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Introduction

Since the National Research Council released its last evaluation of workforce needs in the biomedical and behavioral sciences in 1994, the continuing contributions of researchers to the nation's health have touched the lives of millions of Americans. A striking example was the sharp decline in the death rate from AIDS in 1997, a result of more than a decade of research on the disease and on strategies for its prevention and treatment. Mortality from AIDS now stands at the lowest level in the United States since data were first collected in 1987.¹

With the designation of the 1990s as the Decade of the Brain,² researchers have focused attention on disorders of the brain, such as autism, schizophrenia, and impairments in speech, language, and hearing. At the same time, advances in imaging techniques have provided investigators with noninvasive approaches for observing the living brain, allowing them to study normal functioning as well as damage and disorder. Notable advances over the last half of the 1990s included the identification of genes associated with the development of degenerative disorders such as Alzheimer's, Parkinson's, and Huntington's diseases; new medications for depression, anxiety, and bipolar disorder; and the increasing use of more effective treat-

ments to lessen the damage of spinal injuries and stroke.³

Of great significance as well are the improvements in health that were celebrated when two of the National Institutes of Health's (NIH) oldest institutes marked their fiftieth anniversaries: the National Heart, Lung, and Blood Institute and the National Institute of Dental and Craniofacial Research. Since they were established as the second and third institutes in 1948, research has transformed the practice of both medicine and dentistry.

If a heart attack did not result in early death 50 years ago—as it did for one-third of patients who reached the hospital—it often marked the end of an active life. In the late 1940s, treatment for a heart attack was often limited to pain control and bed rest. Many patients were not permitted to sit up in a chair for many weeks.⁴ At the time, heart disease and its associated conditions were by far the largest single cause for retirement under the disability provisions of the Civil Service Retirement Act.⁵

The age-adjusted rate of death from coronary heart disease has decreased by more than half over the past 30 years as a result of increased public awareness and adoption of lifestyles that reduce heart disease (especially decreased tobacco use), medications that control

¹ Ventura, Stephanie J., Robert N. Anderson, Joyce A. Martin, and Betty L. Smith. *Births and Deaths: Preliminary Data for 1997*. National Vital Statistics Reports 47, no. 4. Hyattsville, Md.: National Center for Health Statistics, 1998.

² President George Bush. Proclamation. "Decade of the Brain, 1990-1999, Proclamation 6158." *Federal Register* 55, no. 140 (1990): 29553.

³ Dana Alliance for Brain Initiatives. *Update 1998: Reshaping Expectations*. New York: Dana Press, 1998.

⁴ National Institutes of Health. National Heart, Lung, and Blood Institute. *Scientific Advances: Heart Attack and Counterattack*. Bethesda, Md.: NIH, 1998.

⁵ Lenfant, Claude. "Heart Research: Celebration and Renewal." *Circulation* 96, no. 11 (1997): 3822–23.

high blood pressure and cholesterol, and such advances in diagnostics, treatment, and surgery as stress tests, “clotbuster” drugs, and balloon angioplasty.⁶ Improvements in treatment now allow most survivors to return to normal activities within weeks of a heart attack.

Similarly, the anniversary of the National Institute of Dental and Craniofacial Research provided an opportunity to reflect on the enormous improvements in oral health over the last half century. At the outbreak of World War II, almost 10 percent of military-age American men were ineligible for the draft because they had less than six opposing teeth in each jaw.⁷ Most people living in the U.S. at the time could expect to be toothless by the age of 45.⁸ Today, the combination of fluoridated drinking water, dental sealants, and other improvements in prevention and treatment allow the majority of Americans to retain their teeth throughout their lives.

Beyond the latest improvements in medical care and health brought about by their research, investigators are also contributing to the nation’s economy in new ways. The rise of cost-effectiveness studies (which may eventually help guide health care spending)^{9,10} is one example; another, much further advanced, is evident in the field of biotechnology. After a period of steep growth—and occasional setbacks—in the 1980s, the biotechnology industry is now on firm footing and turning out new products at a rapid pace. Of the 65 drugs developed by biotechnology companies on the market

in 1998, half had been introduced in the previous two years and the Food and Drug Administration is reviewing another 200.¹¹

ORIGINS OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM

Many roots of today’s research training programs in the biomedical and behavioral sciences extend back to 1930 and the beginnings of the NIH. The enactment of the Ransdell Act that year established the NIH as the focus of the growing research activities of the Public Health Service and assigned the new agency a role in maintaining the research workforce. Recognizing that the agency would require a supply of trained personnel to fulfill its mission, legislators provided for the NIH to award fellowships to investigators interested in conducting research.¹²

Before the decade was out, the first of NIH’s “categorical” institutes had been founded, and the agency’s duties had been expanded to include advanced clinical training as well. In establishing the National Cancer Institute in 1937, Congress charged it with providing “training and instruction in technical matters relating to the diagnosis and treatment of cancer,”¹³ along with research training. As additional institutes were formed (the National Heart Institute and the National Institute for Dental Research in 1948, the National Institute of Mental Health in 1949, and the National Institute of Arthritis and Metabolic Diseases and the National Institute of Neurological Diseases and Blindness in 1950), their training responsibilities were based to a large degree on those established for the National Cancer Institute.¹⁴ As a result, for much of its first two decades, NIH training support was divided between clinical and research training.

By the mid-1950s, NIH policymakers concluded that medical specialty training in most fields could be sustained without continuing NIH support, and the agency

⁶ National Institutes of Health. National Heart, Lung, and Blood Institute. *Scientific Advances: Heart Attack and Counterattack*. Bethesda, Md.: NIH, 1998.

⁷ Harris, Ruth Roy. *Dental Science in a New Age: A History of the National Institute of Dental Research*. Rockville, Md.: Monrose Press, 1989.

⁸ U.S. Congress. House. Committee on Appropriations. Subcommittee on Labor, Health and Human Services, and Education. *Statement by Dr. Harold Slavkin on Fiscal Year 1999 President’s Budget Request for the National Institute of Dental Research*. 17 March 1998.

⁹ Berman, Stephen, Patricia J. Byrns, Jessica Bondy, Pamela J. Smith, and Dennis Lezotte. “Otitis Media-Related Antibiotic Prescribing Patterns, Outcomes, and Expenditures in a Pediatric Medicaid Population.” *Pediatrics* 100, no. 4 (1997): 585-92.

