

The Stanford Medical Youth Science Program: 18 Years of a Biomedical Program for Low-Income High School Students

Marilyn A. Winkleby, PhD, MPH

Abstract

The Stanford Medical Youth Science Program (SMYSP) is a biomedical pipeline program that seeks to diversify the health professions by providing academic enrichment in the medical sciences and college admissions support to very low-income high school students. Each summer 24 students are recruited from over 250 California high schools for the five-week residential program, led by 10 undergraduate students. Participants divide their time between classroom instruction, anatomy practicums, hospital field placements, research projects, and college admissions advising. Since its inception in 1988, 405 students have completed SMYSP and

96% have been observed for up to 18 years. The majority are from underrepresented minority groups (33.3% Latino, 21.7% African American, 4.0% Native American), many with poor academic preparation. One hundred percent of age-eligible participants have graduated from high school, and 99% have been admitted to college. Of those admitted to college (and not currently college students), 81% have earned a four-year college degree, the majority majoring in biological and physical sciences (57.1%). Among four-year college graduates, 52% are attending or have graduated from medical or graduate school. Many of the four-year

college graduates (44.4%) are becoming or have become health professionals. This program, distinguished by direct participation in the sciences, strong mentoring, college admissions preparation, and long-term career guidance, has been highly successful in reaching low-income students and preparing them for medical and other careers. Results highlight the need to track students for as long as 10 to 15 years to accurately assess college graduation rates and acceptance to medical and graduate school.

Acad Med. 2007; 82:139–145.

Far too few students from underrepresented ethnic minority groups in the United States complete postsecondary education. Seventeen percent of African American, 11% of Latino, and 12% of Native American adults aged 25 and older earn a college degree, compared with 28% of white, non-Latino adults.^{1,2} Even fewer minority students earn degrees in the sciences and enter biomedical and health professions.³ For example, African Americans, Latinos, and Native Americans together make up 25% of the U.S. population, yet these three groups make up only 6% of physicians, 8% of registered nurses, and 5% of dentists.³ Similarly, low-income students are severely underrepresented in health professions—students from families in the lowest quintile of family incomes account for less than 3% of medical students.⁴ These disparities by

ethnicity and income have been called one of health care's biggest failures.

Training more ethnic minority and low-income students in science and promoting their interest in health careers is one solution to this national problem.^{5,6} It is well known that minority physicians are more likely to specialize in primary care medicine than their nonminority counterparts (e.g., family practice, internal medicine, pediatrics).⁷ They are also much more likely than nonminority physicians (66% versus 33%, respectively) to practice in inner-city and rural areas where medically underserved populations are concentrated, population growth is greatest, and shortages of health care personnel are most acute.^{7,8} Minority allied health professionals (e.g., physician assistants, nurses, medical technicians) have similar practice patterns in medically underserved areas.

Future health professionals from ethnic minority and low-income groups are “lost” early. Studies show that students’ interest in science and attitudes toward achievement decline during middle and high school, before they enter college.⁹ Even when their interest in science

endures, these students are often discouraged from taking honors or college preparatory science and math classes. In addition, the high schools that many of these students attend often have few research opportunities, little collaboration with community-based health facilities, and almost no partnerships with health professionals at the university level. Furthermore, these schools often lack teachers and counselors who are available to advise students about scientific and health careers and/or the college admission process.

Biomedical programs, developed for students during their high school years, can help address the shortage of health professionals because these are the years when the life sciences and physical sciences are taught and when students’ interest in health careers may start to develop in a meaningful way. In addition, the college admissions process is most relevant to high school students when they are taking college placement tests and applying to colleges. Education programs offered at this critical juncture in the “pipeline” from high school to college can reach students who are still undecided about postsecondary

Dr. Winkleby is professor of medicine, Stanford Prevention Research Center, Stanford University School of Medicine, Stanford, California.

