

Impact of Medical Student Research in the Development of Physician-Scientists

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ABSTRACT

Context: A decline in the number of physician-scientists has been identified in the United States for at least two decades. Although many mechanisms have been proposed to reverse this trend, most of these have concentrated on MD/PhD programs, research in subspecialty fellowships, and other approaches later in physician training. Few have emphasized early medical student research experiences as a contributing solution.

Objective: To determine the effect of a medical student research experience on career choices and attitudes about biomedical research.

Design, Setting, and Participants: We jointly report 25 years of experience with National Institutes of Health (NIH)-sponsored Medical Student Research Fellowship programs (MSRFs) at two colleges of medicine, the University of Tennessee Health Science Center and Vanderbilt University. In both programs, students work during the summer of their first or second year of medical school on a research project that is mentored by an established scientist and participate in a structured program (lectures, visiting professor).

Main Outcome Measures: We gathered data using pre- and postresearch fellowship questionnaires to assess (a) quality of research experiences; (b) tabulation of productivity, that is, pre-

sentations, abstracts, publications, and awards; (c) long-term tracking of former program participants; (d) comparison of residency placements by medical student researchers; and (e) comments from former program participants on the effects of their students' research experiences on career choices.

Results: During this time, approximately 1,000 medical students participated in the two programs. Follow-up data (for short-term evaluations, 96–132 respondents with a response rate > 82%; for long-term evaluations, 88–118 respondents with a response rate > 29–33%) strongly suggest (a) interest in an academic career increased, (b) one-third to half of former student respondents considered themselves to be in academic medicine, (c) the vast majority of students conducted additional research after their medical student research experience, and (d) a large number of students were currently doing research or had published or presented their work at scientific meetings.

Conclusions: Over two decades of experience with NIH-sponsored medical student research programs at two medical schools strongly support the ability of these programs to interest medical students in research and academic careers. MSRFs should be included in strategies to reverse the decline in the number of physician-scientists.

Key Words: physician, scientist, medical student, research, training

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The rapid expansion and progress in biomedical research will transform medical care. Physician-investigators will play key roles in translating progress in basic science into clinical practice by defining the physiologic and pathophysiologic implications of the human genome, in guiding basic science research into clinically relevant directions, and in designing and evaluating new therapies based on basic science discoveries. However, the number of physicians trained to play these important roles in biomedical research is projected to be woefully inadequate, and a number of groups or individuals have noted the continued decline in the number of physicians entering research careers.¹⁻⁶ For example, Rosenberg projected that if the current rate of decline in physician applications for National Institutes of Health (NIH) funding continues, within the next 5 years there will be no first-time applications from physicians.³ Although a number of existing and new mechanisms seek to address this problem,^{3,6-10} one

mechanism cited, but not emphasized, is a medical student research experience. Many feel that medical student research fellowships (MSRFs), first initiated by the NIH in the late 1950s and then reinitiated in 1980, represent a critical "turn-on" period for medical students by allowing them to seriously consider careers in academic medicine and research early in their professional training.

In the late 1970s, the University of Tennessee College of Medicine (UTCOCM) and the Diabetes Center of the Vanderbilt University School of Medicine (VUSM) initiated institutionally funded MSRFs that have been subsequently funded by the NIH for nearly two decades. Although sharing a common goal and providing an infrastructure for student research, each program was independent, had a unique organization, and collected data from medical student participants before, during, and after their MSRF experiences over the past 25 years. This joint report describes the very positive effect of both MSRF programs on student attitudes about research and career choices.

METHOD

UTCOCM Program

In 1977, the UTCOCM initiated a program in medical student research funded with existing budget dollars. Subsequently, the program has been funded by the NIH. Since 1980, approximately 400 students have conducted research through this program and approximately 24 fellowships are available to all UTCOCM medical students each year. At UTCOCM, participants are predominantly first-year medical students, with a small number of entering students. Many students return for a second year in the MSRF program and many continue their research during their remaining years of medical school. Students work just prior to entering medical school, during the summer vacation after the first year of medical school, or at other individually arranged times (usually 10–12 weeks). Students work throughout the UTCOCM in a laboratory, general clinical research center, or other site (hospital, clinic, etc). On entry into the program, students write a miniproposal (including a hypothesis, literature review, and methodology) that is peer-reviewed (by UT faculty). This usually involves two to three reviewers, and, in some cases, the research plan is revised as a result of these reviews. The acceptance rate for the research proposal is high as the requirements are well known throughout the UTCOCM research community and only motivated students and preceptors apply. At the conclusion of their research, students write a final report and present their findings to fellow students and, in most cases, present them at regional or national meetings. The program has a core lecture series and brings a distinguished visiting scientist to enhance role modeling during the MSRF. Students participate in ongoing research seminars and activities with their preceptor's discipline or department.