¹⁰ Gleason, Patrick P., Wishwa N. Kapoor, Roslyn A. Stone, Judith R. Lave, D. Scott Obrosky, Richard Schulz, Daniel E. Singer, Christopher M. Coley, Thomas J. Marrie, and Michael J. Fine. “Medical Outcomes and Antimicrobial Costs with the Use of the American Thoracic Society Guidelines for Outpatients with Community-Acquired Pneumonia.” *JAMA* 278, no. 1 (1997): 32-39.

¹¹ McDonald, Duff, Pablo Galarza, and Sarah Rose. “The Biotech Boom.” *Money* (September 1998): 83-98.

¹² National Institutes of Health. Task Forces for the Review of NIH Biomedical Research. *Review of the National Institutes of Health Biomedical Research Training Programs*. Bethesda, Md.: NIH, 1989.

¹³ *Ibid.*

¹⁴ U.S. Congress. Senate. Committee on Labor and Public Welfare. *National Research Service Award Act of 1974*. 93rd Cong., 1st sess., 1973. S. Rept. 93-381.

returned to its earlier emphasis on research training.¹⁵ This change was followed by the formation of the Division of General Medical Sciences in 1958 and by a redistribution of research training responsibilities among the NIH institutes. As the new division (later an institute itself) took over responsibility for predoctoral training in the basic biomedical sciences, the categorical institutes increasingly focused on postdoctoral research training for Ph.D.s and physicians in the areas most closely allied with their missions. The only exception was the National Institute of Mental Health, which continued to support predoctoral training in the behavioral sciences.¹⁶

By 1968 about 15 percent of NIH extramural research funding was dedicated to research training programs, and the agency was supporting the training of some 16,000 new investigators each year. But by this time, growing inflation and the Vietnam war were taking a toll on the federal budget, and spending for domestic programs, including research and research training, was subjected to heightened scrutiny.^{17,18} After several years of fiscal constraint, the federal budget proposed by President Nixon in 1973 eliminated funding for the NIH's training grant and fellowship awards. The NIH was not the only target; the National Science Foundation's research training grants had already been slated to be phased out as well.¹⁹

In making the case for eliminating the NIH's training programs, the Nixon administration cited several significant concerns. With the NIH receiving many more applications for research grants than it had funds to support, administration officials contended that the supply of investigators was more than sufficient to carry out the agency's research mission and that the NIH's responsibilities for building up the research workforce had been fulfilled. Furthermore, many of those undergoing research training did not pursue ca-

reers in either academics or research but instead established private practices as medical specialists or clinical psychologists.²⁰ Though not explicitly stated, some believed that the Nixon administration's greatest concern was that training new investigators at the same pace as in the past would create a continuing cycle of pressure for increases in research funding.²¹

For their part, universities, faculty, and their professional organizations vigorously objected to the White House proposal, maintaining that their concerns did not merit such drastic measures. Ultimately, Congress entered the debate, holding hearings and initiating legislative action. The result was the National Research Service Award Act of 1974,²² which consolidated the research training activities then sponsored by the NIH and the Alcohol, Drug Abuse, and Mental Health Administration into a single inclusive program of training grants and fellowships: the National Research Service Awards. The National Science Foundation, however, did not fare so well; its program of research training grants was eliminated in 1973.²³

Yet supportive as it was of the NIH and its sister agency, the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA), Congress shared some of the Nixon administration's reservations about the management of research training support.²⁴ As a result, legislators incorporated measures into the National Research Service Award Act to ensure that the new training program would be equitably administered and responsive to the needs of research. From the outset, Congress signaled its intent that the National Research Service Award (NRSA) program should treat its participants evenhandedly and eliminate the "discrepancy in stipends paid to Ph.D. as opposed to M.D. graduate students"²⁵ that existed in the earlier NIH training pro-

¹⁵ Shannon, James A. *Federal Support of Biomedical Sciences: Development and Academic Impact*. Washington, D.C.: Association of American Medical Colleges, 1976.

¹⁶ U.S. Congress. Senate. Committee on Labor and Public Welfare. *National Research Service Award Act of 1974*. 93rd Cong., 1st sess., 1973. S. Rept. 93-381.

¹⁷ Strickland, Stephen Parks. *Research and the Health of Americans*. Boston: D. C. Heath and Company, 1978.

¹⁸ Shannon, James A. *Federal Support of Biomedical Sciences: Development and Academic Impact*. Washington, D.C.: Association of American Medical Colleges, 1976.

¹⁹ Walsh, John. "NIH Training Grants: The Uncertainty Factor." *Science* 188, no. 4193 (1975): 1092-94.

²⁰ Strickland, Stephen Parks. *Research and the Health of Americans*. Boston: D. C. Heath, 1978.

²¹ Shannon, James A. *Federal Support of Biomedical Sciences: Development and Academic Impact*. Washington, D.C.: Association of American Medical Colleges, 1976.

²² U.S. Congress. Senate. Committee on Labor and Public Welfare. *National Research Service Award Act of 1974*. 93rd Cong., 1st sess., 1973. S. Rept. 93-381.

²³ National Science Foundation. *Twenty-second Annual Report for Fiscal Year 1972*. Washington, D.C.: NSF, 1973.

²⁴ Walsh, John. "NIH Training Grants: The Uncertainty Factor." *Science* 188, no. 4193 (1975): 1092-94.

²⁵ U.S. Congress. Senate. Committee on Labor and Public Welfare. *National Research Service Award Act of 1974*. 93rd Cong., 1st sess., 1973. S. Rept. 93-381.

grams. Legislators also took steps to discourage individuals from going into medical specialties or other nonresearch careers following their training by requiring that trainees and fellows “pay back” their funding support by engaging in health research or teaching.

Finally, Congress decreed that National Research Service Awards be made only in areas for which “there is a need for personnel” and directed that the National Academy of Sciences provide periodic guidance on the fields in which researchers were likely to be required and on the numbers that should be trained (see Box 1-1). The present study is the eleventh to offer such guidance.

