



Helping Scholars Overcome Socioeconomic Barriers to Medical and Biomedical Careers: Creating a Pipeline Initiative

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ABSTRACT

Problem: To achieve their potential in medical and biomedical careers, students (scholars) from under-resourced backgrounds must build sophisticated skills and develop confidence and professionalism. To flourish in an advanced educational system that may be unfamiliar, these scholars also need networks of mentors and role models. These challenges can affect scholars at multiple stages of their education. **Intervention:** To meet these challenges, we created a broad and innovative biomedical research-focused pipeline program: the Johns Hopkins Initiative for Careers in Science in Medicine (CSM Initiative). This initiative targets three levels: high school, undergraduate, and post-baccalaureate/pre-doctoral (graduate and medical). We provide training in essential academic, research, professional, and social skills to meet the unique challenges of our scholars from under-resourced backgrounds. Scholars also build relationships with mentors who provide career guidance and support. We present an overview of the training and assessment at each level of this initiative. **Context:** The initiative took place at an institution located in the greater Baltimore area and that is endowed with exceptional doctoral and postdoctoral trainees, staff, and faculty including clinicians, physician-scientists, and scientists who served as key role models and mentors. Our pipeline program draws from local high school students and a local and national pool of undergraduates and post-baccalaureates preparing for medical or graduate school. **Impact:** Our goals for the high school scholars are significant improvement in academic skills, increased confidence, and matriculation into higher education systems. Currently, at least 83% of high school scholars have matriculated into four-year college programs and 73% have chosen science, technology, engineering, math, and medicine (STEMM)-related majors. Among undergraduate participants, 42% have matriculated thus far into medical or biomedical graduate programs and this number is expected to rise as more scholars graduate from college and either enter graduate training or pursue STEMM careers. Another 25% have returned to our post-baccalaureate program. Among post-baccalaureate scholars, 71% have now matriculated into doctoral-level graduate biomedical programs (medical or graduate school) and the remaining 29% are pursuing careers in STEMM-related fields such as biomedical research with some still aiming at graduate-level education. Our long-term goal is to see a large majority of our scholars become successful professionals in medicine, biomedical research, allied healthcare, or other STEMM fields. Analysis of the early phases of the CSM initiative demonstrates such outcomes are attainable. **Lessons Learned:** This program provides experiences in which scholars develop and practice core competencies essential for developing their self-identity as scientists and professionals. The most important lesson learned is that mentorship teams must be highly dynamic, flexible, thoughtful, and personal in responding to the wide range of challenges and obstacles that scholars from under-resourced backgrounds must overcome to achieve career success.

KEYWORDS

low-income; educationally under-resourced; outreach; pipeline; diversity

Introduction

Increasing diversity in the healthcare workforce is a key step toward achieving health equity.¹ However, socioeconomic barriers are major challenges to achieving this goal. For example, only about 5% of the U.S. medical students come from households in the lowest quintile of income.² Early exposure to science, technology, engineering, mathematics, and medicine (STEMM) increases student interest in STEMM fields; early exposure also improves confidence, aspirations, and outcomes including the pursuit of college-level and advanced training in STEMM and health-related fields.^{3–7} Exposing under-resourced high school students to topics such as health disparities also stimulates their interest in advocating for changes in their communities.⁸ Organized internships and clerkships that expose scholars to academics and professional development are particularly inspiring,^{6,7,9,10} with impacts even at advanced stages of training.^{11,12} However, the need exceeds the capacity of current programs, meaning that significant new investment is required to overcome the shortage of young people from under-resourced backgrounds who enter STEMM fields across our nation.

Thus, our national challenge is to ensure that all students with the interest and passion also have the necessary skills, resources, and access to mentoring needed to succeed at each stage of training and beyond. Recognizing this challenge, West Virginia has already launched a state-wide effort to overcome health disparities by enhancing the pipeline of students in STEMM.⁷ Our decades of experience as a community of educators, researchers, and medical professionals suggested that we can—and should—leverage our academic infrastructure and networks to

help meet this challenge. To this end, we established the Johns Hopkins Initiative for Careers in Science and Medicine (CSM) to develop promising individuals from under-resourced backgrounds at three stages of development: high school, college, and recent postgraduates.

The CSM's goals are to help our high school students ('scholars') matriculate into, and succeed in, 4-year college programs and to help undergraduates from colleges nationwide and recent college graduates achieve advanced education in medical and biomedical professions. To be a CSM scholar, students must be under-resourced both economically (coming from households with annual incomes less than 200% of the U.S. federal poverty level) and educationally (*e.g.*, first-generation college student, raised in a single-parent household, and/or attending a high school where most students come from low-income families). Here, we present our program, its early impacts and key lessons learned.