Students complete a questionnaire at the beginning and end of their research experience. Data from students over the last 5 years are presented ($n = 96$). To determine the long-term influence of the UTCOCM program, students who are now in practice or academics complete a questionnaire about the influence of the program on choice of medical specialty, where they matched for residency, whether they continued research, and/or whether they chose a career in academic medicine. In this follow-up, 118 of 400 MSRF participants completed these long-term tracking questionnaires (response rate = 29.5%).

VUSM Program

The Vanderbilt Medical Student Research Training Program in Diabetes, Endocrinology, and Metabolism seeks to provide an intensive, high-quality research experience to medical students early in their academic careers. Since its inception in 1975, this program has provided research training for over 600 students from 60 medical schools. Originally conceived and directed by Drs. Oscar Crofford and Phillip Felts, this program allows medical students to spend the summer (10–12 weeks) between their first and second years of medical school immersed in an independent research project that is mentored by an established scientist. The thematic focus of the program is diabetes and endocrinology, and it takes advantage of the long-standing, broad-based excellence of basic and clinical research in this area at Vanderbilt. The research opportunities for the medical student are quite diverse and range from gene regulation to signal transduction to *in vivo* human studies to behavioral psychology. The program is supported by a combination of NIH funds, private monies raised through the Vanderbilt Diabetes Center, and funds provided by Vanderbilt University. The program is administered from within the NIH-supported Vanderbilt Diabetes Research and Training Center (VDRTC) and the Division of Endocrinology. The faculty is carefully selected based on both their research interest and their desire to provide a research opportunity for medical students and is composed of over 80 investigators from the Departments of Molecular Physiology and Biophysics, Medicine, Biochemistry, Pharmacology, Pediatrics, Surgery, Pathology, Obstetrics-Gynecology, Psychology, Engineering, and Cell Biology. Most preceptors are members of the VDRTC. A director and associate director, both of whom are active investigators, guide the Vanderbilt program.

Participants in the Vanderbilt program are chosen from the Vanderbilt University School of Medicine and from other US medical schools. Through a variety of electronic and personal networks and through printed announcements, all US medical students are informed midway through their first year about the program. A brief application asks the students for a one- or two-paragraph answer to three questions: (1) Why are you interested in diabetes and diabetes-related research? (2) Describe any

prior research experience; and (3) What are your future career plans? Most students had participated in some research during their undergraduate studies, although a small number of students had worked as research assistants or technicians in biomedical research before attending medical school (data not shown). The focus of the Vanderbilt program on diabetes was a major attraction for most students. In response to questions on the application, many students related how diabetes had affected a family member or friend and how this influenced their decision to participate in diabetes research. Some participants had diabetes, and this was cited as a reason to pursue diabetes research. An occasional student became interested in glucose homeostasis as a result of his/her medical school courses. Although a small number of students were interested in a career in endocrinology or diabetes, most students were uncertain of career plans. A large number of students indicated a desire for a career involving patient care and research or teaching (that would fit in the broad category of academic medicine). The program selects students based primarily on potential interest in exploring a career in biomedical investigation. Prior research experience is not required. Usually, 25 to 30 students participate in the program each summer (approximately 30–50% of applicants are accepted into the program). A monthly stipend is provided to participants.

Students spend approximately 90% of their time in the laboratory or research arena of their preceptor working on their research project. The preceptor and the student jointly design a research project. To assist the student's understanding of his/her research project, each student prepares a brief (two pages) research plan that is patterned on an NIH application. At the end of the summer, each student delivers an oral presentation summarizing his/her research in the traditional scientific format (10 minutes for presentation and 5 minutes for questions). Additional components of the program expand the student's exposure to biomedical research. A lecture series by VDRTC investigators highlights aspects of clinical and basic diabetes research and encourages students to consider how biomedical research might solve current clinical problems in diabetes care. A series of small-group sessions provides the opportunity for the student to observe specialized research approaches such as transgenic and knockout mice, metabolic studies on the general clinical research center, and the use of large animals (dogs) to study carbohydrate metabolism. A visiting professorship program exposes students to an investigator who has made contributions to diabetes research and serves as a role model for a career in biomedical research.