Correspondence should be addressed to Dr. Winkleby, Stanford Prevention Research Center, Stanford University School of Medicine, 211 Quarry Road, Room N229, Stanford, CA 94305-5705; telephone: (650) 723-7055; fax: (650) 725-6247; e-mail: (winkleby@stanford.edu).

education and career choices, thus providing a unique window of opportunity for increasing the numbers of underrepresented minority and low-income students in medical and other health professions.⁵

Many schools of medicine and schools of public health in the United States offer academic enrichment programs designed to reach “disadvantaged” students before they enter college.^{5,10} Unfortunately, many such pipeline programs have experienced financial cutbacks in recent years, and others have not been sustained. Other programs in schools of medicine and schools of public health are designed for students who are already within the higher education system at the baccalaureate level or beyond.¹¹ Although valuable, these programs have not been consistently effective in increasing the total number of underrepresented students in health professions because medical and health professions schools compete for the same small pool of students.

The SMYSP: Background

The purpose of this article is to describe the components of a biomedical pipeline program that seeks to diversify the health professions, the Stanford Medical Youth Science Program (SMYSP), which was initiated in 1988. The SMYSP is based on the premise that there are large numbers of low-income students who are interested in the health sciences but lack the academic preparation, career-building skills, peer and academic support, and understanding of the college admissions process to succeed in higher education. A previous article provided a description of the SMYSP from a student perspective¹²; the current article provides 18 years of participating students’ college and career achievements.

The SMYSP has a number of key components (List 1). These are congruent with typologies identified in the precollege enrichment program literature—academic enhancement, motivation, mentorship, research apprenticeship, academic partnerships, college admissions preparation, and career counseling.^{6,13} An emphasis on low-income and/or underrepresented ethnic minority students ensures the selection of students who are often missed by academic enrichment

List 1

Key Components of the Stanford Medical Youth Science Program (SMYSP)

- Recruits low-income and/or underrepresented ethnic minority students
 - Offers academic enrichment in the biological and health sciences
 - Imparts knowledge about scientific and health careers
 - Offers personalized college admissions preparation and career counseling
 - Provides exposure to college life
 - Provides individualized and participatory activities
 - Offers stimulating and in-depth learning environments
 - Provides direct interaction and apprenticeships with role models—health professionals, scientists, college and medical students
 - Creates academic partnerships within the university, school of medicine, hospitals and clinics, and scientific facilities
 - Reinforces learning through technology-based resources
 - Provides long-term college and career support
 - Demonstrates effectiveness
 - Disseminates best practices and resources
 - Secures organizational support to help sustain program
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programs but who have experienced common barriers to higher education and may best benefit from individualized programs such as the SMYSP. One SMYSP alumnus who is a practicing physician in rural central California and who attended Stanford after completing the program recently reflected on his background: “When I was growing up, I worked in the fields with my mother. I was my high school valedictorian with strong grades but I didn’t know anything about college. I had never heard of Stanford or any other universities before SMYSP.”

Other key components include a combination of academic enrichment in the biological and health sciences, stimulating learning environments, information about scientific and health careers, personalized college and career advising, and exposure to college life. Scientific lectures from faculty and

physicians enhance and build on information that students have received in high school classes, and individualized and in-depth learning environments create an excitement about science and medicine. One SMYSP alumna who is a dental student commented about faculty lectures 10 years after her participation in the program: “Then the lectures, man those were some great lectures. I felt like I was in heaven, sitting in front of college professors and doctors. It was like a dream come true.” Personalized guidance about college and careers motivates students and creates self-confidence. A student who participated in the SMYSP 10 years ago and who is now an allied health professional stated: “One thing I remember strongly was our counselor saying that it didn’t matter where we came from, how much money we had or didn’t have, or any other obstacles we faced socially, but if we worked hard enough and had a solid plan then we could go to college and be whatever we wanted to be because we were bright students and nobody could ever take that away from us.”