FROM 1975 TO 1994: THE FIRST TEN STUDIES

While explicit in its instruction that the number of National Research Service Awards be determined by the “national need” for biomedical and behavioral research personnel, Congress left it to those examining the workforce to define “need” and the specific fields to be considered. The earliest committee to study the subject, convened by the National Academy of Sciences in early 1975, characterized need in terms of demand for faculty, as shaped by federal support for university-based research and enrollments in higher education.²⁶ This committee also interpreted the term “biomedical and behavioral” as encompassing investigators in the basic biomedical sciences, the behavioral sciences, the clinical sciences, and health services research. In their first full-length report, issued the following year, committee members concluded that Ph.D. production in the biomedical and behavioral sciences was more than adequate to meet existing demand.²⁷

Indeed, with college enrollments leveling off and federal research expenditures growing at more modest rates than in the past, the committee called on the NIH to reduce the number of predoctoral students in the basic biomedical sciences by 10 percent and to limit postdoctoral support to existing levels. The committee recommended, furthermore, that predoctoral students in the basic biomedical sciences be supported largely

²⁶ National Research Council. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy of Sciences, 1975.

²⁷ National Research Council. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy of Sciences, 1976.

Box 1-1 National Research Service Award Act of 1974 (P.L. 93-348)

- Sec. 472. (a) (3) Effective July 1, 1975, National Research Service Awards may be made for research or research training in only those subject areas for which, as determined under section 473, there is a need for personnel.
- Sec. 473. (a) The Secretary shall, in accordance with subsection (b), arrange for the conduct of a continuing study to—
- (a) establish (A) the Nation’s overall need for biomedical and behavioral research personnel, (B) the subject areas in which such personnel are needed and the number of such personnel needed in each such area, and (C) the kinds and extent of training which should be provided such personnel;
 - (b) assess (A) current training programs available for the training of biomedical and behavioral research personnel which are conducted under this Act at or through institutes under the National Institutes of Health and the Alcohol, Drug Abuse, and Mental Health Administration, and (B) other current training programs available for the training of such personnel;
 - (c) identify the kinds of research positions available to and held by individuals completing such programs;
 - (d) determine, to the extent feasible, whether the programs referred to in clause (B) or paragraph (2) would be adequate to meet the needs established under paragraph (1) if the programs referred to in clause (A) of paragraph (2) were terminated; and
 - (e) determine what modifications in the programs referred to in paragraph (2) are required to meet the needs established under paragraph (1).

through training grants, reserving fellowships for postdoctorates, who were more likely to require mentoring than formal instruction in the practice of research.

In its evaluation of the behavioral science workforce, the committee found that overall Ph.D. production was in balance with the demand for faculty, but graduate schools were not providing sufficient numbers of Ph.D.s with the specialized training necessary to examine health-related research problems. The committee recommended shifting most NRSA training in the behavioral sciences from the predoctoral to the postdoctoral level. Because support for research training in the behavioral sciences was almost entirely (90 percent) directed toward graduate students at the time, the committee recognized that sudden changes in funding patterns could be disruptive and called for an “orderly tapering down of predoctoral support” until the recommended new distribution of 30 percent predoctoral and 70 percent postdoctoral training was reached. In contrast to its recommendation for the basic biomedical fields, the committee suggested that the NIH and ADAMHA devote most of their research training support in the behavioral sciences to training grants, even at the postdoctoral level, in order to encourage institutions to develop interdisciplinary approaches to training.

The committee found the clinical research workforce more difficult to evaluate, partly because it could not effectively measure the supply of physician investigators, but also because it was a more diverse group of researchers. The clinical research workforce includes not only M.D.s but also Ph.D.s, dentists, and other health care professionals. With available data pointing toward a decline in the supply of physician-investigators at the same time that demand for medical school faculty was growing, the committee concluded that a 10 percent increase in postdoctoral clinical research training was needed. Because of the importance of formal instruction in research methodology, the committee urged that the majority of this training (80 percent) be offered through training grants, rather than fellowships.

The committee also found health services research difficult to evaluate, in part because it was an emerging field but also because, like clinical research, it drew investigators from a variety of backgrounds. The committee recommended that because of the interdisciplinary nature of the field, research training be concentrated at the postdoctoral level and be provided

primarily through training grants. The overall number in training was to be maintained at existing levels.

In the next five studies, conducted from 1977 to 1983, subsequent committees recognized the demand for researchers in industry, government, teaching hospitals, and other settings and incorporated employment trends in these sectors into their analyses of national need.²⁸⁻³² Yet it was not until 1985, when the biotechnology industry began to recruit significant numbers of Ph.D.s, that a committee called for additional research training in the basic biomedical sciences.³³ A second increase was recommended in the subsequent report in 1989,³⁴ but by 1994 demand from industry appeared to be slowing, and the committee advised that NRSA training support in the basic biomedical sciences be maintained at existing levels. The 1994 committee also called for an increase in research training in the behavioral sciences. The latter recommendation was not based on an increased demand for faculty (which was expected to grow slowly at best) but was justified in the committee’s view by the “continuing gains being made by behavioral scientists in areas of national interest.”³⁵

Throughout the first 10 studies the supply of clinical researchers was a persistent concern. In every report, committees called for increases in clinical research training largely but not exclusively through efforts to

²⁸ Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy of Sciences, 1977.

²⁹ Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy of Sciences, 1978.

³⁰ Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research, 1979 Report*. Washington, D.C.: National Academy of Sciences, 1980.

³¹ Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy Press, 1981.

³² Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy Press, 1983.

³³ Institute of Medicine. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy Press, 1985.

³⁴ National Research Council. Committee on Biomedical and Behavioral Research Personnel. *Biomedical and Behavioral Research Scientists: Their Training and Supply. Volume I: Findings*. Washington, D.C.: National Academy Press, 1989.

³⁵ National Research Council. *Meeting the Nation's Needs for Biomedical and Behavioral Scientists*. Washington, D.C.: National Academy Press, 1994.

attract additional numbers of physicians into research. Committees also periodically addressed the demand for investigators in health services, nursing, and dental research and generally recommended that additional opportunities for research training be offered in these areas to build up what were regarded as emerging and underutilized fields.

