

Effect of Two Howard Hughes Medical Institute Research Training Programs for Medical Students on the Likelihood of Pursuing Research Careers

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ABSTRACT

Purpose. To assess the effect of Howard Hughes Medical Institute's (HHMI) two one-year research training programs for medical students on the awardees' research careers.

Method. Awardees of the HHMI Cloister Program who graduated between 1987 and 1995 and awardees of the HHMI Medical Fellows Program who graduated between 1991 and 1995 were compared with unsuccessful applicants to the programs and MD-PhD students who graduated during the same periods. Logistic regression analyses were conducted to assess research career outcomes while controlling for academic and demographic variables that could affect selection to the programs.

Results. Participation in both HHMI programs increased the likelihood of receiving National Institutes of Health postdoctoral support. Participation in the Cloister Program also increased the likelihood of receiving a faculty appointment with research responsibility at a medical

school. In addition, awardees of the Medical Fellows Program were not significantly less likely than Medical Scientist Training Program (MSTP) and non-MSTP MD-PhD program participants to receive a National Institutes of Health postdoctoral award, and awardees of the Cloister Program were not significantly less likely than non-MSTP MD-PhD students to receive a faculty appointment with research responsibility. Women and underrepresented minority students were proportionally represented among awardees of the two HHMI programs whereas they were relatively underrepresented in MD-PhD programs.

Conclusions. The one-year intensive research training supported by the HHMI training programs appears to provide an effective imprinting experience on medical students' research careers and to be an attractive strategy for training physician-scientists.

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Clinical research is the link between advances in basic biomedical research

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For another research report on this topic, see page 1281.

and innovations in medical practice. Physician-scientists, trained in patient care and biomedical research, are crucial in developing and performing cutting-edge clinical research. Although the future of biomedical research has never been brighter, a shortage of physician scientists threatens the United States' ability to translate basic research into new therapeutic applications. Recognizing the significance of the problem, a variety of different models have been developed to train physicians for research. Currently, the National Institutes of Health (NIH)-funded Medical

Scientist Training Program (MSTP) supports the costs of research training and stipends for candidates for the combined MD-PhD degree at 39 U.S. medical schools. In addition, more than 60 U.S. medical schools offer MD-PhD programs with financial support from non-MSTP sources. A number of private foundations also provide training awards for medical students who are interested in research careers.

The Howard Hughes Medical Institute (HHMI), one of the largest non-profit medical research organization in the United States dedicated to basic

biomedical research and education, established the HHMI-NIH Research Scholars Program (Cloister Program) in 1985 and the Medical Fellows Program in 1989. Aimed at attracting medical students to careers in research, both programs provide support for one year of intensive research training. The Cloister Program provides awards to approximately 45 students each year, who, under the guidance of senior scientists, work in laboratories on the NIH campus in Bethesda, Maryland. The Medical Fellows Program supports approximately 60 students each year in their conduct of supervised research with mentors at individual medical schools or nonprofit research institutions across the United States. These numbers (45 and 60) are relatively modest, compared with nearly 600 MD-PhD students who commence MD-PhD training annually in the United States.¹

The HHMI has been interested in determining the career outcomes of awardees of the Cloister and Medical Fellows programs. Do these one-year research training programs provide a good experience for medical students that encourages their choice of a research career? The success of the HHMI programs would have important policy implications regarding strategies to increase the physician-scientist workforce. Under a contract agreement, the Association of American Medical Colleges (AAMC) has worked with the HHMI to track the career outcomes of its awardees. In this study, we assessed the effectiveness of the two HHMI training programs by addressing the following research questions:

1. Are awardees of the HHMI programs more likely than unsuccessful program applicants to pursue research careers?
2. Are differences in research career outcomes between awardees and nonawardees attributable to the effect of the HHMI programs, or are these differences merely a re-

sult of the selection of superior applicants to the programs?

3. In what ways do the research career outcomes of awardees of the HHMI programs differ from the outcomes of participants in MSTP-supported and non-MSTP-supported MD-PhD programs?
4. Are there differences in relative numbers of underrepresented minority students and female students in the HHMI programs compared with the MD-PhD programs and the annual pool of U.S. medical students?