Another key component of the SMYSP is its long-term support, which is viewed as particularly meaningful by many students. Long-term support includes letters of recommendation for colleges and jobs, identification of scholarships and research apprenticeships, career guidance, and encouragement from staff during difficult personal and family times. Continuing support is especially critical for low-income students who often lack academic mentors and role models in their families, schools, or communities. As noted by an SMYSP alumnus who is now a third-year medical student, “SMYSP accepted me when I was a struggling kid with failing grades and part of a gang. It supported me then and for years to come.”

Recruitment and Eligibility

Applicants to the SMYSP are recruited from over 250 northern and central California high schools via applications sent to their schools and made available on the Internet in late winter of each year. Students who will have completed their sophomore or junior year and are interested in the sciences and health professions are eligible to apply. Although all students must be from

low-income homes, applicants can be from any ethnic background.

Students complete an application about their family background and submit a copy of their high school transcript, two letters of recommendation from teachers, counselors, or work supervisors, and four short essays about their background and career goals. Low-income status is determined by an evaluation of parents' or guardians' educations and occupations, family income, number supported by the family income, and cost of living in the family's geographic area. Priority is given to students who are the first in their families to attend college, lack role models, have shown resiliency in the face of personal hardship (e.g., death of a parent, family violence, gang affiliation, foster care placement), and are from underresourced schools and communities (e.g., rural and inner-city schools, agricultural labor camps). Students who are on a well-defined career path (e.g., parent or sibling graduated from college, participation in other academic enrichment programs, attendance at a private high school) are rarely selected.

Transcripts are evaluated for types of classes taken and grades. Although high grades are not mandatory, all students must have completed biology and have earned at least a B grade in a science course. Additional data on the academic status of students (e.g., standardized test scores, college prep and AP classes) are not evaluated because of the difficulties of obtaining school records and of comparing grades and types of classes across different schools.

Approximately 200 students apply each year. The SMYSP executive director and 10 Stanford undergraduate students who staff the summer residential program review applications. Each application is reviewed blindly by two student staff, scored from 1–5, where 5 is the most favorable score, and rereviewed if the two scores show a discrepancy of more than two points. The top 100 applicants are interviewed by telephone, and the 45 finalists, along with their families and teachers, are invited to Stanford for a day of group discussions and personal interviews. Each application is then evaluated by the program's executive director and faculty director, as well as student staff, with the final decision made

by consensus. A final class of 24 students is selected, with approximately equal representation by gender and ethnicity.

Direction of the Program

The 10 Stanford students who staff the summer program serve as counselors, teachers, and role models. They receive stipends and are often from similar socioeconomic and ethnic backgrounds as the high school students. The student staff consists of two directors, two assistant directors (who become directors in the following year), and six counselors. This creates an approximate student-to-staff ratio of two to one. Graduates of the program who are subsequently admitted to Stanford often return as student staff.

The continuity of the program is provided by a full-time executive director and administrator. Additional support is provided by the faculty director and an advisory board composed of SMYSP alumni, Stanford faculty, hospital and university staff, and community leaders.

Environment and Curriculum

Students live in a residential house on Stanford's campus that fosters a stimulating academic environment marked by enthusiasm, creativity, openness, and scientific dialogue. The students' shared experience of overcoming adversity and interest in higher education create a strong sense of community. Faculty, medical students, and health professionals are frequent visitors to the residential house, allowing for informal discussions and mentoring. A computer laboratory, set up in the house, facilitates research projects, college admissions work, and technology training.

Participants divide their time between classroom instruction for academic preparation, anatomy and pathology practicums, hospital field placements, research projects, and college admissions guidance. Instruction is by medical and other faculty, staff, and medical students—it is informal and offers a hands-on approach to education. Group discussions and peer teaching supplement didactic presentations. Students work in groups on research projects that they present as scientific posters and oral presentations to over 200

family and faculty members at the graduation ceremony.