In the years since the NRSA program was established, funding for research training has grown much more slowly than the NIH budget,³⁶ a result in part of recommendations from the studies of the research workforce conducted between 1975 and 1994. When the first NRSA awards were made for research training in 1975, the program supported 14,443 students and postdoctoral fellows.³⁷ In 1998 the NRSA program supported 15,670 students and fellows, a number projected to increase slightly in 1999 to 15,681.³⁸

To date, the NRSA program has provided research training in the biomedical and behavioral sciences to more than 130,000 students and young investigators through a combination of individual fellowship awards and institutional training grants at almost 750 universities, research institutes, and teaching hospitals.³⁹

CHANGES IN THE NATIONAL RESEARCH SERVICE AWARD PROGRAM

Since its beginnings, NRSA research training has undergone a number of modifications as a result of steps taken by the Congress and the NIH, which in some cases were prompted by recommendations from committees convened by the National Academies. These actions have extended the program into new areas of research training, established funding levels for selected disciplines and educational expenses, reduced the service obligation for recipients of NRSA support, and sought to foster the recruitment of women and minorities into research careers.

The first changes in the scope of research training came in 1976, when Congress broadened the new

NRSA program to encompass nursing.⁴⁰ Then, along with the NIH appropriations that year, Congress directed the administrators of the Minority Access to Research Careers program in the National Institute of General Medical Sciences to support research training for undergraduates.⁴¹ With that mandate, the NIH began to make NRSA training available to undergraduates at historically black colleges and other minority-serving institutions. (The full array of NRSA training grants and fellowships is described in Appendix A.)

In 1978, Congress waived the service payback component of the NRSA program for those pursuing short-term training for periods up to three months.⁴² The payback requirement, which had been put into place when the NRSA program began, obligated recipients to engage in a year of health research or teaching for each year of NRSA support. As soon as the requirement went into effect, however, there was a sharp decline in the number of medical and other health professions students participating in summer or other short-term training experiences. It was widely believed at the time, and substantiated by later studies,⁴³ that early research experience played a role in the decision to seek formal research training and pursue a research career. Therefore, the dramatic drop in participation was a cause for concern and ultimately prompted congressional action.

The scope of the program was further broadened in 1978, when Congress expanded the NRSA program to cover training in health services research⁴⁴ and again in 1985 when Congress incorporated primary care research.⁴⁵ Specific funding targets were established with the Health Research Extension Act of 1985, when Con-

³⁶ National Institutes of Health. Department of Health and Human Services. *NIH Data Book, 1985*. Bethesda, Md.: NIH, 1985.

³⁷ National Research Council. *Personnel Needs and Training for Biomedical and Behavioral Research*. Washington, D.C.: National Academy of Sciences, 1975.

³⁸ National Institutes of Health. Office of Financial Management. *FY 2000 Congressional Justification Overview*. Bethesda, Md.: NIH, 1998, p. 30.

³⁹ Unpublished tabulation from the NIH IMPAC System; on file in the archives of the Academies.

⁴⁰ *Health Research and Health Services Amendments of 1976*. P.L. 94-278, Title II, Section 201. 94th Cong., 2nd sess., 22 April 1976.

⁴¹ U.S. Congress. Senate. Committee on Appropriations. *Departments of Labor and Health, Education, and Welfare and Related Agencies Appropriation Bill, 1977*. 94th Cong., 2nd sess., 1976. S. Rept. 94-997, p. 57.

⁴² *Community Mental Health Centers Extension Act of 1978*. P.L. 95-622, 95th Cong., 2nd sess., Title II, Part D, 15 May 1978.

⁴³ Sherman, Charles R., H. Paul Jolly, Thomas E. Morgan, Elizabeth J. Higgins, Donald Hollander, Terry Bryll, and Ezekiel R. Sevilla. Office of Program Planning and Evaluation, National Institutes of Health. *On the Status of Medical School Faculty and Clinical Research Manpower, 1968-1990*. Washington, D.C.: Association of American Medical Colleges, 1982.

⁴⁴ *Health Services Research, Health Statistics, and Medical Technology Act of 1978*. P.L. 95-623, Section 3. 95th Cong., 2nd sess., 9 November 1978.

⁴⁵ *Health Research Extension Act of 1985*. P.L. 99-158, Title IV, Section 487. 99th Cong., 1st sess., 20 November 1985.

gress required that 0.5 percent of NRSA funds be allocated to each of the two fields.⁴⁶ The same law directed that funds for training in health services research be administered by what is now the Agency for Healthcare Research and Quality. Research training in primary care originally came under the purview of the NIH but was delegated to the Health Resources and Services Administration by Congress in 1988 after concerns were raised that the NIH was interpreting the meaning of “primary care” too broadly.^{47,48} With the passage of the NIH Revitalization Act of 1993, funding levels for training in health services and primary care research were doubled (to 1 percent of the NRSA budget for each), and these two fields remain the only ones for which specific funding levels have been established by law.⁴⁹

The 1993 legislation instituted major changes in the service payback requirement as well. With the change in the law, predoctoral trainees and fellows were no longer obligated to pay back their NRSA support. The law was further modified to limit the payback requirement for postdoctoral trainees and fellows to 12 months and to add research training to the roster of eligible activities, prompted in part by a belief that physicians and other professional doctorates who received at least two years of training are more likely to gain the skills necessary to successfully pursue research careers. As a result, a second year of NRSA-supported postdoctoral study now fulfills the obligation incurred in the first year of postdoctoral support.⁵⁰

In response to concerns in the early 1990s about the need for more women and minorities in research, the 1993 law also directed that NRSA training be administered so as to encourage women and individuals from disadvantaged backgrounds (including racial and eth-

nic minorities) to pursue research careers.⁵¹ At the same time, Congress required the NIH to ensure that women and minorities were routinely included as subjects in clinical research studies.

More recently, the NIH adopted a new approach to educational expenses associated with research training. In the 1970s and the first part of the 1980s, NIH training grants and fellowships generally covered complete tuition and fees, but by the early 1990s rising tuition costs led a number of institutes to choose to pay less than full tuition rather than cut the number of fellows and trainees. In 1996, to restore uniformity, the NIH announced a new standard for the NRSA program: It would cover 100 percent of tuition and fees up to \$2,000 and 60 percent of those costs above that level.⁵²

A PORTRAIT OF RESEARCH TRAINING TODAY

As illustrated in Table 1-1, NRSA training support today is almost evenly divided between graduate students and postdoctorates, is concentrated in the basic biomedical sciences (70.7 percent), and is largely provided through training grants (83.5 percent) that are awarded to institutions that then select graduate student and postdoctoral trainees.

