Total Professional Activities Time) Among MD–PhD Graduates Engaged in Research in a Study of MD–PhD Joint-Degree Program Graduates, 1991–2010

Characteristic	Total no.[a]	% research time, M (SD)	*P* value
Total	2,572	49.9 (30.1)	
Sex			.007
Men	1,933	50.9 (29.9)	
Women	639	47.1 (30.7)	
Race/ethnicity			.025
White	1,831	49.1 (30.3)	
URM	163	47.7 (29.2)	
Asian	496	52.7 (29.7)	
Other/unknown	82	55.8 (30.4)	
Debt at graduation			.003
None	692	50.3 (30.6)	
$1 to $24,999	428	49.7 (30.1)	
$25,000 to $79,999	451	47.5 (30.3)	
≥ $80,000	179	43.9 (29.0)	
Missing	822	52.4 (29.7)	
Career intention at graduation			< .001
Clinical practice/other/undecided	87	37.0 (30.1)	
Full-time faculty/research scientist	1,721	49.5 (30.2)	
Missing	764	52.5 (29.7)	
≥ 1 year of GME research			< .001
No	1,514	44.6 (30.0)	
Yes	930	55.7 (28.9)	
Missing	128	71.8 (22.3)	
Specialty			< .001
Internal medicine	605	60.7 (28.7)	
Anesthesiology	58	37.2 (28.7)	
Dermatology	72	45.7 (31.9)	
Neurology	217	55.1 (27.2)	
Ophthalmology	85	44.6 (29.2)	
Pathology	343	42.6 (29.7)	
Pediatrics	279	57.5 (28.6)	
Psychiatry	116	56.4 (29.7)	
Diagnostic radiology	105	25.7 (20.8)	
Radiation oncology	104	33.8 (26.6)	
Surgery	191	29.3 (22.1)	
Other	223	47.1 (29.6)	
No designated specialty	174	63.1 (26.6)	
Graduation year			< .001
1991–1995	466	45.9 (30.1)	
1996–2000	636	48.8 (29.8)	
2001–2005	843	50.5 (30.2)	
2006–2010	627	53.4 (30.0)	
Current employment setting			< .001
Academia-fulltime	2,087	51.0 (28.0)	
Academia-parttime	48	19.6 (19.3)	
NIH/other research institutes/ pharmaceutical and biotech industry	226	74.3 (27.5)	
Nonacademic clinical	106	8.0 (8.7)	
Other/unknown[b]	105	32.0 (31.3)	

Abbreviations: M, mean; SD, standard deviation; URM, racial/ethnic groups underrepresented in medicine; GME, graduate medical education; NIH, National Institutes of Health.
[a]Column numbers add up to the total within each variable category.
[b]Includes 2 respondents with missing data for current employment setting.

school seniors graduating with a PhD degree (a group that may include some who obtained PhD degrees through pathways other than MD–PhD joint-degree programs) comprised about 4% of all U.S. senior applicants who matched to their chosen specialties.[24] However, this percentage varied considerably by specialty. For example, among U.S. seniors who matched to radiation oncology, 21% had PhD degrees,[24] which aligns with the selection factors that radiation oncology program directors have reported they prioritize.[25] According to the National Resident Matching Program 2018 Program Director Survey,[25] only 41% of all program directors considered "demonstrated involvement/ interest in research" in selecting applicants to invite for interviews, rating this factor a 3.7 in importance (on a 1–5 scale of not important to very important); however, 96% of radiation oncology program directors considered this factor, rating it a 4.4 in importance.[25]

Specialty-specific efforts to support physician–scientists' development as researchers beyond medical school are already underway. According to a 2016 American Board of Medical Specialties (ABMS) report, 6 ABMS-member boards provided research pathways for trainees, including the American Boards of Anesthesiology, Internal Medicine (ABIM), Pathology, Pediatrics, Physical Medicine and Rehabilitation, and Radiology; the American Board of Allergy and Immunology reportedly had such a pathway in development.[13] Recently, the American Board of Dermatology approved a research track,[26] and the American Board of Family Medicine approved a pilot physician–scientist pathway.[27] A recent study of ABIM research pathway outcomes reported that 91% (352/385) of respondents to a 2012 survey to pathway completers through 2007 were engaged in research at least to some degree, and 65% (240/371) held a PhD (or other doctoral-level equivalent) degree before pathway entry, which was associated with higher research engagement at follow-up.[11] We did not have ABMS-member boards' research pathway participation information to include in our study, but our findings and those of others[11] support a role for GME models to promote the retention of physician–scientists in the research workforce in a broad range of specialties.[28,29] The recently created