Although the number of programs designed to train medical students for research careers has continued to expand, assessments of these programs have been limited. A few MSTP-supported MD-PhD programs have reported that their graduates were highly successful in securing academic or research positions.²⁻⁵ However, no comparison groups were included in these studies. A 1998 NIH study of MSTP-funded programs found that MSTP graduates were more likely than dropouts, or MD-PhD graduates from non-MSTP funded programs, to hold academic appointments, to receive research support, and to produce publications in peer-reviewed journals.⁶ However, this study did not control for certain factors that could affect selections to different programs. For example, because MSTP-funded graduates were often from research-intensive schools and non-MSTP-funded MD-PhD graduates tended to come from non-research-intensive schools, it would be difficult to assess the independent effects of MSTP programs on research career outcomes without controlling for the effects of research intensity of medical schools.

In brief, there are only limited studies in the literature assessing training programs aimed at educating medical students for research careers. Issues such as selection of comparison groups and selection bias may inhibit a better under-

standing of program effects in these studies. In addition, although we were able to identify a number of outcome studies focused on MD-PhD programs, we were unable to find any reports on the effectiveness of short-term research training programs for medical students.

METHOD

The first class of Cloister Program awardees graduated from U.S. medical schools in 1987, whereas the first class of Medical Fellows Program graduated in 1991. We selected the entire pool of 270 Cloister Program awardees who graduated between 1987 and 1995 as our sample of interest from this program. (To avoid a possible cohort effect, seven nonawardees of the Cloister Program who graduated before 1987 were not included because of their small numbers.) These graduates were compared, in terms of research career outcomes, with 597 unsuccessful applicants to the Cloister Program during this period, as well as with the 1,484 MD-PhD students from MSTP-funded programs and 674 MD-PhD students from non-MSTP institutions who graduated over the same period. We selected the entire pool of 214 awardees of the Medical Fellows Program who graduated between 1991 and 1995. (Six awardees and nonawardees of the Medical Fellows Program who graduated before 1991 were not included because of their small numbers.) Their research career outcomes were compared with the 150 unsuccessful applicants to the program, the 892 MD-PhD students from MSTP programs, and the 497 MD-PhD students from non-MSTP programs who graduated during the same period. Demographic data on the HHMI-funded cohorts from the Cloister and Medical Fellows programs were compared with data on all U.S. medical students who had graduated over the same periods to determine whether these programs were successfully reaching women and underrepresented minority medical students.

Records of MD-PhD students either were provided by NIH or were obtained from the AAMC 2000 MD-PhD Program Director Survey (91% of total 101 MD-PhD programs surveyed completed the survey.). MSTP students included all participants in MSTP-supported MD-PhD programs regardless of program completion* and source of support, whereas non-MSTP MD-PhD students were participants in non-MSTP-supported programs. Students' demographic and academic variables were obtained from the Medical College Admission Test (MCAT), AAMC Prematriculation Questionnaire, AAMC Matriculating Student Questionnaire, and American Medical College Application Service.

Because HHMI awardees have not reached the stage in their careers where their long-term research success can be validated, we were obliged to use outcome indicators such as receipt of NIH postdoctoral awards and faculty appointments with research responsibility at medical schools as early evidence of success in research career development. To test the utility of the first measure, we selected a cohort of U.S. medical students who graduated between 1981 and 1985 and divided them into two groups. The first group included those who received NIH postdoctoral awards between 1986 and 1990, and the second group included those who did not receive NIH postdoctoral awards in the same period. We found that 13% of the first group received an R01 award between 1991 and 2000, whereas only 1% of the second group received the award during the same period. This finding suggests a strong association between receipt of a NIH postdoctoral award at an earlier time and receipt of a R01 award at a later time. Our second out-

come measure, faculty appointments with research responsibility, was defined as having at least 10% of time in research in initial faculty employment. The NIH Trainee and Fellow File provides information on NIH postdoctoral training support and fellowships through 2000, whereas the AAMC Faculty Roster System, the official data system for tracking U.S. medical school faculty, provides information for approximately 90% of all full-time faculty members through 2001.

Regarding research career outcomes, awardees of the two HHMI training programs were compared with non-awardees and participants in the MD-PhD programs. Bivariate analyses were conducted to examine the percentage distribution of various demographic and academic variables across groups. Assessing the specific effects of the HHMI training programs on awardees' research careers requires adjustment for nonprogrammatic factors that could influence the outcomes. Logistic regression analyses were conducted to assess the relative probability of receiving NIH postdoctoral awards and medical school faculty appointments with research responsibility between HHMI awardees and non-awardees, and between HHMI awardees and MD-PhD students. The logistic regression analyses enabled us to control for important academic and demographic variables that could affect selection to the programs and/or career outcomes. These variables included gender, race, age at matriculation, parental education level (MD or PhD), MCAT scores, interest in research careers before/at matriculation, and research intensity of medical schools (as judged by relative NIH research support).