An emphasis is given to developing skills needed for college admissions and success, including SAT preparation, scientific writing, public speaking, networking, time management, and cultural awareness. Career guidance workshops help students distinguish between types of colleges, identify colleges that are matched to their academic level and interests, and locate financial aid. Students prepare drafts of their personal statements for college applications and, in doing so, gain additional writing skills. They also receive 10 units of physiology credit from their high schools for participating in the program.

Participants spend two afternoons a week in the gross anatomy laboratory, during which time they dissect human cadavers. They are taught by medical students who gain teaching experience and who serve as yet another set of role models. The curriculum is adapted from the Yale University Anatomy Teaching Program (<http://info.med.yale.edu/surgery/anatomy>) and follows a systems approach that is integrated with personal risk factors and complemented by quizzes, lectures, and Web activities. For example, when learning about the cardiovascular system, students directly observe arteriosclerosis by feeling the involved vessels and then discuss the importance of healthy diets; when learning about the pulmonary system, students observe the structure of the bronchi and discuss the causes of asthma.

Two days a week, participants complete hospital field placements at either Stanford University Hospital or the Veterans Affairs Palo Alto Health Care System, in departments such as cardiac surgery, obstetrics, labor and delivery, emergency medicine, and physical therapy. Several placements occur in the morgue, allowing students to learn about forensic science. During these placements, students work side by side with physicians and other health care professionals, learning about various health and medical careers while developing relationships that often result in long-term support. Evening programming provides additional exposure to health professionals, including those from allied health professions and integrative medicine.

To provide additional role models, each participant is matched with a Stanford medical student, graduate student, or health professional, often from a similar ethnic and socioeconomic background, with whom they spend an evening each week. Students are introduced to cultural events and other prominent universities and laboratories through weekend field trips. Family visits on Sundays allow the staff to facilitate discussions between participants and their families about higher education.

A web site (<http://smysp.stanford.edu>) that is tailored to first-generation college students provides detailed information about the college admissions process, financial aid, health careers, samples of college essays, and profiles of SMYSP alumni. It also provides links to other college and health professions sites.

Post-Program Support

The SMYSP organization is available for long-term college, career, and emotional support to all alumni, enabling the program to exert a strong influence on participants after they return home. The national SMYSP alumni association of past students and staff provides a leadership structure and communication system for a professional network of alumni and former staff who are dedicated to furthering the mission of the SMYSP. Workshops and reunions provide channels through which participants stay in touch with each other, the program staff, hospital supervisors, and mentors. Each fall, all participants who are applying to college return for an all-day college admissions and career advising workshop. Emails and mailings are regularly sent to inform participants about scholarship, public service, research internship, and health career opportunities. Through these contacts, SMYSP graduates obtain further guidance about college, financial aid, and career choices.

Funding and Evaluating the SMYSP

Participation is free of charge and includes tuition, room and board, and educational costs. The program costs \$250,000 annually for new and continuing student support. It is funded by grants from foundations, the

Table 1

Demographic Characteristics of 405 Stanford Medical Youth Science Program (SMYSP) Participants, 1988–2005

Characteristic	No. (%)
Gender	
Male	209 (51.6)
Female	196 (48.4)
Ethnicity	
African American	88 (21.7)
Latino	135 (33.3)
Native American	16 (4.0)
Southeast and East Asian	108 (26.7)
White, non-Latino	29 (7.2)
Other ethnicity	29 (7.2)
Country/regions of birth	
United States	230 (56.8)
Africa	9 (2.2)
Mexico, Central, and South America	58 (14.3)
Southeast and East Asia	78 (19.3)
Europe	6 (1.5)
Other countries/regions	24 (5.9)
Low family income	405 (100.0)
Mother's highest year of education*	
<9 years	112 (28.6)
9–11 years	53 (13.5)
12 years	127 (32.4)
≥13 years	100 (25.5)
Father's highest years of education*	
<9 years	101 (28.9)
9–11 years	39 (11.1)
12 years	110 (31.4)
≥13 years	100 (28.6)

* Numbers vary slightly because of missing data.

government, and private donors and receives in-kind support from Stanford University, Stanford University Hospital, Stanford School of Medicine, and the Veterans Affairs Palo Alto Health Care System. Faculty donate teaching time, and hospital staff supervise field placements.