There are significant differences in NRSA support among fields, stemming in part from the distinctive patterns of education and career development in the basic biomedical, behavioral, and clinical sciences. Training in clinical research, for example, is more likely to be provided at the postdoctoral level (71.8 percent) than that in other fields so as to build on a foundation of clinical expertise. Clinical research training is also much more likely to be supported through training grants (95.6 percent) than that in other fields, a pattern recommended in previous NRSA studies in order to encourage universities and teaching hospitals to provide instruction in methodology.

In contrast, the current pattern of NRSA research training in the behavioral sciences illustrates the challenges of changing the allocation of research training support. Though training in the behavioral sciences was

⁴⁶ Ibid.

⁴⁷ U.S. General Accounting Office. Division of Human Resources. *Medical Research: National Research Service Awards for Research in Primary Medical Care*. A report to the chairman, Subcommittee on Health and the Environment, Committee on Energy and Commerce, House of Representatives. Washington, D.C.: Government Printing Office, July 1987.

⁴⁸ *Health Omnibus Programs Extension of 1988*. P.L. 100-607, Title VI, Section 635. 100th Cong., 2nd sess., 4 November 1988.

⁴⁹ *National Institutes of Health Revitalization Act of 1993*. P.L. 103-43, Title XVI, Section 1641. 103rd Cong., 1st sess., 10 June 1993.

⁵⁰ *National Institutes of Health Revitalization Act of 1993*. P.L. 103-43, Title XVI, Section 1602. 103rd Cong., 1st sess., 10 June 1993.

⁵¹ *National Institutes of Health Revitalization Act of 1993*. P.L. 103-43, Title XVI, Section 1601. 103rd Cong., 1st sess., 10 June 1993.

⁵² “Tuition Costs on NIH NRSA Training Grant and Fellowship Awards.” *NIH Guide for Grants and Contracts*, 2 February 1996. Available: <http://grants.nih.gov/grants/guide/index.html>.

TABLE 1-1 Distribution of Full-Time NRSA Trainees and Fellow Positions, Fiscal Year 1998

	Predocctoral	Postdoctoral	Undergraduate ^a	Total
Basic biomedical	5,399	4,211	641	10,251
MSTP ^b	824	—	—	824
Subtotal	6,223	4,211	641	11,075 (70.7%)
Behavioral	639	475	89	1,203 (7.7%)
Clinical	882	2,280	15	3,177
Health services (AHCPR)	64	55	—	119
Primary care (HRSA)	—	96	—	96
Subtotal	946	2,431	15	3,392 (21.6%)
Total	7,808 (49.8%)	7,117 (45.4%)	745 (4.8%)	15,670

	Basic Biomedical	Behavioral	Clinical	Total
Trainees				
Predocctoral	5,791	500	840	7,131
Postdoctoral	2,478	357	2,388	5,223
Undergraduate ^a	627	89	15	731
Subtotal	8,896	946	3,243	13,085 (83.5%)
Fellows				
Predocctoral	432	139	97	668
Postdoctoral	1,733	118	52	1,903
Undergraduate ^a	14	—	—	14
Subtotal	2,179	257	149	2,585 (16.5%)
Total	11,075 (70.7%)	1,203 (7.7%)	3,392 (21.6%)	15,670

^a Receiving support through Minority Access to Research Careers or Career Opportunities in Research training grants for the undergraduate education of minority students who plan to pursue graduate studies in the biomedical or behavioral sciences.

^b Students in the Medical Scientist Training Program for M.D.-Ph.D. training.

SOURCES: Data are from the NIH Trainee and Fellow File; the Office of Research and Review, Education, and Policy, AHRQ; and the Bureau of Health Professions, HRSA.

more evenly divided between graduate students (53.1 percent) and postdoctorates (39.5 percent) in 1998 than in the past, the shift to an emphasis on postdoctoral training recommended by previous NAS committees has not occurred.

Today the typical duration of predoctoral support is three years in the basic biomedical sciences and two years in the behavioral sciences.⁵³ Although NRSA policy permits trainees and fellows to receive up to five years of predoctoral funding, many NIH institutes encourage more limited appointments, with the expecta-

tion that doctoral students have opportunities to serve as research or teaching assistants during the course of their studies. Working as a research assistant is widely regarded as an important educational experience for graduate students, particularly in the basic biomedical sciences. Federal policy has long encouraged this practice by permitting investigators to employ graduate students as research assistants and to provide tuition remission as a form of compensation, as long as “there is a bona fide employer-employee relationship between the student and the institution.”⁵⁴

⁵³ Pion, Georgine M. Office of Extramural Research, National Institutes of Health. *The Early Career Progress of NRSA Predoctoral Trainees and Fellows*. Bethesda, Md.: NIH, 2000.

⁵⁴ Office of Management and Budget. *Circular A-21 (Revised), Cost Principles for Educational Institutions*. Washington, D.C.: OMB, 1998.

Indeed, in 1975, when Congress replaced the NIH and ADAMHA's existing research training programs with NRSA training grants and fellowships, it took little note of the support by the two agencies of other training-related activities, such as research assistantships. At the time, more than 4,700 graduate students were working as research assistants on grants from the NIH and other agencies of the Department of Health and Human Service (DHHS). The number of postdoctorates holding similar NIH- or DHHS-funded positions is not known but was probably the majority of the nearly 3,200 postdoctoral fellows in the biomedical, behavioral, and clinical sciences supported by federal research grants that year.⁵⁵ Among these were over 100 postdoctoral fellows, mostly from Western Europe, who were awarded fellowships from NIH's Fogarty International Center for study in the U.S.⁵⁶ Close to 950 newly appointed faculty members received career development awards from the agency, allowing them an opportunity to polish their research skills before

⁵⁵ Unpublished tabulation from the Survey of Graduate Students and Postdoctorates in Science and Engineering; on file in the archives of the Academies.