RESULTS

Early Career Outcomes

By 2000, 21% of awardees of the Cloister Program, who graduated between

1987 and 1995, had received NIH postdoctoral awards. This percentage was significantly higher than the 13% of nonawardees of the program (see Table 1). In addition, by 2001, 20% of the awardees had received faculty appointments with research responsibility at U.S. medical schools, which was also significantly higher than the 14% of nonawardees of the program. MSTP program participants who graduated between 1987 and 1995 showed the highest rates of receipt of NIH postdoctoral awards (35%) and faculty appointments with research responsibility (33%). In contrast, 20% of non-MSTP MD-PhD program participants who graduated in the same period had received NIH postdoctoral awards by 2000, and 21% had received faculty appointments with research responsibility by 2001. The success rates of participants in non-MSTP-supported MD-PhD programs were not significantly different from those for participants in the Cloister Program.

By 2000, 24% of awardees of the Medical Fellows Program who graduated between 1991 and 1995 had received NIH postdoctoral awards (see Table 2). The figure was significantly higher than the 10% for nonawardees. By 2001, 16% of the awardees had received faculty appointments with research responsibility, which was marginally significant ($p = .07$) from the 9% of nonawardees. As in the larger cohort (1987–1995) described in the preceding paragraph, MSTP program participants who graduated between 1991 and 1995 exhibited the highest rates of receipt of NIH postdoctoral awards (33%) and faculty appointments with research responsibility (24%). Both figures were significantly higher than those for awardees of the Medical Fellows Program. In contrast, 20% of MD-PhD students in non-MSTP institutions, who graduated in the same years, had received NIH postdoctoral awards by 2000, and 16% had received faculty appointments with research responsibility by 2001. The relative achievements of

*Based on results from the AAMC 2000 MD-PhD Program Director Survey, 88% of participants in MSTP-supported programs who matriculated between 1980 and 1989 completed the programs, whereas 77% of participants in non-MSTP-supported programs who matriculated in the same years completed the programs.

Table 1

Comparisons between Awardees of the Howard Hughes Medical Institute Cloister Program with Other Student Categories, 1987–95 Graduation Cohorts*									
Characteristic	Cloister Program			Medical Scientist Training Program (MSTP) MD–PhD Program Participants (n = 1,484)	p Value	Non-MSTP MD–PhD Program Participants (n = 674)	p Value	All Other U.S. Medical Students (n = 137,006)	p Value
	Awardees (n = 270)	Nonawardees (n = 597)	p Value†						
National Institutes of Health postdoctoral awards	21%	13%	<.010	35%	<.001	20%		4%	<.001
Faculty appointments with research responsibility‡	20%	14%	<.050	33%	<.001	21%		7%	<.001
Women	31%	26%		18%	<.001	21%	<.01	36%	
Underrepresented minorities§	7%	10%		2%	<.001	2%	<.001	8%	
Mean Years at Medical School	5.2	4.3	<.001	7.1	<.001	6.2	<.001	4.1	<.001
Age 25 or older	6%	13%	<.010	6%		20%	<.001	23%	<.001
Interest in research careers	48%	44%		70%	<.001	65%	<.001	20%	<.001
Parents with MD or PhD	32%	32%		37%		28%		25%	<.05
Attended a U.S. medical school ranked top 20 in research intensity	60%	37%	<.001	79%	<.001	2%	<.001	17%	<.001
Attended a U.S. medical school ranked 21–40 in research intensity	14%	13%		20%	<.05	31%	<.001	17%	
Attended a U.S. medical school ranked 41 or lower in research intensity	26%	50%	<.001	1%	<.001	67%	<.001	66%	<.001
Mean total Medical College Admission Test score	65	60	<.001	69	<.001	62	<.001	56	<.001

*Data sources were the Howard Hughes Medical Institute applicants file, the Association of American Medical Colleges (AAMC) Faculty Roster System and students data system, and National Institutes of Health Trainee and Fellow File.