Table 5

Predictors of Percentage of Research Time Among MD–PhD Graduates Engaged in Research in a Study of MD–PhD Joint-Degree Program Graduates, 1991–2010

Characteristic	Beta (β) coefficient	*P* value	95% CI Lower	95% CI Upper
Sex				
Men	Reference			
Women	−4.70	< .001	−7.13	−2.26
Race/ethnicity				
White	Reference			
URM	−2.45	.270	−6.81	1.91
Asian	2.92	.037	0.17	5.67
Other/unknown	3.94	.200	−2.09	9.97
Debt at graduation				
None	Reference			
\$1 to \$24,999	0.81	.630	−2.48	4.09
\$25,000 to \$79,999	0.49	.767	−2.76	3.73
≥ \$80,000	0.15	.948	−4.36	4.66
Missing	2.68	.417	−3.79	9.15
Career intention at graduation				
Clinical practice/other/undecided	Reference			
Full-time faculty/research scientist	7.67	.011	1.79	13.52
Missing	5.78	.180	−2.68	14.24
≥ 1 year of GME research				
No	Reference			
Yes	7.99	< .001	5.53	10.44
Missing	22.79	< .001	16.37	29.20
Specialty				
Internal medicine	Reference			
Anesthesiology	−20.23	< .001	−27.62	−12.84
Dermatology	−15.30	< .001	−21.94	−8.65
Neurology	−1.03	.647	−5.45	3.38
Ophthalmology	−14.27	< .001	−20.61	−7.94
Pathology	−14.80	< .001	−18.51	−11.09
Pediatrics	−1.96	.317	−5.80	1.88
Psychiatry	−1.47	.598	−6.96	4.01
Diagnostic radiology	−32.92	< .001	−38.63	−27.22
Radiation oncology	−28.70	< .001	−34.36	−23.05
Surgery	−29.61	< .001	−34.08	−25.14
Other	−10.89	< .001	−15.13	−6.66
No designated specialty	−6.65	.026	−12.50	−0.79
Graduation year				
2006–2010	Reference			
1991–1995	−11.90	< .001	−15.25	−8.55
1996–2000	−6.84	< .001	−9.91	−3.78
2001–2005	−3.51	< .001	−6.33	−0.70
Medical school FREs rank, per unit increase	0.18	< .001	0.13	0.23

Abbreviations: CI, confidence interval; URM, racial/ethnic groups underrepresented in medicine; GME, graduate medical education; FREs, federal research expenditures.

NIH Stimulating Access to Research in Residency (StARR) program is designed to expand opportunities, beyond those provided in ABMS-member board research pathways, for residents to perform research during GME.[29]

In addition to specialty-specific strategies for growing and supporting the physician–scientist workforce, institution-level approaches during and after GME training are being explored. The AAMC has launched a project to identify key institutional components for creating a home for physician–scientist trainees, which may be a formal institutional program, network, or other community that supports the training and development of individuals pursuing physician–scientist careers (including physicians with and without additional advanced degrees) across specialties.[30]

Many MD–PhD programs seek to recruit and train a diverse physician–scientist workforce[12,31]; our findings regarding sex and race/ethnicity should inform these efforts. The differences we observed by sex and race/ethnicity were not large, particularly compared with the differences we observed by specialty. Our finding of an independent association between sex and research engagement and similar findings from a recent survey of Canadian MD–PhD graduates[10] align with other reports of sex differences in biomedical research career trajectories[32,33]; however, gender was not independently associated with ABIM Research Pathway outcomes.[11] Our race/ethnicity findings suggest that efforts by MD–PhD programs (including the 50 currently supported by MSTP grants[34]) and funding agencies to graduate a racially and ethnically diverse MD–PhD workforce should increase the diversity of the physician–scientist workforce engaged in research. Although URM race/ethnicity was not independently associated with research engagement in our study, URM graduates comprised only 6.8% of our sample and, in recent years, URM applicants have reportedly been underrepresented to a greater extent among MD–PhD program applicants than among MD program applicants.[9]

Our observation of an association between a medical school's FREs rank and the research engagement of its MD–PhD graduates was not unexpected. This finding likely reflects, at least to some extent, differences in overall institutional resources for students, levels of external MD–PhD program support,[34] and MD–PhD program goals, as well as differences in the characteristics of the MD–PhD program participants themselves (e.g., extent of research participation in high school and college).[35]