Overview of the CSM initiative

The CSM Initiative strives to develop scholars specifically interested in pursuing STEMM careers into successful professionals (Figure 1).⁹ The majority of scholars are from racial/ethnic groups under-represented in medicine and science (UIM/UIS). Because we sought to develop scholars during their formative years, our pipeline program draws from local high school students and a local and national pool of undergraduates and post-baccalaureates preparing for medical or graduate school (Figure 2).

Our mission is to develop scholars' academic, research, professional, and social skills, and other tangible competencies. We use a combination of mentored research experiences, structured academic

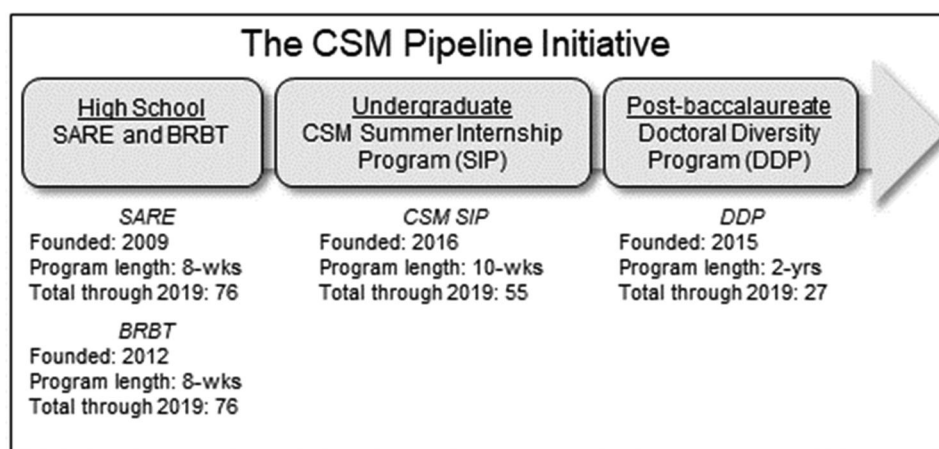


Figure 1. The CSM Initiative.