†p value is for comparison between Cloister Program awardees and nonawardees or between Cloister Program awardees and other student categories.

‡Research responsibility was measured as having at least 10% of time in research.

§This study used the AAMC pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

Medical Fellows Program awardees were comparable to participants in non-MSTP-funded MD–PhD programs.

Characteristics of the Program Participants

Although we found significant differences in early research career outcomes between awardees and nonawardees of the two HHMI training programs, the effects of the characteristics of program participants need to be taken into account. We found that 31% of Cloister Program awardees who graduated between 1987 and 1995 were women,

which was not significantly different from the 26% of nonawardees, or the 36% of all students in these graduating classes who were women. Thirty-five percent of awardees of the Medical Fellows Program who graduated between 1991 and 1995 were women. This was higher than the 25% of nonawardees (significant at the $p = .06$ level) and not significantly different from the 38% of all students in these graduating classes who were women. However, compared with both MSTP-supported and non-MSTP-supported MD–PhD programs, women were signif-

icantly more likely to participate in the two HHMI programs.

Underrepresented minorities (URM)† constituted 7% of awardees of both HHMI programs, which was not significantly different from the percentage of underrepresented minorities among nonawardees of the programs, or for all

†This study used the AAMC's pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

Table 2

Comparisons between Awardees of the Howard Hughes Medical Institute's Medical Fellows Program with Other Student Categories, 1991–95 Graduation Cohorts*									
Variable	Medical Fellows Program			Medical Scientist Training Program (MSTP) MD–PhD Program Participants (n = 892)	p Value	Non-MSTP MD–PhD Program Participants (n = 497)	p Value	All Other U.S. Medical Students (n = 75,329)	p Value
	Awardees (n = 214)	Nonawardees (n = 150)	p Value†						
National Institutes of Health postdoctoral awards	24%	10%	<.001	33%	<.05	20%		3%	<.001
Faculty appointments with research responsibility‡	16%	9%		24%	<.01	16%		5%	<.001
Women	35%	25%		20%	<.001	22%	<.001	38%	
Underrepresented minorities§	7%	4%		2%	<.001	2%	<.001	8%	
Mean years at Medical School	5.0	4.4	<.001	7.3	<.001	6.4	<.001	4.2	<.001
Age 25 or older	9%	15%		7%		21%	<.001	23%	<.001
Interest in research careers	64%	55%		72%	<.05	67%		22%	<.001
Parents with MD or PhD	36%	39%		37%		28%	<.05	25%	<.001
Attended a U.S. medical school ranked top 20 in research intensity	77%	57%	<.001	78%		2%	<.001	17%	<.001
Attended a U.S. medical school ranked 21–40 in research intensity	14%	17%		21%	<.05	28%	<.001	17%	
Attended an U.S. medical school ranked 41 or lower in research intensity	8%	27%	<.001	1%	<.001	70%	<.001	66%	<.001
Mean total Medical College Admission Test score	65	61	<.001	69	<.001	62	<.001	55	<.001

*Data sources were the Howard Hughes Medical Institute applicants file, the Association of American Medical Colleges (AAMC) Faculty Roster System and students data system, and National Institutes of Health Trainee and Fellow File.

†p value is for comparison between Medical Fellows Program awardees and nonawardees or between Medical Fellows Program awardees and other student categories.

‡Research responsibility was measured as having at least 10% of time in research.

§This study used the AAMC pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

enrolled students over this time period (8%). URM students were also significantly more likely to enroll in the HHMI programs than in MSTP-supported or non-MSTP-supported MD–PhD programs (2%, respectively).

On average, awardees of the Cloister Program and Medical Fellows Program spent 5.2 and 5.0 years, respectively, at U.S. medical schools, significantly more years than the 4.3 years and 4.4 years for nonawardees of the two programs and for all other U.S. medical students (4.1 years). However, they were significantly fewer years than the 7.1 years (for the 1987–95 cohort) or 7.3 years (for the 1991–95 cohort) for

students in MSTP programs, and the 6.2 years (for 1987–95 cohort) or 6.4 years (for the 1991–95 cohort) for students in non-MSTP institutions.