The impact of the research experience on the individual student was assessed by questionnaire and evaluation form at the end of his/her summer research experience. The before and after questionnaires/evaluations were not anonymous. Because this evaluation form is completed just prior to the presentation day and prior to students

obtaining their final stipend check, compliance is excellent ($\geq 82\%$). At the completion of the Vanderbilt research experience over the past 5 years, all 132 participants (58% from Vanderbilt and 32% from other medical schools) completed a 33-question survey on biomedical research, career plans, and their research experience. To determine the long-term influence of the Vanderbilt program, Vanderbilt participants were sent a questionnaire in late 2000 asking about career pathways after medical school, their current position, and their current views about research. Of 265 former Vanderbilt student participants who were in the program from 1975 to 1994 and who had a current address on file with the Vanderbilt Medical School Alumni office, 88 completed a 25-question follow-up survey (response rate = 33.2%). Students who had completed the MSRF more than 8 years earlier were included in the analysis to allow time for completion of medical school and clinical training. Questionnaires used by the UTCOM and Vanderbilt asked similar, but slightly different, questions. Responses from each program are reported separately.

RESULTS

Students from the UTCOM and Vanderbilt programs were queried and data compiled to address three basic questions. First, does the MSRF program result in a "good" experience for students? Second, does participation in MSRF result in meritorious scientific findings? Third, does participation in the MSRF result in greater interest in conducting more research beyond the MSRF experience and/or motivate students to pursue a career in research or academic medicine?

Short-Term Effect of MSRF on Student Attitudes

The responses of students who participated in the program in the last 5 years are presented. The MSRFs were well received by participants at both institutions, with > 90% of respondents reporting that the MSRF was worthwhile and should be continued and that they would recommend that future students from their schools participate in the program (data not shown).

UTCOM Program

In the UTCOM program respondents over the last 5 years ($N = 96$), interest in an academic career increased; 27% felt that their research experience changed their career goals. At the completion of the program, 79% of UTCOM students were interested in academic and research-oriented careers (Table 1). The data from 1994 to 1998 from UTCOM, presented in Table 2, illustrate that almost all students were credited with either a full paper, abstract, or presentation and about half appeared as a coauthor on full publication in peer-reviewed national journals.

TABLE 1 Short-Term Impact of MSRF on Student Attitudes

Statement on Questionnaire	Preprogram		Postprogram	
	Yes (%)	No (%)	Yes (%)	No (%)
I am interested in academic medicine and research as a career.	74	26	79	21
I think research will be of value in my career. My career goals have changed, ie, to include research.	NA	NA	48	52

Statement on Questionnaire	SA (%)	A (%)	D (%)	SD (%)
	I am more likely now than before I attended the summer program to pursue a clinical or basic research career.	28	55	16
I think my research will be of value in my career development.	49	48	4	1

*Number of replies = 96 (students from 1995–1999); †number of replies = 109–111 (students from 1996–2001) from 132 student respondents (not all students answered every question). The percentage of students is rounded to a whole number so the total may not equal 100%. A = agree; D = disagree; MSRF = Medical Student Research Fellowship; NA = not available; SA = strongly agree; SD = strongly disagree; UTCOM = University of Tennessee College of Medicine.

Vanderbilt Program

Based on student respondents over the past 5 years (response rate $\geq 82\%$), the summer research experience helped students clarify their attitudes about biomedical research and a possible career involving biomedical research. Even though students were aware of the importance of biomedical research before the program, their summer experience further emphasized this point of view (Figure 1). In the Vanderbilt program, 83% either strongly agreed or agreed with the statement that they were more likely to pursue a career in basic or clinical research as a result of the program and thought that the research experience would be useful later in their career (see Table 1). Whereas most students were more likely to pursue a career in research than prior to entry in the summer program (72% of respondents expressed moderate to great interest in research on entry to the program), a small number of students (18%) indicated that they were less likely to pursue a career in biomedical research after their summer research experience (see Table 1).