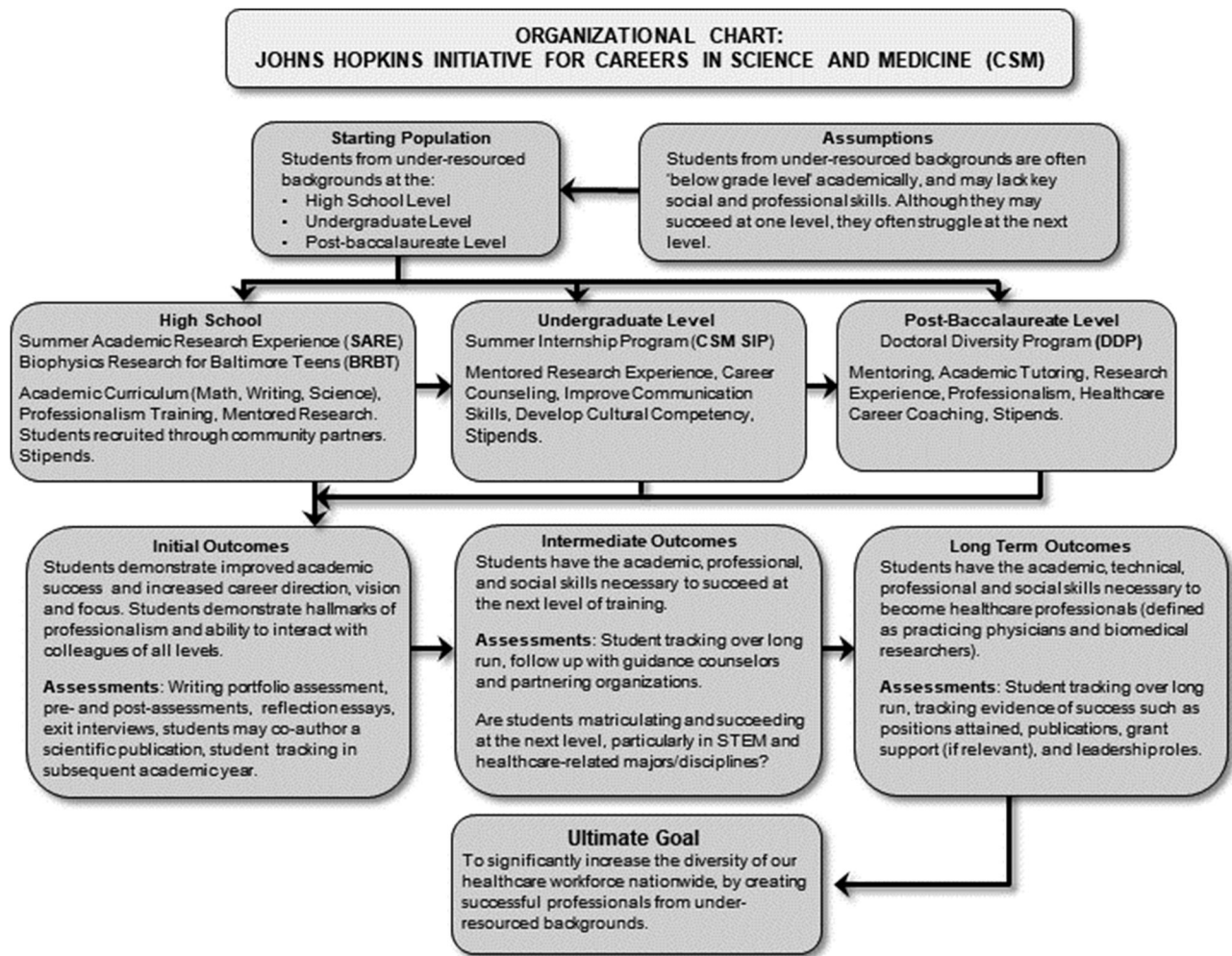


Figure 2. Program organizational structure, including logic flow.

training, professional communication, analytical skills development, and individual attention. To achieve these goals, we draw upon the scientific research enterprise at Johns Hopkins University, endowed with exceptional doctoral and postdoctoral trainees, staff, and faculty including clinicians, physician-scientists, and scientists. These individuals serve as key role models and mentors.

Each year our pipeline initiative serves ~60 students via four programs: (a) ~30 high school students through the Summer Academic Research Experience (SARE) and Biophysics Research for Baltimore Teens (BRBT) programs, (b) ~16 undergraduates through our CSM Summer Internship Program (CSM-SIP), and (c) ~5–8 post-baccalaureate scholars through our Doctoral Diversity Program (DDP). All scholars receive stipends that may be used to cover living expenses. Stipends must be earned, which is a critical tenet of professionalism. All four programs develop their scholars' core academic, social, and professional competencies, as well as their creativity, technical

expertise, and passion for advanced careers. Our goal is to prepare CSM scholars for advanced training and successful healthcare careers including medicine, nursing, biomedical sciences, and related STEM professions.

Program design

High school scholars

Since early opportunities can be life-changing, our high school programs were the first to be implemented. The CSM provides opportunities for high school students predominantly (but not exclusively) from the greater Baltimore area. We created two high school programs, one (SARE) located at the Johns Hopkins School of Medicine campus and one (BRBT) located at the Johns Hopkins University undergraduate campus four miles away, to take advantage of the collective resources and creativity of faculty at each location.

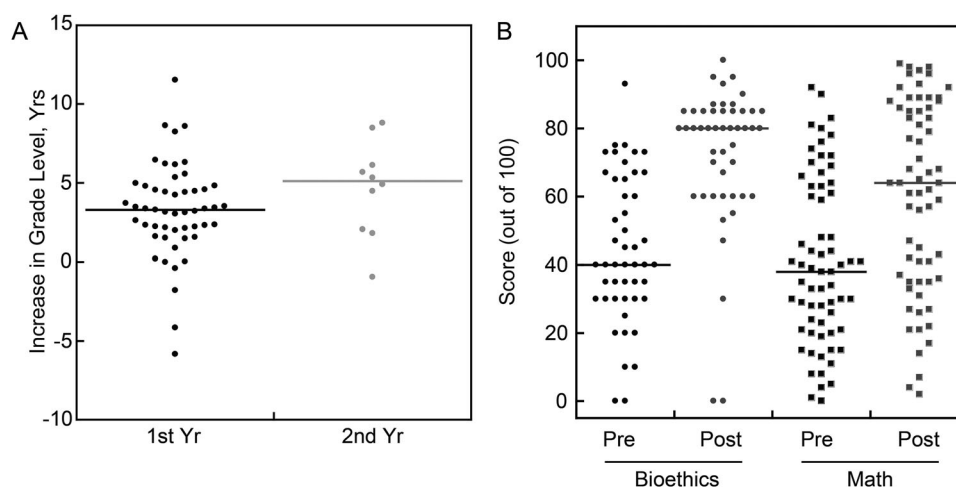


Figure 3. Assessment of structured coursework impact on writing, mathematics, and bioethics skills (SARE program). (A) Grade-level increases in writing skills are recorded and plotted for first and second-year SARE students ($n = 51$). Grade level is assessed via the Flesch-Kincaid writing algorithm. Students grew by an average of 0.44 grade levels/week and 3.5 grade-levels total over the course of the summer. (B) Bioethics pre- and post-assessment scores are plotted ($n = 47$). The median scores were 40 and 80 on the pre- and post-assessments, respectively. Math pre- and post-assessment scores for all students where we collected such information are also presented ($n = 63$). Median scores were 38.5 and 64, respectively. For data sets in B, Mann-Whitney-Wilcoxon U-Test: $Z = -5.93$; $p < 0.00001$. Note that although 76 scholars (through summer, 2019) have participated in SARE, we did not collect every type of data in every year.