In terms of age, 6% of awardees of the Cloister Program were 25 years or older at matriculation, a figure that differed significantly from nonawardees (13%). Nine percent of awardees of the HHMI Medical Fellow Program were in this age group, which was marginally different ($p = .08$) from the 15% of nonawardees. Compared with awardees of the HHMI programs, participants in the MSTP programs were significantly younger: only 6% (for the 1987–95 co-

hort) and 7% (for the 1991–95 cohort) were 25 years or older at matriculation. In contrast, 20% of the 1987–95 cohort and 21% of the 1991–95 cohort of non-MSTP-supported MD–PhD students were in this age group.

Forty-eight percent of awardees of the Cloister Program reported before/at matriculation that they expected to have significant involvement in research during their medical careers. This was not significantly different from the 44% of nonawardees of the program, but it was significantly lower than the 70% of participants in MSTP-supported programs and the 65% of participants in non-

MSTP programs. Sixty-four percent of awardees of the HHMI Medical Fellows cohort reported before/at matriculation that they expected to have significant involvement in research during their medical careers. This figure was marginally higher ($p = .07$) than the 55% for nonawardees of the program, and not significantly different from the rate of self-reported research interests of participants in non-MSTP programs (67%); however, it was significantly lower than the 72% of MSTP program participants who indicated an interest in research careers.

Parents with a PhD degree may be more likely to conduct research, which may influence their children to pursue research careers as well. We found that 32% of awardees of the Cloister Program had at least one parent with a PhD or MD degree. (Because of data limitations, we could not separate parents holding a PhD degree from parents holding a MD degree.) This was similar to the rate for nonawardees of the program, and was not statistically different from the 28% of participants in non-MSTP programs or from the 37% of students in MSTP programs. Among awardees of the Medical Fellows Program, 36% had at least one parent with a MD or PhD degree. This was not significantly different from the 39% of nonawardees of the program or the 37% of MSTP program participants; however, it was significantly higher than the 28% of participants in non-MSTP-supported programs.

The research intensity of medical schools was an important factor differentiating HHMI awardees from nonawardees, and in differentiating MD-PhD students in MSTP-supported programs from non-MSTP-supported programs. Sixty percent of awardees of the Cloister Program came from the 20 most research-intensive U.S. medical schools, which was significantly higher than the 37% for nonawardees. Seventy-seven percent of awardees in the Medical Fellows Program came from the top 20 research-intensive schools; this

was significantly higher than the 57% of nonawardees. Seventy-nine percent (for the 1987–95 cohorts) and 78% (for the 1991–95 cohorts) of participants in MSTP-supported programs also came from the 20 most research-intensive medical schools. In contrast to all of these programs, participants in non-MSTP-supported programs were less likely to come from the most research-intensive schools. Only 2% (for both the 1987–95 and the 1991–95 cohorts) of these students came from the 20 most research-intensive schools.

Mean total MCAT scores for awardees of the Cloister Program and Medical Fellowships Program were both 65, which was significantly higher than the scores for the two nonawardee groups (60 and 61, respectively) or for students of non-MSTP programs (62). The mean total score of 69 for participants of MSTP programs was significantly higher than that of any other group.

In summary, we found that relative to the total pool of enrolled U.S. medical students, women and URM students were proportionally represented among awardees of the two HHMI programs. These groups were relatively underrepresented in MSTP-supported and non-MSTP-supported MD-PhD programs. In terms of expressing strong interest in research careers at matriculation, level of parental education (i.e., PhD or MD) and enrollment at one of the 20 most research-intensive U.S. medical schools, awardees in the Medical Fellows Program and participants in MSTP programs were remarkably similar. Compared with awardees of the HHMI programs and students in MSTP-supported programs, students in non-MSTP-supported programs were more likely to be older (25 years or older), and to come from non-research-intensive schools. Finally, compared with nonawardees, awardees of the two HHMI training programs were younger, had better MCAT scores, and were more likely to come from top research-intensive schools.

Because each of the demographic or academic characteristics was differentially distributed among HHMI program awardees and nonawardees and among MSTP-supported and non-MSTP-supported program participants, we performed a series of logistic regression analyses to parse out the specific effect of the training program on early indicators of research career outcomes.