Long-Term Effect of MSRF on Student Attitudes

UTCOM Program

From long-term tracking data of 118 former student respondents at UTCOM years after their MSRF experiences, 46% reported that they were involved in academic medicine at some level; 65% conducted additional research after participating in the MSRF program; 42% were currently engaged in research; 45% published the results of their MSRF projects; 49% published at least one other postprogram project; and 46% presented other work

at a regional or national meeting (Table 3 and data not shown). In the UTCOM program, 63% felt that their research influenced their ability to obtain the residency of their choice, and 61% felt that their MSRF preceptor positively influenced their postgraduate training. Over the last 5-year period, 82% of the MSRF graduates of the UTCOM matched at university or strongly university-affiliated programs, whereas 15% less or 67% of non-MSRF graduates matched in this type of training program (data not shown). For comparison at UTCOM, the research training experi-

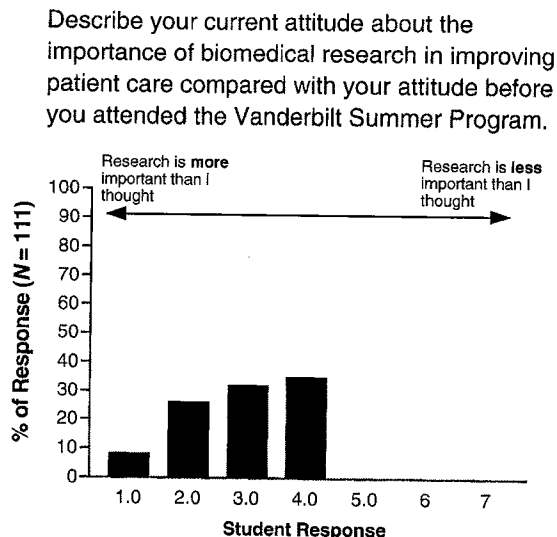


FIGURE 1 Student attitudes about biomedical research in the Vanderbilt program. At the conclusion of the summer program, students registered their opinion about the statement above the graph on a scale of 1 (more important) to 7 (less important). $N = 111$ of 132 participants.

TABLE 2 Publications, Presentations, and Research Prizes by UTCOM Participants (n = 114)

Year	Manuscripts	Abstracts	Presentations	Prizes
1994	14	7	6	1
1995	10	14	13	3
1996	7	15	12	1
1997	9	10	9	0
1998	13	60	52	5

UTCUM = University of Tennessee College of Medicine.

ences of the faculty in the UT Department of Medicine were examined. Although a relatively small sample size, one of three (6/17) had conducted research as a medical student; 28% (5/18) had published an article from work done as a student. Examples of selected comments from the long-term survey indicate the multiple dimensions of the MSRF experience on the participants in their own words:

1. My experience with the MSRF program was instrumental in my decision to complete a PhD in pharmacology following graduation from medical school.
2. The most significant residual effect of the MSRF program on my career is my emphasis on student involvement in my own laboratory. I have supervised five graduates and medical students in the past 5 years. I was also motivated to pursue research during my residency. This work resulted in my first three publications. This would not have occurred without the MSRF experience.

Vanderbilt Program

Of the Vanderbilt student respondents from 1975 to 1994 ($n = 88$ respondents of 265 participants; response rate = 33.2%), 81% participated in additional research during subsequent training and one-third secured funding for the research training from the NIH or nonprofit foundations (see Table 3). Approximately one-third of student respondents in the Vanderbilt program list their current professional affiliation at a medical school (23 associate professors, 2 chairs, 1 instructor), and 28% of these individuals have been the principal investigator of a research grant (8 individuals with NIH grants, 1 with a Veterans Administration grant, 6 with pharmaceutical grants, and 15 with a grant from a nonprofit foundation). For comparison at VUSM, 16% of all Vanderbilt medical school graduates from 1977 to 1995 are currently faculty members of US medical schools (based on information from the American Association of Medical Colleges [AAMC] and the dean's office at Vanderbilt). The diabetes and endocrinology focus of the Vanderbilt program influenced some, but

not all, students in that career direction (see Table 3). Additional responses from both programs indicate a positive impact of the MSRF programs on physician opinions about the value of research in clinical practice and their lives and careers even 20 years after their student research experience (see Table 3; also data not shown). Data available from graduates of the VUSM program demonstrate that the MSRF respondents continued to publish papers after establishing their careers (data not shown).