Summer Academic Research Experience (SARE): high school students (8 weeks)

SARE was the first CSM program, founded in 2009 on the premise that early exposure to a professional research environment, coupled with rigorous academic development and individual mentorship, would improve scholar performance and ultimately, career outcomes.

Student selection: SARE invites applications from under-resourced high school students who are recruited through multiple community partners and organizations. Selection criteria include prior academic success, motivation to succeed, or recognition by advisors and teachers as having untapped passion for learning. Candidates submit applications and are interviewed by the CSM team. Due to effective preselection by the partnering organizations, we offer positions to approximately half of those interviewed; 99% accept our offer, and all complete the 8-week program. Many scholars return for additional summers.

Program overview: Scholars spend 30% of their time on academic development and 70% on a mentored research project. Day 1 includes an orientation session during which expectations for professionalism and achievement goals are laid out. Scholars sign a contract, committing to ‘striving for excellence.’

Academics: The structured academic program (three and a half hours per day, five days per week) includes curricula for writing, mathematics, science, and bioethics. As part of the bioethics curriculum,

scholars also read “The Immortal Life of Henrietta Lacks” by Rebecca Skloot (2010), a book that interweaves the life of Henrietta Lacks with the Johns Hopkins Hospital, Baltimore communities, race relations, and the evolution and ethics of research on human subjects. We directly quantify student performance in specific areas using pre- and post-assessments, and routinely observe considerable growth in each topic area (Figure 3).

Mentored research: After training in laboratory safety, scholars are assigned to a research lab and paired with a doctoral/postdoctoral scientist with whom they work on a research project. Scholars develop laboratory skills including how to design and conduct experiments. Over the course of the summer, scholars build experience, generate and interpret data, and occasionally even coauthor a scientific publication.^{13,14} At summer’s end, each scholar prepares and presents a poster at the SARE/DDP symposium, which is attended by their families, lab colleagues, and the greater Johns Hopkins and Baltimore communities. Extensive and rigorous preparation ensures that the quality of poster presentations is comparable to that of many doctoral students. Preparing and presenting a poster after weeks of research provides multiple reinforcing experiences (competencies) that are known to contribute to ‘science identity’ among under-represented groups in science, including competence in one’s field, practicing science and being recognized as a scientist by other scientists.^{15,16}

Biophysics Research for Baltimore Teens (BRBT): high school students (8 weeks in summer)

Founded in 2012, BRBT is a tiered two-year program that helps scholars achieve the skills necessary to undertake research in professional laboratories. BRBT scholars start during the summer preceding their senior year in high school, and this program is typically their first exposure to university-level biomedical research. The first-summer program consists of a structured laboratory “boot camp,” with a 6-week curriculum focused on basic laboratory skills that translate to all biomedical research and STEMM fields. During the remaining two weeks, each intern is assigned to a research lab for mentored research experience. In the second summer, returning scholars perform basic biomedical research in a faculty member’s laboratory.

Student Selection: Close relationships with community partners are essential to recruit under-resourced scholars for BRBT. We developed standing relationships with science teachers in Baltimore City public high schools who play key roles in identifying students interested in participating. To apply, students submit a letter of recommendation from a science teacher, their transcripts, and a short personal statement. Applications are evaluated by the BRBT team to identify the most promising candidates. Scholars must come from a Baltimore City public high school and must have taken chemistry, physics, and/or biology to be eligible. We also evaluate factors such as the student’s interest in STEMM subjects, their commitment to a STEMM career, and performance and potential.

Program Overview: The first-year “boot camp” uses a state-of-the-art undergraduate teaching lab at Johns Hopkins and is taught by a Johns Hopkins undergraduate laboratory instructor and a Baltimore City high school chemistry teacher. We also have Johns Hopkins undergraduates participate as teaching assistants and role models. Classroom instruction encompasses molecular biology, chemistry, recombinant DNA, protein purification, and bacteriology. Scholars subsequently apply these concepts through structured laboratory experiments. To determine needs and progress, scholars take a pre-instruction exam on Day 1 that covers laboratory math, basic biology, chemical principles, and technical writing. Scholars take a similar exam at the end of the summer, as a post-assessment. In the second summer, as rising college students, scholars conduct full-time biomedical research in Johns Hopkins research laboratories. All BRBT scholars prepare and present their own research poster at a symposium attended by their peers, summer undergraduate interns, and faculty.

For enrichment, students also participate in: (i) lunches with faculty to discuss educational and career questions, and (ii) weekly field trips to state-of-the-art instrument facilities (X-ray crystallography, nuclear magnetic resonance, high-resolution microscopy).

Undergraduate and post-baccalaureate scholars

We created the CSM SIP and DDP programs to provide next-stage opportunities for scholars who came through our SARE and BRBT high school programs, and for scholars nationwide who grew up in under-resourced communities. Alumni from earlier phases of our programs are encouraged to apply to later stages and receive priority for admission, creating a pipeline structure.