Logistic Regression Analysis

Logistic regression is a statistical modeling technique that is appropriate for analysis of categorical outcomes. It describes the relationship between a categorical response variable, such as receiving a NIH postdoctoral award, and a set of explanatory variables. Table 3 reports the results of a logistic regression analysis on the probability of receiving a NIH postdoctoral award for awardees and nonawardees of the Cloister Scholar program. Being a Cloister Scholar significantly increased the probability of receiving a NIH postdoctoral award after controlling for the demographic and academic variables that could affect selection to the HHMI program. Table 3 also summarizes the results of logistic regression on the probability of receiving a NIH postdoctoral award, comparing MSTP and non-MSTP program participants with participants in the Cloister Program. Awardees of the Cloister Program were significantly less likely to receive a NIH postdoctoral award than MSTP program participants. Although there was no significant difference in the rate of receiving NIH postdoctoral awards between awardees of the Cloister Program and participants in non-MSTP-supported programs as reported in our bivariate analysis (see Table 1), the former group became less likely to receive a NIH award than the latter group after the demographic and academic variables discussed previously were controlled. The finding suggests that given the same demographic and academic characteris-

Table 3

Logistic Regressions on Probability of Receiving National Institutes of Health Postdoctoral Awards,* 1987–95 Graduation Cohorts			
Variable	Odds Ratio		
	Howard Hughes Medical Institute Cloister Program Awardees and Nonawardees (<i>n</i> = 811)	Cloister Program Awardees and Medical Scientist Training Program (MSTP) MD–PhD Students (<i>n</i> = 1,508)	Cloister Program Awardees and Non-MSTP MD–PhD Students (<i>n</i> = 836)
Cloister Scholars	1.76†	.64‡	.45†
Women	.57‡	.78	1
Underrepresented minorities¶	.9	1.25	1.52
Age 25 or older	1.29	1.07	.59‡
Interested in research careers	1.09	.97	1.05
Parents with MD or PhD	1.03	1.2	.82
Attended a U.S. medical school ranked top 20 in research intensity	2.01†	2.04‡	3.43§
Attended a U.S. medical school ranked 21–40 in research intensity	1.42	1.89	1.2
Total Medical College Admission Test scores	1	1.01	1.01

*Data sources were the Howard Hughes Medical Institute's applicants file, the Association of American Medical Colleges students data system, and the National Institute of Health Trainee and Fellow File.

†*p* < .01.

‡*p* < .05.

§*p* < .001.

¶This study used the Association of American Medical Colleges (AAMC) pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

tics, awardees of the Cloister Program would be less likely to receive a NIH postdoctoral award than non-MSTP program participants.

Table 4 summarizes the results of logistic regression analyses on the probability of receiving a NIH postdoctoral award, comparing participants in the Medical Fellows Program who graduated between 1991 and 1995 with non-awardees, MSTP, and non-MSTP program participants from the same graduation cohorts. We found that being a HHMI Medical Fellow significantly increased the probability of receiving a NIH postdoctoral award compared with being a nonawardee. In addition, awardees of the Medical Fellows Program were not significantly less likely to receive a NIH postdoctoral award than either MSTP or non-MSTP program participants.

The logistic regression analysis reported in Table 5 confirmed that Cloister scholars were significantly more likely than nonawardees to receive faculty appointments with research responsibility, after controlling for the same sets of demographic and academic variables that could affect selection to the HHMI program. Again, awardees of the Cloister Program were significantly less likely to receive a medical school faculty appointment with research responsibility than MSTP program participants. However, they were not significantly less likely than non-MSTP program participants to receive such appointment (see Table 5). We did not find a significant difference between awardees and nonawardees of the Medical Fellows Program in receiving a faculty appointment with research responsibility in a logistic regression analysis.

In summary, the results of the logistic regression analyses confirmed that participation in both HHMI programs significantly increased the probability of receiving NIH postdoctoral support. Participation in the Cloister Program also significantly increased the likelihood of receiving a faculty appointment with research responsibility at a medical school. Because the logistic regression analysis statistically parses out the contributions of subject selection and program effects, these data strongly support the program effectiveness of these HHMI-supported programs in achieving these specific outcomes.