⁵⁶ Eiss, Robert. Office of International Science Policy and Analysis, Fogarty International Center, National Institutes of Health. Personal communication, February 1998.

becoming independent investigators.⁵⁷ In addition to those training in academic institutions, an estimated 1,000 postdoctoral fellows and clinicians were pursuing research training on the agency's Maryland campus.⁵⁸

While the number of NRSA training grants and fellowships has grown by less than 10 percent over the past 25 years, NIH training-related activities have increased dramatically, as illustrated in Table 1-2.

Some 12,400 graduate students today work as research assistants on NIH grants, and federal grants employ more than 11,700 postdoctoral fellows in the biomedical, behavioral, and clinical sciences. The Fogarty International Center now limits its support to people from developing nations and former socialist economies, such as the countries of Central and Eastern Europe; in 1997 the center funded about 500 full-time and another 1,000 short-term students and postdoctoral fellows. Several new types of career development awards have been introduced in recent years, and altogether these awards support more than 1,600 faculty on their way to becoming independent

⁵⁷ Unpublished tabulation from the NIH IMPAC System; on file in the archives of the Academies.

⁵⁸ Chen, Philip. Office of Intramural Research, National Institutes of Health. Personal communication, February 1999.

TABLE 1-2 Training-Related Activities of the NIH

	1975	1997
Graduate research assistants	4,800	12,400
Postdoctoral research associates	3,200	11,700
Recipients of career development awards	900	1,600
Participants in Fogarty International Center training programs	100	500 full-time 1,000 part-time
Postdoctoral fellows on the NIH campus	1,000	3,500

NOTES: (1) Numbers rounded to the nearest hundred; (2) these figures include all postdoctoral research associates in the biomedical, behavioral, and clinical sciences supported by federal funds and thus overestimate the NIH role in postdoctoral training.

SOURCES: Data on graduate research assistants and postdoctoral research associates are from the Survey of Graduate Students and Postdoctorates in Science and Engineering; data on career development awards are from the NIH IMPAC system; estimates of participants in Fogarty International Center training programs and NIH intramural fellows are from the FIC Office of International Science Policy and Analysis and the NIH Office of Intramural Research.

investigators. The NIH campus now hosts almost 3,500 postdoctoral fellows and clinicians for research training.⁵⁹

Only citizens and permanent residents of the U.S. are eligible for NRSA training grants and fellowships and NIH career development awards, whereas Fogarty International Center programs are restricted to those from outside the U.S. Opportunities for research training through most other avenues are equally available to U.S. citizens and those from abroad. There are few restrictions on employment as a research assistant or postdoctoral fellow under federal grant funding, and increasing numbers of foreign graduate students and postdoctorates in the biomedical sciences and, to a lesser extent, the behavioral sciences are supported by these mechanisms.

Because of these developments, the role of NRSA training programs in the biomedical and behavioral sciences has diminished over the years. As a result, the NIH's ability to ensure that federal funds are directed where most needed has also declined.

With fewer data available, the role NRSA support plays in training clinical investigators cannot be determined as accurately as the role it plays in the basic biomedical and behavioral sciences. Because clinical research training for physicians, dentists, and doctoral-level professionals who do not hold a Ph.D. generally takes place at the postdoctoral level, two major sources of funding that support research training in the biomedical and behavioral sciences—graduate research and university teaching assistantships—are not available. Consequently, a larger fraction of those preparing for clinical research careers may depend on NRSA training grants and fellowships than their counterparts in other fields.

RECENT DEVELOPMENTS IN RESEARCH TRAINING

Since the National Research Council's 1994 report, *Meeting the Nation's Needs for Biomedical and Behavioral Scientists*,⁶⁰ the U.S. research workforce has been the focus of considerable attention and discussion

and the subject of numerous national meetings, public policy studies, and congressional hearings. Much of this activity has centered on two broad areas of concern: (1) the declining numbers of health care professionals pursuing research training and careers in clinical research and (2) the growing population of Ph.D.s, particularly in the basic biomedical sciences.

A synopsis of these developments must surely begin with the 1994 "national needs" report itself and the response to the report by the NIH, the Agency for Healthcare Research and Quality, and the Health Resources and Services Administration. Of the eight principal recommendations of the committee that preceded ours, the agencies focused on two: (1) increasing the stipends for trainees and fellows and (2) evaluating the NRSA program. Since then, NRSA stipend levels have been increased three times, and the NIH has evaluated its NRSA training in the biomedical and behavioral sciences. Recommendations for expanding the number of NRSA training grants and fellowships in the behavioral and clinical sciences, oral health, nursing, and health services research were not acted on, prompting Congress to request a report on the agencies' progress in 1996. In explaining their actions to Congress, NIH, AHRQ, and HRSA officials indicated that they had focused initially on the highest-priority recommendations, and they expected to direct additional research training funds to stipends until NRSA stipend levels were comparable to other sources.⁶¹

Following the 1994 study on the NRSA program as a whole, several subsequent reports focused on clinical research and training. In the fall of 1994, an Institute of Medicine committee issued *Careers in Clinical Research: Obstacles and Opportunities*, which included recommendations for:

- evaluating existing clinical research training programs;
- redirecting funds to the most effective forms of clinical research training;
- emphasizing training programs resulting in an advanced degree in the evaluative sciences related to clinical research;

⁵⁹ Alexander, James. Office of Education, National Institutes of Health. Personal communication, February 1999.

⁶⁰ National Research Council. *Meeting the Nation's Needs for Biomedical and Behavioral Scientists*. Washington, D.C.: National Academy Press, 1994.

⁶¹ National Institutes of Health. *Implementing the Recommendations in the 1994 Report from the National Academy of Sciences: Meeting the Nation's Needs for Biomedical and Behavioral Scientists*. Report to the U.S. House of Representatives, Subcommittee on Labor, Health and Human Services, and Education, Committee on Appropriations. Bethesda, Md.: NIH, 1997.