Our undergraduate (CSM SIP) and post-baccalaureate (DDP) programs recruit socio-economically under-resourced scholars from across the U.S. including Territories, Tribes, and all 50 States. Students apply through our online application system. After confirming that students meet the socioeconomic eligibility requirements, we assess their academic performance, personal statements, and letters of recommendation. Our SIP and DDP admissions committees each review ~100 promising applicants in detail, from freshmen to seniors, based on academic performance, personal qualities (creativity, motivation, enthusiasm, and collegiality gleaned from personal statements and letters of recommendation) and potential for our program to have a real impact on their trajectory (e.g., few research opportunities at their home institution; notably, some of our SIP scholars were effectively homeless during summer).

CSM SIP scholars are then invited to the program. Because the DDP is a two-year program, we identify a short list of applicants who are interviewed by phone using a defined set of questions, before extending offers. The CSM SIP and DDP programs each accept 3–5% of applicants. To some extent, the CSM SIP program competes with dozens to hundreds of summer internship programs that are well-established nationwide. By contrast, every student who received an offer from the DDP has accepted (100%), suggesting a great unmet need for this type of opportunity among socio-economically under-resourced students nationwide. Details of each program follow below.

CSM SIP (CSM SIP): undergraduates (10 weeks)

The CSM SIP arose from our long-standing SIP for under-represented minority undergraduates, which

began in 1991, expanded over the years, and now provides summer research opportunities for ~100 undergraduates annually from colleges and universities nationwide and receives >1,400 applications each year. In 2016, we created the CSM SIP, which serves 16 scholars per year, with support from the Health Careers Opportunity Program of the US Health Resources and Services Administration.

Structure: The centerpiece of this 10-week program is that each CSM SIP scholar is immersed in an active research lab that matches their area of interest. Scholars receive biosafety training and other training (e.g., radiation safety) as needed. CSM SIP scholars do experiments and participate in lab meetings, research seminars, and other activities that stimulate them to integrate knowledge, practice their analytical and communication skills, and ‘think on their feet.’ Each scholar prepares a poster and presents their research at an end-of-summer symposium attended by all ~120 summer students from all programs at Johns Hopkins Medical Institutions, including undergraduates and high school participants in basic and clinical research programs. This poster session is very well received by the Johns Hopkins community due to the high quality of work presented. One scholar has coauthored a scientific publication.¹⁷

Professional opportunities and mentoring: CSM SIP scholars gain professional insight by attending workshops on medical and graduate school admissions, mock interviews, and having roundtable lunches with current MD, PhD, MD/PhD and MPH students. Scholars also meet with the CSM SIP director (K.L.W.) in small groups (2–3 scholars) for about two hours at the beginning and again near the end of the program, to discuss goals and concerns, give and receive feedback about their written personal and research statements, ask questions and get to know each other, thus seeding peer-support networks.

Doctoral Diversity Program (DDP): post-baccalaureate, up to 2 years

Under-resourced students who enter medical or doctoral degree programs frequently encounter family, social, and economic challenges that differ widely from their affluent peers. To prepare recent college graduates from under-resourced backgrounds for future success and leadership as physicians or biomedical research professionals, we created the post-baccalaureate Doctoral Diversity Program (DDP). This program receives ~140 applications annually; from these we select 5–8 DDP scholars who are committed

to pursuing MD, MD/PhD, or PhD degrees or other allied health and biomedical research careers. Scholars spend up to two years in the DDP. One former SARE scholar and three former CSM SIP scholars have joined the DDP, exemplifying the pipeline nature of the CSM Initiative. Our goal is to arm scholars at each level with the knowledge and confidence to apply to and participate in graduate programs nationwide. This deliberate national perspective empowers scholars to explore and identify the programs and institutions that best suit their interests and aspirations.

Structure: DDP Scholars experience training in four core competencies: Research, Professional Training, Healthcare Community, and Personal Growth.

Research: Each DDP scholar conducts research in their chosen mentor’s basic or clinical research laboratory, with day-to-day guidance by an experienced PhD student or postdoctoral fellow. Scholars participate fully in the scientific and intellectual life of their labs, including weekly meetings and departmental seminars, and present a research poster at our summer SARE/DDP symposium. In year two, most DDP scholars also present their work at a national or international scientific meeting. Many also first- and/or coauthor scientific publications, e.g.,^{18–22} to date more than 20 publications, have been authored by DDP scholars.

Professional training and healthcare community: Scholars prepare for professional and/or graduate school entrance examinations (e.g. Medical College Admission Test), as needed, through our partnership with a test preparation company. DDP scholars also complete a biomedical communications course designed and taught by a CSM Initiative faculty member (S.L.P.) to hone their public speaking and scientific writing skills. Some DDP scholars also take graduate-level courses related to their research offered by our School of Medicine or School of Public Health.