DISCUSSION

To attract medical students to careers in research, the Howard Hughes Medical

Table 4

Logistic Regressions on Probability of Receiving National Institutes of Health Postdoctoral Awards,* 1991–95 Graduation Cohorts			
Variable	Odds Ratio		
	Howard Hughes Medical Institute Medical Fellows Program Awardees and Nonawardees (<i>n</i> = 354)	Medical Fellows Program Awardees and Medical Scientist Training Program (MSTP) MD–PhD Students (<i>n</i> = 1,052)	Medical Fellows Program Awardees and Non-MSTP MD–PhD Students (<i>n</i> = 649)
Medical Fellows	2.57†	.79	.48
Women	.73	.84	.84
Underrepresented minorities§	.44	.86	.46
Age 25 or older	1.29	1.06	.58‡
Interested in research careers	1.35	.98	1.38
Parents with MD or PhD	1.88‡	1.46‡	1.25
Attended a U.S. medical school ranked top 20 in research intensity	1.60	1.64	3.85†
Attended a U.S. medical school ranked 21–40 in research intensity	.88	1.54	1.09
Total Medical College Admission Test scores	1.01	1.02	1.00

*Data sources were the Howard Hughes Medical Institute's applicants file, the Association of American Medical Colleges (AAMC) students data system, and the National Institute of Health Trainee and Fellow File.

†*p* < .01.

‡*p* < .05.

§This study used the AAMC pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

Institute established the HHMI-NIH Research Scholars Program (Cloister Program) in 1985 and the Medical Fellows Program in 1989. Both programs provide support to medical students for one year of intensive research training. Awardees of the Cloister Program conduct supervised research at the NIH campus, whereas awardees of the Medical Fellows Program carry out mentored research at individual medical schools or nonprofit research institutions. In recent years, the NIH Clinical Center and some foundations have also established one-year clinical research electives for medical students, in an effort to generate interest in careers inpatient oriented research. These programs are similar to the HHMI supported Cloister and Medical Fellows Programs. Thus, an analysis of the early career outcomes of HHMI program awardees may have broad implications for programs aimed at in-

creasing the pool of physician–scientists and of patient-oriented researchers.

Our study found that awardees of the HHMI Cloister Program are significantly more likely than nonawardees to pursue research careers, as reflected in their higher rates of receipt of NIH postdoctoral awards and faculty appointments with research responsibility. Awardees of the HHMI Medical Fellows Program are also more likely than nonawardees to receive NIH postdoctoral awards, and are somewhat more likely to receive faculty appointments with responsibility.

The awardees in the two HHMI programs differed in significant ways from the nonawardees. They were younger, had higher average MCAT scores, and were more likely to come from the most research-intensive schools. Because each of these characteristics could result in better outcomes for awardees of the

HHMI-funded programs, we performed a series of logistic regression analyses to control for the effects of these factors. These analyses confirmed the effectiveness of the Cloister Program in increasing the likelihood of receipt of NIH postdoctoral awards and of faculty appointments with research responsibility at medical schools, and the effectiveness of the Medical Fellows Program in increasing the likelihood of receipt of NIH postdoctoral research support. The likelihood of receipt of a NIH postdoctoral award between Medical Fellows awardees and MSTP or non-MSTP MD–PhD program participants is also quite comparable.

The failure to find a difference, in securing medical school faculty appointments with research responsibility, between Medical Fellows awardees and nonawardees might be explained by several factors. Nonawardees in the

Table 5

Logistic Regressions on Probability of Receiving Faculty Appointments with Research Responsibility,* 1987–95 Graduation Cohorts			
Variable	Odds Ratio		
	Howard Hughes Medical Institute Cloister Program Awardees and Nonawardees (<i>n</i> = 806)	Cloister Program Awardees and Medical Scientist Training Program (MSTP) MD–PhD Students (<i>n</i> = 1,505)	Cloister Program Awardees and Non-MSTP MD–PhD Students (<i>n</i> = 833)
Cloister Scholars	1.51†	.60‡	.80
Women	.85	.66‡	.87
Underrepresented minorities¶	.33†	.82	.48
Age 25 or older	.63	.36§	.57†
Interested in research careers	.91	1.03	1.20
Parents with MD or PhD	1.43	1.14	1.43†
Attended a U.S. medical school ranked top 20 in research intensity	1.69†	.89	1.26
Attended a U.S. medical school ranked 21–40 in research intensity	1.23	.93	1.26
Total Medical College Admission Test scores	1.00	1.01	1.03†

*Data sources were the Howard Hughes Medical Institute's applicants file, and the Association of American Medical Colleges (AAMC) Faculty Roster System and students data system.

† $p \leq .05$.

‡ $p < .01$.

§ $p < .001$.

¶This study used the AAMC pre-June 2003 definition of underrepresented minorities that included blacks, Native Americans, Mexican Americans, and mainland Puerto Ricans. Since June 2003, the AAMC has used a new definition that includes all racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population.