Debt has been cited as a factor that might deter physician–scientists from a research career.[10,12,28] Most graduates in our study reported some debt, but only a small proportion of graduates had a large amount, and debt was not independently associated with the research outcomes we examined. The relatively low debt levels we observed were consistent with the fully funded status of training positions at many U.S. MD–PhD programs, which cover tuition costs and stipends for trainees.[12,18] Also, many graduates with debt in our study may have participated in the NIH Loan Repayment Program, designed to counteract "financial pressure by repaying up to $35,000 annually of a researcher's qualified educational debt in return for a commitment to engage in NIH mission-relevant research."[36]

Our study has several strengths. We were able to disaggregate specialty data into numerous categories for analysis and to examine our outcomes of interest in relation to specialty in models that controlled for several other factors. We also were able to examine sex and race/ethnicity for their independent associations with our outcomes of interest.

Our study also has notable limitations. First, it was retrospective and observational, so we cannot infer causality. Next, the ≥ 1 year of GME research variable was based on annual GME survey data; availability of these data was generally lower for trainees who graduated before the introduction of the online AAMC GME Track Resident Survey in 2000. In addition, for the MD–PhD Program Outcomes Survey item about percentage of time spent in research, "research" and "clinical care at an academic medical center" were listed as 2 separate categories.[18] Bensken and colleagues recently noted that surveys of physician–scientists that ask respondents to report time spent in research and in clinical activities as separate items may underestimate physician–scientists' time spent and contributions made conducting research through clinical activities rather than through protected-time research.[37]

Finally, the optimal "balance" of research time with other professional activities for physician–scientists may differ by specialty, and no single outcome measure for physician–scientist career paths—such as percentage of time doing research, NIH research award receipt, or "research as a major professional activity"—alone can be equated with physician–scientist success.[6,12,37,38] Beyond their direct research involvement, many physician–scientists make important contributions to the biomedical research enterprise through teaching, mentoring, leadership, and a range of clinical activities. Thus, in the current academic and clinical research environment, physician–scientist contributions should be broadly considered.[37] For example, Finney and colleagues evaluated a comprehensive set of outcomes for federal career development awardees that included academic rank, grants, publications, journal editor positions, grant review committee memberships, and number of mentees.[39] Jagsi and colleagues developed a composite measure of success that considered subsequent grants received, publications, and leadership positions among a cohort of mentored K award recipients who they followed longitudinally.[40]

In conclusion, we found that, among more recent cohorts of MD–PhD graduates (i.e., those who graduated since the 1998 NIGMS report[1]), most were engaged in careers involving at least some time devoted to research in various academic and nonacademic settings across many different specialties. These findings may encourage students with a broad range of career interests and aspirations to apply to MD–PhD programs. Our findings also provide support for MD–PhD program efforts to identify physician–scientist mentors in a range of specialties and to engage trainees in substantive career planning during medical school. Finally, our results may be of interest to the many medical schools, federal agencies, and other organizations supporting MD–PhD programs nationally[34,41,42] and to leaders at institutions seeking to recruit, and optimally support, physician–scientists (both MD–PhD and MD graduates) in their continued development during and beyond GME in many different specialties.

Acknowledgments: The MD–PhD Program Outcomes Survey was developed and conducted in close collaboration with the directors and administrators of 80 U.S. MD–PhD programs, who identified their graduates and encouraged them to participate in the survey. Myles Akabas, MD, PhD, Albert Einstein College of Medicine, and Lawrence Brass, MD, PhD, University of Pennsylvania Perelman School of Medicine, collaborated closely with staff from the Association of American Medical Colleges (AAMC), including Lindsay Roskovensky, Marie Caulfield, PhD, and Irena Tartakovsky, MD, MS, on the MD–PhD Program Outcomes Survey project. Additional AAMC staff, including David Matthew, PhD, Andrew Nees, Diana Tung, and Jay Youngclaus, MA, assisted with data coding for the study reported here, and Charles Rhoads, JD, MA, MS, assisted with manuscript preparation.

Funding/Support: None reported.

Other disclosures: None reported.

Ethical approval: The Human Subjects Protection Program staff at the AAMC reviewed this study and determined it was exempt from further institutional review board review because it did not involve human subjects.

Data: This manuscript was reviewed before submission for publication by AAMC Data Operations and Services staff. The manuscript includes AAMC data and data from the Liaison Committee on Medical Education (LCME) Part I-A Annual Financial Questionnaire, used with the permission of Andrew Nees, the AAMC data steward for the LCME Part 1-A Annual Financial Questionnaire, who reviewed this manuscript.

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