Healthcare community: The DDP scholars can shadow Johns Hopkins physicians who are specialists in a wide range of areas including bariatric and cardiothoracic surgery, general internal medicine, nephrology, neurology, pediatrics, and pulmonary/critical care medicine. Medically-oriented DDP scholars also participate in surgical simulation training at the Johns Hopkins Minimally Invasive Surgery Training and Innovation Center.

Personal growth: Scholars benefit from peer mentorship and guidance from the DDP director (D.C.C.) through monthly ‘Coffee Breaks’ with groups of 4–6 scholars. Scholars meet individually with the DDP director and/or CSM Initiative director (D.N.R.) to

identify specific areas the scholar needs to strengthen, and create and update their individual development plan. We also schedule DDP scholars for individual mock interviews with Johns Hopkins faculty to help them prepare as they seek admission to medical and/or graduate school.

DDP mentor selection and training. Each DDP scholar meets with 3 to 5 faculty who have expressed interest in mentoring a scholar and whose research aligns with the DDP scholar's interests. To nurture successful scholar-mentor relationships, we prepare mentors through a group training session as each new cohort of DDP scholars begins, wherein we review the aims of the program and discuss expectations for mentors and scholars.

Longitudinal mentoring by Health Care Profession Advisors (HCPA)

Each CSM SIP and DDP scholar is matched with a HCPA (faculty from Johns Hopkins School of Medicine, Bloomberg School of Public Health, or School of Nursing) who commits to mentoring ~5 scholars per year. Each advisor is expected to connect with their scholars both during their time in the program and periodically afterward. Our goal is to build peer mentoring and support teams for the scholars.

Focus on individual scholar needs

In addition to coming from low-income households, many CSM scholars are overcoming unique struggles which can and have included homelessness, single parent households, sexual assault, or parents who have been or are currently incarcerated or dealing with addiction or other mental health issues. Our mentoring network of graduate students, post-doctoral fellows, staff, and faculty are alert to challenges scholars may be facing, and respond by providing immediate support, advice, and in some instances, referral to mental health services. Our ability to identify and deliver individual support for many scholars has created bonds that frequently extend well beyond the timeframe of the program.

Cohesiveness between the programs

Although our four programs were constructed individually, the CSM Initiative is managed and coordinated by a unified team of faculty and staff. Our motivation for including the undergraduate (CSM SIP) and post-baccalaureate (DDP) programs began

with a SARE scholar who reached his senior year of college and realized that he needed more development before advancing further in his career. Thus, we make sure that our high school and undergraduate scholars are aware of 'next-stage' opportunities in the CSM Initiative. One key aspect of our team's cohesiveness, in addition to frequent direct communication and twice-yearly social events, is that our faculty leaders all serve on admissions committees for multiple CSM programs; this allows us to 'chaperone' scholars across the full spectrum of the CSM Initiative. Several CSM scholars have participated in at least two programs.

One key activity that also promotes cohesiveness is the 'Lunch and Learn' Weekly Speaker Series: Exposure to Health Care Professionals. For 6–8 weeks each summer, CSM scholars from all four programs (SARE, BRBT, SIP, DDP) gather to meet and hear from an accomplished academic physician or faculty researcher from an under-represented background. Each speaker tells their story from the forefront of healthcare or research from medical conditions prevalent in underserved populations to the socio-economic implications of their work. As Johns Hopkins faculty, these speakers are inspiring and approachable role models for the CSM scholars.

Program evaluation

All four programs (SARE, BRBT, CSM SIP, DDP) perform self-assessments (summarized below) to identify areas that need improvement and ensure the strongest outcomes for scholars as well as their mentors (faculty, doctoral students, postdoctoral fellows, and staff).

Summer Academic Research Experience (SARE)

SARE evaluates two components: academics and research.⁹ For writing, we use portfolio and Flesch-Kincaid analyses to quantify scholars' improvement over the summer and across summers when scholars return for an additional summer⁹ (Figure 3). Progress in mathematics is measured using pre- and post-assessments. The bioethics and science curricula are assessed using tests and/or essays covering specific topics. To assess the research component, each SARE scholar meets with their laboratory mentor and SARE coordinator (C.K., L.M.) every two weeks to discuss student performance and any concerns. This approach allows the program to provide positive reinforcement and to address any concerns without the awkwardness of scheduling a special meeting. At summer's end,

Table 1. Summer Academic Research Experience (SARE): Outcomes Summary for 2009–2018.

Parameter	No.	%
Total scholars		
joining SARE ^a	63	
completing the 8-week program	63	100
reaching college age ^b	46	73
Scholars of college age		
confirmed to matriculate into 4-year college program ^c	40	87
of those matriculating, confirmed to pursue a pre-med, STEM, or health and human services major ^d	22	55

^a15 scholars have participated in multiple years.