A computer database maintains information about all SMYSP graduates and student staff and allows for the long-term evaluation of the program. Each participant completes an initial survey that provides information about their family and detailed contact information. After completion of the program, each student is surveyed annually by telephone to assess college status and career goals. From this, a student and staff directory is generated and mailed to all graduates annually, thus

encouraging continuing contact among participants. All research is approved by the ethics committee at Stanford University School of Medicine and conforms to the principles of the Declaration of Helsinki.

Characteristics and Achievements of the Program's Participants

Since 1988, 405 students have completed the SMYSP; program staff have followed up on 96% of these individuals for up to 18 years to assess college and career outcomes. Sixteen students have been lost to follow-up at different time points, and one student is deceased. An almost equal number of young women and men have participated in the SMYSP since the program's inception (Table 1). Fifty-nine percent have been from underrepresented ethnic minority groups (21.7% African

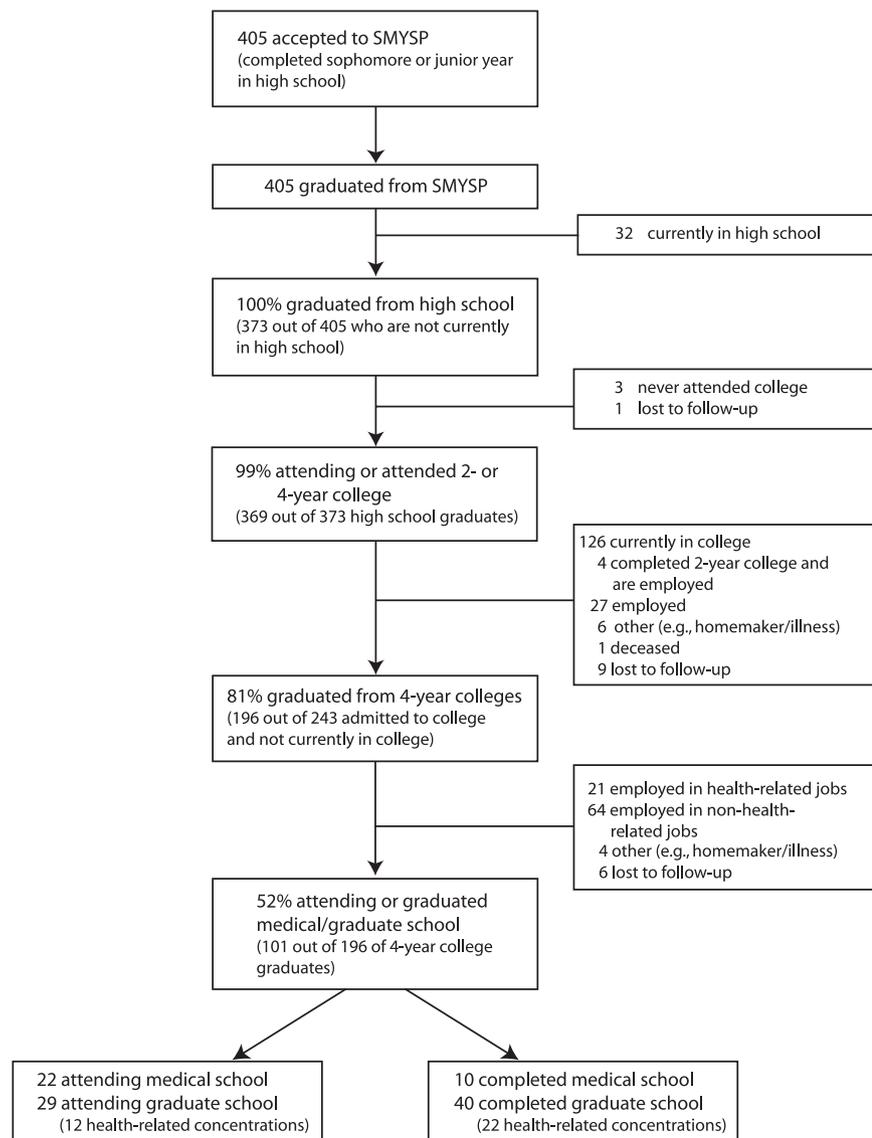


Figure 1 Flow diagram of Stanford Medical Youth Science Program participants, 405 California students, observed for up to 18 years, 1988–2005.

American, 33.3% Latino, 4.0% Native American). All have been from low-income families. Over 40% of the students' parents have lacked a high school education and over 50% of their fathers have been employed in blue-collar or farming occupations. A number of students have been from homes where their father or mother was disabled (11.6%) or deceased (10.4%). Others have had parents who are incarcerated, have substance use problems, and/or have been homeless.

Figure 1 presents a flow diagram documenting the progress of the 405 students, from high school to college, and then to medical and graduate school. All students accepted to the SMYSP have completed the program and all have

graduated from high school (among those not currently in high school). Among high school graduates, 99% have been admitted to college. Of those admitted to college (and not currently college students), 81% have earned a four-year college degree. Among four-year college graduates, 52% are attending or have graduated from medical or graduate school.

Among students admitted to college, 45.5% have attended the Universities of California, 7.0% have attended Stanford University, and 3.0% have attended the Ivy Leagues (Table 2). The majority of students who have graduated from four-year colleges have majored in the sciences; 51.0% have majored in the biological sciences, 6.1% in the physical

sciences, and 42.9% in the social sciences or liberal arts (data not shown). Among the 101 participants doing postgraduate work, 65% have selected health-related fields, including medicine, dentistry, pharmacy, public health, and mental health.