DISCUSSION

The importance of physician-investigators in advancing biomedical research is clear. By overwhelming consensus, too few physicians will be available and trained to play this crucial role in the coming years. How to reverse this trend has been discussed extensively.^{3-7,9-11} The current report details the impact of MSRF from two medical schools, one public and one private, and strongly suggests that a positive research experience as a medical student provides an important, perhaps crucial, entry point to a possible career in academic medicine and research. We have elected to jointly report the experience of our two programs because the findings are quite similar, although the two institutions have different missions and different types of students (public university and a private, research-intensive university). Our joint report suggests that early exposure to research (1) allowed students to test their "fit" in conducting biomedical research; (2) taught them to appreciate the effort it takes to create new information; (3) increased their attractiveness and acceptability as house staff to university residency programs; (4) made them more likely to pursue careers in research and/or academic medicine; and (5) seemed to maintain a lasting positive influence on their professional activities and attitudes throughout their careers. Rosenberg noted that a survey by the AAMC found that the number of graduating medical students interested in a career involving research had declined from 14 to 10% from 1989 to 1996.³ In contrast, the vast majority of students in both MSRF programs were interested in research careers at the completion of the MSRF program, and most respondents (65%

Table 3 Long-Term Impact on Student Attitudes and Career Choices**Part A. UTCOM (n = 118)**

<i>Statement on Questionnaire</i>	<i>Yes (%)</i>	<i>No (%)</i>
I am currently in academic medicine.	46	54
I have participated in or conducted research (in any field at any time) after I participated in the NIH MSRF.	65	35
I am currently participating in or conducting a research project in any field.	42	58
I have published the results of my MSRF project in the scientific literature.	45	55
I presented the results of my MSRF project at a regional or national meeting.	25	75

Part B. UTCOM (n = 118)

<i>Statement on Questionnaire</i>	<i>SA (%)</i>	<i>A (%)</i>	<i>N (%)</i>	<i>D (%)</i>	<i>SD (%)</i>
My research experience was an important factor in being selected by my residency program.	17	46	22	10	5
My research experience in the MSRF program influenced my choice of fields.	14	28	19	32	7
My research experience influenced my overall career path.	18	44	14	20	3

Part C. Vanderbilt (n = 88 from students in the program from 1975–1994)*

<i>Statement on Questionnaire</i>	<i>Yes (%)</i>	<i>No (%)</i>
My current professional affiliation [†] is university or medical school. [‡]	32	—
My current professional affiliation is private practice/practice medical group/health maintenance organization.	60	—
My current professional affiliation is pharmaceutical industry.	1	—
Did you participate in any type of medical research after the Vanderbilt Student Research Program?	81	19
Did you ever receive funding for additional research training?	35	64
Have you ever been the principal investigator on a research grant?	28	72

Part D. Vanderbilt (n = 88 from students in the program from 1975–1994)*

<i>Statement on Questionnaire</i>	<i>SA (%)</i>	<i>A (%)</i>	<i>N (%)</i>	<i>D (%)</i>	<i>SD (%)</i>
Medical students should participate in medical research.	69	28	2	—	—
The Vanderbilt summer program was a valuable experience for me.	73	26	—	1	—
The Vanderbilt summer research program had an impact on my choice of residency or fellowship.	22	23	32	19	5
The Vanderbilt summer research program had an impact on my choice of a career that includes ongoing involvement in research.	26	31	35	18	1

*N = 88 respondents of 265 participants (response rate = 33.2%); †3 individuals currently in residency or fellowship are not included; ‡includes two individuals at Centers for Disease Control and Prevention.

A = agree; D = disagree; N = no opinion or neutral; SA = strongly agree; SD = strongly disagree; MSRF = Medical Student Research Fellowship; NIH = National Institutes of Health; UTCOM = University of Tennessee College of Medicine.

of the UTCOM program and 81% in the Vanderbilt program) had additional research experience after medical school. Long-term follow-up showed that respondents in the Vanderbilt program were twice as likely to be faculty members of medical school than their classmates. Alumni of this program include a number of physician-scientists and physicians in academic medicine.

The infrastructure of both MSRF programs provided mechanisms (lectures, seminars, visiting professors, and a forum for student presentation) to supplement the student's research experience. We feel that such an infrastructure is important and helps students better understand the opportunities and strategies for becoming a physician-investigator. In addition, the programs allowed students to

hear about their peers' research projects and provided a sense of community and camaraderie for the students. A difference between the two programs was the diabetes and endocrinology focus of the Vanderbilt program. Because diabetes involves many areas of medicine (ophthalmology, wound healing, neuropathy, cardiovascular disease, etc) and science (gene regulation, signal transduction, development biology, immunology, etc), students in the Vanderbilt program worked in a wide array of areas. The diabetes focus provides a context for the student's research and was very instrumental in attracting many students to participate in the Vanderbilt summer research program. We feel that medical students believe that research should be relevant to clinical care/human disease rather than driven solely by the discovery of new scientific knowledge. However, medical students may underappreciate the relevance of scientific research as the foundation for modern medicine. Thus, a focus on an important clinical disease such as diabetes greatly enhances students' research experience and encourages medical students to take a broad view on medical research and to see the importance of research in improving human health.