^bRemaining 18 scholars will matriculate in 2019.

^cIncluding Allegheny, William and Mary, Furman, LaSalle, Loyola of Maryland, Penn State, Stevenson, Maryland College Park.

^dIncluding biology, biomedical engineering, chemistry, mathematics, and other health-related subjects.

scholars complete a reflection essay and give exit interviews with the SARE program director that provide personal insights and frank programmatic evaluation. For long-term assessment, our SARE team works with partnering organizations to track each scholar's career trajectory and update our outcomes table (Table 1) semiannually, ensuring up-to-date information on each scholar.

Biophysics Research for Baltimore Teens (BRBT)

The director (J.S.) and instructors conduct individual exit-interviews and anonymous surveys to evaluate scholars' experiences in boot camp and research. These yearly evaluations guide future improvements in our curriculum and approaches. Each fall, the leadership team and instructors convene to identify any issues that arose the previous summer and outline plans for the upcoming year. The BRBT administrator sends out semiannual e-mails to former scholars to request updates on their career paths (Table 2).

CSM Summer Internship Program (CSM SIP)

To evaluate CSM SIP, we conduct exit surveys for program participants and mentors and use these data to improve the program. Although some SIP scholars naturally keep in touch with their mentors and program staff, our greatest administrative challenge is long-term tracking of undergraduates who attend colleges nationwide as they move to new institutions and cities. We therefore use multiple strategies to track program participants, including social media and e-mail. Tracking of CSM SIP alumni, in particular, improved significantly after the director began meeting with scholars in small groups twice each summer. Collectively, the SIP programs at Johns Hopkins have supported approximately 1000 scholars from 1995 to 2018 and 80% of all SIP scholars have pursued graduate or medical training. Several students have returned to Johns Hopkins for their postdoctoral fellowship or

medical residency after completing graduate degrees at other institutions. Current outcomes for CSM SIP, which completed its third year in 2018, are shown in Table 3.

Doctoral Diversity Program (DDP)

The DDP is a young program, formed in 2015. Program assessment occurs through real-time evaluation and quality improvement. Information is collected by direct discussions with scholars and their mentors and by tracking grades in courses and scores during MCAT/GRE exam preparation and testing. We use group and individual exit interviews to gain final reflections on the scholars' experiences. Current outcomes for DDP scholars are shown in Table 4. Among our first 14 scholars, 64% matriculated into MD, MD/PhD or MD/MBA programs, 7% matriculated into MS/PhD program, 7% in an MS program, and 21% are working in biomedical research or healthcare.

Program management and funding

The CSM Initiative is managed by a team of faculty, each of whom leads one of the individual programs. Each high school program also has an individual who directs the program including the application process, execution of the program, program evaluation, and student assessments and review. We also hire school teachers to help develop and deliver structured academic activities, in collaboration with our Johns Hopkins team to ensure that topics are taught in a manner consistent with the process of scientific inquiry.

In addition to personnel, scholar stipend, and health insurance expenses, our budget covers expenses such as lunches for the high school scholars and MCAT or GRE preparation for the DDPs. To cover these costs, over the years of the program, the CSM Initiative has been supported by a combination of

Table 2. Biophysics Research for Baltimore Teens (BRBT): Outcomes Summary for 2012–2018.

Parameter	No.	%
Total scholars		
joining BRBT ^a	66	
completing the 6-week program	66	100
reaching college age ^b	47	71
Scholars of college age		
confirmed to matriculate into a 4-year college program ^c	37	79
of those matriculating, confirmed to pursue a pre-medical, STEM, or health and human services major ^d	34	92

^aSome scholars have participated in multiple years.

^bRemaining scholars will matriculate in 2019.

^cIncluding Maryland College Park (UMD), Morgan State, Bowling Green, Brown, and Loyola of Maryland.

^dIncluding biology, biomedical engineering, chemistry, mathematics, and other health-related subjects.

Table 3. Summer Internship Program (SIP): Outcomes Summary for 2015–2018.

Parameter	No.	%
Total scholars		
joining CSM SIP	47	
completing the 10-week program	47	100
reaching medical or graduate school age, to date	12	25
Scholars of medical or graduate school age		
matriculating into medical or graduate programs ^a	5	42
pursuing other STEM or health-related fields	3	25
joined the DDP program	3	25
still in college	35	75

^aIncluding matriculated or accepted into medical or graduate programs: Sidney Kimmel Medical College at Thomas Jefferson, Harvard Medical School, Michigan State, North Carolina Chapel Hill, Ohio State.

Table 4. Doctoral Diversity Program (DDP): Outcomes Summary for 2015–2018.