The work and school status of four-year college graduates is shown in Table 3. These data highlight the need for long-term tracking of high school pipeline programs, as 51 (26%) of these students are still in medical or graduate school: 59% are from the 1988–1995 SMYSP classes and 41% are from the later classes. Of four-year college graduates, many (44.4%) are becoming or have become health professionals—others who are employed in non-health-related jobs have expressed a desire to continue their educations and enter health professions (17.2%).

Conclusions and Lessons Learned

These outcomes suggest that the SMYSP summer residential program, distinguished by direct participation in the sciences, college admissions preparation, and long-term mentoring and career guidance, has been highly successful in reaching low-income students and preparing them for medical and other careers. Data from the program also highlight the need to track students for as long as 10–15 years to accurately assess college graduation rates and career choices. It seems that 10 years of tracking is sufficient to determine whether students complete a four-year college degree; however, only 10 years of follow-up would lead to missing a substantial number of students who continue on to medical or graduate school and become health professionals. Long-term follow-up is a common failure of pipeline programs because of lack of funds and/or an inability to track alumni on a long-term basis. Our success in following 96% of alumni for up to 18 years has been accomplished by developing strong relationships between program staff and students and their families, securing detailed contact information, and diligence in follow-up.

Despite its successes, there are limitations to the data reported on students' participation in the SMYSP. The main limitation is the lack of a comparative group of students who were not exposed

Table 2

Type of College of 369 Stanford Medical Youth Science Program (SMYSP) Participants Who Attended or Are Attending College

Type of college	No. (%)
Universities of California*	168 (45.5)
Stanford University	26 (7.0)
Ivy League colleges	11 (3.0)
Other private colleges and universities	64 (17.3)
California State Universities	38 (10.3)
State universities outside of California	6 (1.6)
Historically black colleges and universities	11 (3.0)
Two-year colleges, community colleges	45 (12.2)

* Includes all 10 campuses. Attending or attended UC Berkeley, 38.1%; UC Davis, 29.2%; UC Los Angeles, 18.5%.

to the program. Therefore, this is a case report with longitudinal data and not a controlled evaluation of SMYSP. The lack of a comparison group limits the interpretation of the SMYSP's success and does not allow us to answer important questions such as whether SMYSP participants perform better on standardized examinations, receive better grades, are accepted to better colleges and universities, receive more scholarship support, and are more likely to attend medical and graduate schools than low-income students who are not exposed to such a program.