- increasing the number of M.D.-Ph.D. and D.D.S.-Ph.D. programs that train investigators with expertise in patient-oriented research; and
- expanding initiatives that reduce educational debt, through tuition subsidies, as in the case of M.D.-Ph.D. programs, and through loan forgiveness.⁶²

In the spring of 1995, NIH Director Harold Varmus convened a committee to review the status of clinical research in the U.S. and consider, among other topics, the recruitment and training of future clinical researchers. The NIH Director's Panel on Clinical Research report, issued in late 1997, echoed many of the suggestions for clinical research training put forth by the Institute of Medicine.⁶³ Its recommendations included:

- clinical research training programs aimed at medical students, such as M.D.-Ph.D. programs for clinical research;
- ensuring that postdoctoral training grants include formal coursework or degree programs in clinical research;
- new support mechanisms for young and mid-term clinical investigators; and
- steps to reduce researchers' educational debts.

Between the time the NIH director's panel was convened and its final report, several of its suggestions for training of clinical investigators had already been adopted by the agency. In late 1996, the NIH announced a program to bring medical and dental students to its Maryland campus for a one- to two-year clinical research training experience.⁶⁴ In early 1997, the National Institute for General Medical Sciences issued new guidelines for its M.D.-Ph.D. training grants, encouraging research training in additional fields such as computer sciences, epidemiology, public health, bioengineering, biostatistics, bioethics, and economics and other social sciences.⁶⁵

⁶² Institute of Medicine. *Careers in Clinical Research: Obstacles and Opportunities*. Washington, D.C.: National Academy Press, 1994.

⁶³ National Institutes of Health. Director's Panel on Clinical Research. *Report to the Advisory Committee to the NIH Director*. Bethesda, Md.: NIH, 1997.

⁶⁴ National Institutes of Health. Clinical Research Training Program. *Application to the National Institutes of Health Clinical Research Training Program*. Bethesda, Md.: NIH, 1996.

⁶⁵ "NIGMS Guidelines for National Research Service Awards," *NIH Guide for Grants and Contracts*, 7 February 1997. Available: <http://grants.nih.gov/grants/guide/index.html>.

After the panel's final report in early 1998, the NIH took several additional steps to respond to the group's recommendations. First, the agency introduced three new types of career development awards: the K23 to provide health care professionals committed to clinical research careers with a period of supervised study and research;⁶⁶ the K24 to support the research and mentoring activities of mid-career clinical investigators;⁶⁷ and the K30 to provide institutions with the funds to develop or expand formal coursework in areas related to clinical research.⁶⁸ Later that year, clinical fellows at the NIH were offered the opportunity to enroll in a joint master's degree program in clinical research with Duke University.⁶⁹

In 1995, another Institute of Medicine committee issued *Health Services Research: Workforce and Educational Issues*, which endorsed the number of training positions in health services research that had been recommended in the 1994 "national needs" study. It also encouraged the AHRQ to focus its training funds on areas in which researchers are in short supply, such as outcomes measurement, biostatistics, epidemiology, health economics, and health policy, and to provide a number of institutional training grants for innovative research training programs.⁷⁰ In 1998, the AHRQ responded to the latter recommendation by granting "innovation awards" to 10 institutions to support the design and implementation of new models of health services research training.⁷¹

Doctoral training in the basic biomedical sciences, and to a lesser extent, in the behavioral sciences, have also been the subject of multiple studies since 1994. In a study sponsored by the National Science Foundation

⁶⁶ "Mentored Patient-Oriented Research Career Development Award," *NIH Guide for Grants and Contracts*, 6 April 1998. Available: <http://grants.nih.gov/grants/guide/index.html>.

⁶⁷ "Midcareer Investigator Award in Patient-Oriented Research," *NIH Guide for Grants and Contracts*, 6 April 1998. Available: <http://grants.nih.gov/grants/guide/index.html>.

⁶⁸ "Clinical Research Curriculum Award," *NIH Guide for Grants and Contracts*, 6 April 1998. Available: <http://grants.nih.gov/grants/guide/index.html>.

⁶⁹ Campbell, Paulette Walker. "Duke U. and NIH Collaborate to Train Clinical Researchers." *Chronicle of Higher Education* 45, no. 14 (27 November 1998): A30.

⁷⁰ Institute of Medicine. *Health Services Research: Work Force and Educational Issues*. Washington, D.C.: National Academy Press, 1995.

⁷¹ Agency for Health Care, Policy, and Research. *Innovation and Incentive Awards*. Rockville, Md.: AHCPR, 1998.

and Department of Energy, the Academies' Committee on Science, Engineering, and Public Policy reviewed graduate education in the biological, physical, engineering, and social sciences. In its 1995 report, *Reshaping the Graduate Education of Scientists and Engineers*, the committee called on universities to offer a broader range of academic options to their students and on federal agencies to promote this goal by supporting graduate education through training grants.⁷² While it believed that research assistantships should remain an option for graduate student support, the committee recognized that an increased emphasis on training grants could reduce the number of research assistantships available. The committee also urged universities to provide better career information and guidance to students and appealed to universities, government, industry, and professional organizations to work together to develop a national human resource policy for scientists and engineers.

In response to a congressional inquiry about how it was planning to adapt its policies in the wake of *Reshaping the Graduate Education of Scientists and Engineers*, NIH indicated that, because the agency already relied heavily on training grants, its approach to funding graduate education was likely to remain much the same.⁷³ With regard to the other major recommendations, the NIH noted that existing training grant guidelines permitted research training in industry and other settings and pledged that it would take steps to encourage institutions with training grants to expose students to a range of career options.

Subsequently, in 1997 the National Institute of General Medical Sciences announced new guidelines for its training grants in the basic biomedical sciences and urged graduate programs to provide opportunities for internships in industry and other settings and for experience in teaching.⁷⁴ In addition, graduate programs were encouraged to supply trainees with information on career outcomes of graduates and to provide seminars and workshops on employment opportunities and career counseling.

Shortly after *Reshaping the Graduate Education of Scientists and Engineers* was published, William Massy of Stanford University and Charles Goldman of RAND released a discussion paper on the supply and demand for Ph.D.s in science and engineering.⁷⁵ The authors concluded that enrollment of doctoral students is driven more by the need for research and teaching assistants than by the labor market for Ph.D.s and that the resulting "overproduction" of Ph.D.s has led to chronic underemployment and deteriorating career attractiveness in affected fields. Consequently, increased research funding will worsen job prospects in the long run if faculty members responded by admitting more doctoral students to serve as research assistants. The authors maintained that restructuring academic research was the only sure way to bring the production of Ph.D.s into balance with demand. While improvements in the development and dissemination of data on the scientific and engineering labor markets can serve as a basis for restraining production rates, major changes in Ph.D. production will occur only when departments reduce their dependence on the research and teaching services provided by doctoral students.