The nature of the programs, the method for soliciting student responses, and the response rate to the long-term surveys create some limitations and caveats regarding the data and conclusions. We used participant questionnaires to evaluate our programs, as is commonly undertaken in education and training in many fields. In particular, with before and after surveys, we feel that we obtained a clear sense of what the participating students really thought and how their opinions changed. First, we feel that the best follow-up is a comprehensive description of the career paths and activities of the former student participants of the MSRFs. Whether our students would have chosen to pursue additional research or whether they would have joined the faculty or obtained research funding without our program cannot be answered conclusively. Nevertheless, data from both programs indicate that student interest in research increased as a result of participating in the MSRF. Second, for the long-term outcomes, we used data for students who were at least 8 years beyond medical school graduation to allow time for career selection. For the short-term survey, we used data from recent program participants. Whether the views on research and career choices are identical among recent medical students and those of more than 8 years ago is not known. However, both groups reported a positive experience and felt that the MSRF was very worthwhile. Third, the response to the long-term survey (29.5% at UTCOM and 33.2% at Vanderbilt) raises the possibility of responder bias. For example, it is possible that students who had a favorable experience or who chose a career in academic medicine were more likely to return their surveys. However, approximately two-thirds of the respondents to the Vanderbilt long-term survey indicated that

they were in private practice, and most of these felt that student participation in research was valuable (see Table 3). We made extensive efforts to contact and collect the views of students more than 8 years from graduation. The difficulty in tracking physicians years after graduation likely explains the response rate to our long-term survey. Because the response rate of our short-term surveys is quite high ($\geq 82\%$), responder bias is not a concern for these results. After taking these limitations and caveats into consideration, we would make the following statements about the UTCOM and Vanderbilt programs. The results should be viewed as observational in nature and are not applicable to all medical students but only to those who enrolled in our programs and completed the survey. Furthermore, one cannot conclude that participation in these programs was directly responsible for career choices because many factors influence career decisions (discussed below). Despite these limitations and caveats, and when both the long-term results are viewed together, one can conclude that students had a positive experience, that their interest in research careers increased, and that these positive feelings were present as long as 25 years after the student research experience.

The factors that influence the career choices of medical students are complex and incompletely defined. In addition to their personal interests in careers ranging from surgical subspecialties to primary care, financial and societal pressures likely influence career decisions of students. Furthermore, most medical school curricula must address an increasingly large number of basic science, clinical care, social, ethical, and economic issues. The time constraints of medical education leave little time for exposing students to the importance of biomedical research in improving health care or for encouraging students to participate in biomedical research. Without such appreciation and exposure to research, we feel that medical students are less likely to seek and enter careers involving biomedical research. We feel that research exposure early in medical training is effective, introduces students to this career option, and both encourages and provides a basis for the student to either pursue or not pursue other research training later in his/her medical training (later in medical school or during residency/fellowship). Clearly, exposure to biomedical research was beneficial to these students as this helped them decide that their long-term career goals should or should not involve research. Both MSRFs served this purpose, as evidenced by the large number of respondents who subsequently participated in research after their MSRF experience (see Table 3). In addition, such MSRFs integrate into national and local programs designed to attract medical students to careers in biomedical research (such as year-long programs sponsored by the Howard Hughes Medical Fellowship, various medical schools, and disease-oriented organizations such as the American Diabetes Association, etc). A number of partici-

pants in our MSRF programs have chosen such year-long research experiences or subsequently entered MD/PhD programs. We feel that it is vital that students hear the loud and consistent message that careers in biomedical research are exciting, important, and accessible. If the student does not hear these messages and have a quality research opportunities during medical school, we feel that a career as a physician-investigator is less likely.

In summary, the experience of two MSRF programs over two decades provides data that clearly show a positive impact on motivated medical students and suggests that these programs encourage students to pursue future research activities and enter academic and research careers. We also feel that our follow-up data provide important information for medical educators as they plan programs to encourage future medical students to participate in biomedical research and to consider careers in biomedical research. Although MSRF programs alone will not address the problem of too few physicians entering academic and research careers, such efforts are a crucial element that should be included in long-term strategies to increase the number of medical students who ultimately become physician-scientists.

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