There are, however, a number of indicators that lend credence to the impact of the SMYSP. We calculated four-year college graduation rates for SMYSP alumni by race/ethnicity and compared these with graduation rates for young adults in both the United States overall and in California specifically. In this calculation, SMYSP alumni who were lost to follow-up or deceased were conservatively classified as not

completing a four-year college degree. Among SMYSP alumni, the graduation rate from four-year colleges (excluding those still in high school or college) is 73% for African American students, 79% for Latino students, 87% for Asian students, and 86% for white, non-Latino students (there were too few Native American students to calculate their graduation rates). In contrast, the graduation rate from four-year colleges for 25- to 34-year-old adults in the United States is 15% for African Americans, 10% for Latinos, 55% for Asians, and 31% for white non-Latinos.^{1,2} The graduation rates for 25- to 34-year-old adults in California are similar for all ethnic groups, except lower for Latinos (8%). Although the SMYSP percentages are based on students who are motivated and interested in college, none of the SMYSP students are from middle- or high-income families, a factor that is the strongest determinant of whether a high school senior will be qualified for college.¹⁴ For example, only

10% of college students who attend the top 146 colleges in the United States are from families with incomes in the bottom half of the nation's income distribution.¹⁵

There are many challenges faced by pipeline programs that seek to diversify the scientific and health professions. Although many programs have similar goals to the SMYSP, most are limited by one or more of the following factors: (1) focus on large numbers of students with little individualized mentoring, (2) short program duration, (3) school-based structure with no direct exposure to college life, science and health professionals, or university resources, (4) minimal personalized college and career guidance, (5) no long-term support, and/or (6) few links with an established infrastructure for sustainability.^{6,13} Almost all programs face the challenge of sustainability. A recent report to The California Endowment, titled *Strategies for Improving the Diversity of the Health Professions*,⁵ makes the following recommendations regarding continuity of programs: (1) develop strategic plans at every health professions school to improve racial and ethnic diversity, (2) develop a strategic plan to maintain funding for programs along the educational pipeline, and (3) prioritize funding of rigorously conducted evaluation research, in addition to funding interventions themselves. Critical to program sustainability are strong partnerships between organizations (e.g., schools, community-based organizations) and institutions (e.g., universities) that are committed to ethnic and income diversity along all stages of the educational pipeline.^{5,13}

An essential aspect of sustainability is dissemination, accomplished through replication of programs, expansion, and/or dissemination of successful components. The SMYSP has grown to have a national presence via these three strategies. It has been replicated at the University of California–San Diego School of Medicine and has expanded its initial summer residential program to an academic-year program in partnership with biology teachers and students at four underresourced high schools. Recently, the SMYSP has initiated College Clusters, which provide regional ongoing activities for alumni. The College Clusters serve as an opportunity for SMYSP alumni and former Stanford student staff to network,

Table 3

Work and School Status of 196 Stanford Medical Youth Science Program (SMYSP) Participants Who Graduated from Four-Year Colleges

Status	No. (%)
Currently in medical/osteopathic school	22 (11.2)
Completed medical/osteopathic school and employed*	10 (5.1)
Currently in graduate school (12 health related)	29 (14.8)
Completed graduate school and employed (22 health related)	40 (20.4)
Working in health-related jobs	21 (10.7)
Working in non-health-related jobs	64 (32.7)
Other (e.g., homemaker, illness)	4 (2.0)
Lost to follow-up	6 (3.1)