A 1996 consensus conference sponsored by the Federation of American Societies for Experimental Biology addressed some of the issues raised by Massy and Goldman and objected to federal regulation of the size of graduate programs.⁷⁶ Instead, the conference report called for prospective students to be informed about employment trends in their fields of interest and for universities to "self-regulate" the size of graduate programs. Though it urged institutions to refrain from admitting graduate students in order to fulfill a need for teaching or research assistants, the conference report did not offer any advice about how those needs should otherwise be met.

In the fall of 1998, a National Research Council committee examining the career paths of young investigators also recommended restraint in the rate of growth in the number of graduate students in the life sciences.⁷⁷ In *Trends in the Early Careers of Life Sci-*

⁷² National Academy of Sciences. *Reshaping the Graduate Education of Scientists and Engineers*. Washington, D.C.: National Academy Press, 1995.

⁷³ Harold Varmus, letter to Congressman Schiff, 30 October 1995.

⁷⁴ "NIGMS Guidelines for National Research Service Awards," *NIH Guide for Grants and Contracts*, 7 February 1997. Available: <http://grants.nih.gov/grants/guide/index.html>.

⁷⁵ Massy, William F., and Charles A. Goldman. *The Production and Utilization of Science and Engineering Doctorates in the United States*. Stanford Institute for Higher Education Research Discussion Paper. Stanford, Calif.: 1995.

⁷⁶ Federation of American Societies for Experimental Biology. *Graduate Education: Consensus Conference Report*. Bethesda, Md.: FASEB, 1997.

⁷⁷ National Research Council. *Trends in the Early Careers of Life Scientists*. Washington, D.C.: National Academy Press, 1998.

entists, the committee warned that the number of Ph.D.s awarded annually may already be too high and echoed the recommendations of previous reports in calling for students to be better informed about career prospects in their fields. The report also urged educators to limit the size of graduate programs in the life sciences and suggested that the federal government shift support for graduate students from research grants to training grants or fellowships.

In November of 1998, Elizabeth Marincola and Frank Solomon of the American Society for Cell Biology published an analysis of the changing career paths in cell biology and their implications for research training.⁷⁸ Drawing on the results of a 1997 survey of the society's members, the authors concluded that by every measure examined (e.g., time to degree, number of postdoctoral appointments, finding an independent position, obtaining grant funding), establishing a research career is more difficult today than in the past. In light of these findings and the high levels of dissatisfaction reported by younger members of the society—31 percent questioned their decision to get a Ph.D., reporting that they “probably” or “definitely” would not do so again—Marincola and Solomon cautioned that the future of research could be at risk if steps were not taken to lessen the barriers to a science or science-related career. Among the measures favored by the authors were adapting training to the career goals of trainees and the creation of professional research positions that do not involve teaching or grant writing.

THE CURRENT STUDY

The Committee on National Needs for Biomedical and Behavioral Scientists began its work in late 1997, in the wake of the studies, meetings, and changes in public policy detailed above. The committee's deliberations benefited a great deal from this work, as will be evident in further discussion of many of these developments throughout the report.

The committees that preceded ours in studying “national needs” for the biomedical and behavioral workforce were charged with estimating the future supply and demand for researchers and with developing rec-

ommendations for the size and other features of the NRSA program. In a departure from that approach, the NIH asked that the current committee make recommendations concerning not only the size of the NRSA program but also the overall production of research personnel. Specifically, the committee was charged with:

- estimating the current and future supply of scientists;
- estimating the future demand for scientists;
- utilizing estimates of the future demand for scientists and information about the current balance between supply and demand to develop recommendations for the appropriate size of the NRSA program and the overall production of research personnel in the biomedical, behavioral, and clinical sciences; and
- developing recommendations for improving the NRSA program.

Following an initial planning session in October of 1997, the committee of eleven experts in the fields of biomedical, behavioral, and clinical research, labor economics, and demography (see Appendix B) held four meetings to gather information on research training and draft their recommendations. During the course of its meetings, the committee heard from representatives of the NIH, AHRQ, and HRSA as well as professional societies, faculty members, and researchers in training. Comments from the interested public were also sought, through letters to 885 research and industry experts, graduate deans, directors of training programs, fellows, and trainees. The committee received 109 letters and statements in response, which are summarized in Appendix C.

The committee concentrated its attention on the three broad fields of biomedical, behavioral, and clinical research, with dental, nursing, and health services research included in the latter category. Because the last committee to consider workforce needs in these fields concluded that models of supply and demand could not be relied on for valid forecasts and suggested that future committees be guided by a demographic analysis of the research workforce, many of the current recommendations are based on the results of such a demographic analysis. This analysis considered such factors as the average age of current investigators in the biomedical and behavioral sciences, the number of Ph.D.s expected to join the workforce in the years ahead, and the likely effect of retirements and deaths. The committee supplemented this analysis by reviewing such

⁷⁸ Marincola, Elizabeth, and Frank Solomon. “The Career Structure in Biomedical Research: Implications for Training and Trainees.” The American Society for Cell Biology Survey on the State of the Profession. *Molecular Biology of the Cell* 9 (November 1998): 3003-6.

indicators of short-term demand as trends in faculty and industry hiring and perceptions of the job market by recent Ph.D.s.

Chapters 2, 3, and 4 review trends in the preparation and employment of basic biomedical, behavioral, and clinical researchers and make recommendations for each field. The report concludes in Chapter 5 with an examination of minority researchers and other issues that cut across the three broad fields.

The committee regards the NRSA program as a substantial achievement, of which the NIH, the Agency for Healthcare Research and Quality, and the Health

Resources and Services Administration can justifiably be proud. The committee believes, however, that the research workforce will require continuing attention and change if its successes are to continue and increase. In particular, the committee believes that the NRSA program must increase its efforts to recruit and train investigators who will address the severe and too often neglected health needs of minority populations and investigators who will integrate and translate the rapidly increasing body of knowledge of fundamental science into programs to improve the health of Americans and people around the world.