1991–95 cohort spent significantly more time in medical school before graduation than was the norm for the pool of graduating medical students. It was therefore possible that some of the nonawardees may have received training awards from other sources that provided them with a research experience that was comparable in time commitment to the awardees. Treating these individuals as “nonawardees” could result in an underestimate of the effects of the HHMI program. Secondly, the Medical Fellows Program started 4 years later than the Cloister Program. Awardees of the former program were therefore less likely than awardees of the latter program to secure faculty positions by 2001. Thus, a longer period of follow-up is needed to assess the success of awardees of the Medical Fellows Program in their employment with research involvement. Such a follow-up will also be

necessary to assess the effect of both HHMI-funded programs on other measures of research productivity, including receipt of NIH-funded investigator-initiated research grants, publications in peer-reviewed journals, and the subsequent award of promotion and tenure to awardees and nonawardees who have received initial faculty appointments.

In addition to their apparent effectiveness in terms of early career outcomes, the HHMI-supported programs have also been successful at recruiting women and URM in proportion to their percentage in the overall pool of U.S. medical students. In this regard, the HHMI-supported programs were more successful than MD–PhD programs. To our knowledge, both the HHMI programs and MD–PhD programs have worked hard to recruit women and URM as students. What factors are associated with the HHMI programs’

achievement? Are short-term training programs more appealing than lengthy programs to these students? Facing the conflict between the needs for professional growth and the desires for family and children, women students may perceive one-year programs as more consistent with their career and family growth than the multiyear MD–PhD programs.

Physician–scientists who are women or URM may contribute more to the treatments of diseases that are more relevant to women and minority populations.^{7,8} However, recruiting them to the biomedical workforce has been challenging. Declining interest in research, conflicting demands on career and family, slower promotion, lack of role models and institutional supports have been cited as obstacles to advancements in academic medicine for them.^{9–13} Some of our logistic regression analyses show that women and

URM are less likely to receive NIH postdoctoral awards or faculty appointments with research responsibility at U.S. medical schools. Are these the same patterns for HHMI program participants who are women or URM? In a separate analysis we found that although they were significantly less likely to receive NIH postdoctoral awards, women awardees were as likely as men awardees to receive faculty appointments with research responsibility. We did not find consistent patterns for HHMI awardees who are URM students. In addition, in a number of comparisons, the number of URM awardees who received faculty appointments with research responsibility is too small for a reliable statistical test.

Although MSTP program graduates were clearly the most successful cohort in our analyses of early indicators of career outcome, the difference in early research career outcomes between awardees of the HHMI programs and non-MSTP MD-PhD program participants was of particular interest. We found that in aggregate MD-PhD students in non-MSTP programs did about as well as awardees of the HHMI programs in receiving NIH postdoctoral awards and faculty appointments with research responsibility. They were more likely than awardees of the Cloister Program, and as likely as awardees of the Medical Fellows Program, to receive NIH postdoctoral awards once demographic and academic variables that could also affect the outcomes were controlled. However, they were not more likely than the awardees of the Cloister Program to receive a faculty appointment with research responsibility, even when the same demographic and academic variables were controlled. Given the comparable years in medical school

between non-MSTP program participants (6.2 years for the 1987-95 graduation cohorts and 6.4 years for the 1991-95 graduation cohorts) and awardees of the HHMI programs (5.0 years for trainees in the Medical Fellows Program and 5.2 years for trainees in the Cloister Program), one must ask whether the HHMI programs provide a more cost-effective and time-effective model for the education of physician scientists than the non-MSTP-supported MD-PhD programs. Factors that differentiated the non-MSTP-supported programs from the other groups included a low percentage in research-intensive schools and a high percentage of older students (older than 25 years at matriculation). In our regression analyses comparing awardees of the HHMI programs and non-MSTP MD-PhD program participants, we found that students who were 25 years or older at matriculation were significantly less likely to achieve early research career success. These MD-PhD programs may need to pay more attention to factors that may discourage older students from pursuing research career opportunities.

In summary, we found that the one-year intensive research training supported by the HHMI programs appears to provide an effective imprinting experience on the trainees' research careers, and therefore seems to be an attractive strategy for training physician-scientists. A longer follow-up period will permit analysis of outcome data that should give some indication of sustained success in receipt of NIH-funded investigator-initiated research grants, publications in peer-reviewed journals, and faculty promotion and tenure.

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