* Two are completing residency training, five are practicing in inner-city or rural areas, two are physicians in the military, and one is taking time off.

identify university and community resources, support other students, build leadership skills, and initiate public service activities. Finally, the SMYSP has disseminated successful program components through technical assistance to new programs and through its national dissemination committee, composed of leaders from 10 schools of medicine and schools of public health. Successful program components are also highlighted in a recently published book (*Healing Journeys: Teaching Medicine, Nurturing Hope*) and documentary film (*Opportunity of a Lifetime*), both of which have received widespread publicity and have been distributed without charge to 800 northern and central California high schools.

Like many pipeline programs, the SMYSP faces ongoing challenges in its long-term sustainability. To ensure its continuity, the SMYSP has embarked on an endowment campaign to secure permanent funding. A separate nonprofit organization, Access to Achievement Education Foundation, has been established to help fulfill this goal, allowing programmatic expansion, support of alumni, and flexibility in fundraising.

In summary, these findings add to the evidence that biomedical pipeline programs can be successfully implemented, evaluated, and sustained. By providing academic enrichment and skills training to low-income high school students, the SMYSP is broadening the number of students from underrepresented backgrounds who are pursuing medical and health-related careers, with the long-term goal of diversifying the health professions. As it approaches its 20th year in 2007, over 450 students, all from low-income backgrounds, will have graduated from the SMYSP, and 150 Stanford undergraduate students will have served as staff. These 600 young adults, primarily underrepresented minorities, are the future of the SMYSP and are helping to address health disparities in medically underserved populations. An alumnus recently summarized the essence of the SMYSP: "In reading the stories of past participants, it struck me that beyond the structure of being a 'medical and science program' lies a deeper and more meaningful social construct of humanity blossoming in all

the individuals from this seemingly scientific exploration."

Acknowledgments

Past funding for this program has been provided primarily by The California Endowment, The California Wellness Foundation, The David and Lucile Packard Foundation, Edmund W. Littlefield Foundation, Flora Family Foundation, The HealthTrust, Howard Hughes Medical Institute, The James Irvine Foundation, The J.W. & H.M. Goodman Family Charitable Foundation, MacDonnell Foundation, The Valley Foundation, Leo Hindery, Jr., John Doerr, John Malone, David Perry, and other private donors. The following two grants to Dr. Winkleby currently fund the program: The Stanford MKITS Science Program: CVD and Public Health, National Heart, Lung, and Blood Institute (R25 HL075748); and the Stanford Medical Youth Science Program School-Based Science Initiative, Fund for the Improvement of Postsecondary Education (FIPSE), U.S. Department of Education (P116B040327).

The author thanks Judith Ned for executive director leadership; David Ahn, Nell Curran, Destinee Cooper, Dale Lemmerick, and Elodie Escobar for leadership within the organization; Alana Koehler and Kathleen Fagliano for maintaining the evaluation system; Jeanne Kennedy, Les DeWitt, Tom David, Jack Farquhar, Greg Vaughn, VaLecia Adams, and Mailee Ferguson Walker for long-term advisory support; Drs. Lawrence Rizzolo and William Stewart for the use of the Yale University Anatomy Teaching Program; and Drs. Michael McCullough and Marc Lawrence for cofounding the program with Dr. Winkleby. The author also thanks Julia Steele for coauthoring *Healing Journeys: Teaching Medicine, Nurturing Hope*, the SMYSP book; Kathy Sloane for photographs in the SMYSP book; Dr. David Satcher for his foreword in the SMYSP book; and Abby Ginzberg for producing *Opportunity of a Lifetime*, the SMYSP film. In-kind resources are provided by Stanford University, Stanford School of Medicine, Stanford Prevention Research Center, Stanford Hospital and Clinics, Lucile Packard Children's Hospital, and the Veterans Affairs Palo Alto Health Care System.

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