Parameter	No.	%
Total scholars		
joining DDP ^a	23	
Among first 14 scholars		
matriculated into MD, MD/PhD or MD/MBA ^{b,c}	9	64
matriculated into MS/PhD program ^d	1	7
matriculated into MS program ^e	1	7
working in biomedical/healthcare field	3	21

^aStates or country from which the DDP scholars come: USA: Arizona, California, Florida, Georgia, Guam, Illinois, Maryland, New York. International: Morocco, Nepal.

^bUniversities where accepted: Albert Einstein, Brown, Chicago, Duke, Emory, Harvard, Johns Hopkins, Mayo Arizona, Ohio State, Stanford, Tufts, Vanderbilt, Washington St. Louis.

^cUniversities where matriculated: Albert Einstein, Brown, Johns Hopkins, Stanford, Vanderbilt.

^dUniversity where matriculated: Kennesaw State.

^eUniversity where matriculated: Johns Hopkins.

federal and foundation grants, contributions from the Johns Hopkins School of Medicine and University and charitable organizations, and private donations.

Impact

Our three-stage pipeline focuses on competencies that we find to be most useful at each stage (Table 5). For high school scholars, our focus on three primary objectives (academic improvement, mentored research experience, professional skills) led to significant improvements in academic competence, confidence,

independence and focus and, for scholars with initially low GPAs, a remarkable (full grade point) improvement in their high school GPA (Table 5). For CSM SIP scholars, our primary focus on mentored research experience and interactions with scientists and physicians during this 10-week internship is contributing to successful matriculation into graduate medical or research programs. For DDP scholars, we have two years to focus on four fundamental objectives: mentored research experience, professional skills, readiness for graduate school applications (MCAT preparation; practice interviews), and self-actualization as physicians and scientists through shadowing, scientific discussions and presentations (Table 5).

Collectively, our current outcomes (Tables 1–4) and objectives (Table 5) suggest the CSM Initiative is having a significant positive impact. To date, 100% of our high schoolers (SARE and BRBT) have graduated from high school and at least 83% have matriculated into four-year college programs in 30 universities across the eastern half of the U.S. Moreover, at least 50% of scholars who are five years beyond high school graduation have now graduated from college. This percentage is likely to increase, but it is already nearly four-fold higher than the national rate (14%; National Center for Education Statistics) of college completion for students from low-income backgrounds. In addition, 73% of our high school scholars are pursuing STEM majors in college. Our undergraduate (CSM SIP) and post-baccalaureate (DDP) scholars are matriculating into medical and/or graduate doctoral programs. Currently, 71% of DDP scholars who applied to graduate medical or biomedical programs have been accepted at MD, MD/PhD, MD/MBA, or MS/PhD programs around the country. Accepting institutions include Stanford, Harvard, Johns Hopkins, Albert Einstein, Brown, Baylor, and several others. One DDP alumnus is now pursuing an MS in healthcare systems engineering at Johns Hopkins and the remaining 21% are working in

Table 5. Impact and outcomes.

Program	Objective	Measure	Outcome
SARE and BRBT	Academic improvement	Pre- and post-assessments; quizzes	Improved academic performance For the lower GPA students, about half have experienced approximately 1 point improvement in the subsequent school year.
DDP	Increased understanding of the medical and biomedical fields through mentorship and shadowing	Increased awareness and competency through conversations with colleagues and the mentor team	More focused, better informed medical and graduate school application essays. Clearer view of what direction they want to take their careers.
All programs	Mentored research experience	Final poster presentation of findings; possible scientific publication	Increased confidence, increased independence, and development of pride in one's work. Many scholars, especially at the high school level, begin to see research as a career possibility. DDP Scholars frequently author/coauthor papers; CSM SIPs and SAREs have also published but the shorter program duration makes this less frequent
	Professionalism skills	Periodic review; final poster presentation	Increased confidence; better understanding of how to conduct themselves in the workplace

biomedical research positions, in some cases still planning to apply to medical or graduate school.

Lessons learned

After nearly 12 years of experience and having served over 200 CSM scholars, several key lessons have emerged (Table 6). First and foremost, each scholar must be the focus of their own experience, and we strive to respond rapidly to individual needs. Our energetic teams of doctoral students, post-doctoral fellows, staff, and faculty aim to build deep, long-lasting relationships with each scholar, allowing us to be sensitive and responsive. One essential feature of this program for high school students is that we identify any specific academic weaknesses and then pair them with a graduate student who tutors them in this area. By being fully engaged with each scholar, especially at the high school stage, we can identify areas where custom mentoring, tutoring, or professional development are needed and provide it promptly.

Beyond academic development, we learned that financial education, especially for high school scholars, is essential. Many scholars thought it was better to use a local check cashing service than to open a bank account. We now have representatives from local banks present the basics of financial savings and planning to our high school scholars. Other types of issues we have addressed include those surrounding romantic or personal relationships, mental health, hunger, and parental struggles, emphasizing the importance of being responsive to the wide range of life issues that scholars may face and must either overcome or move past.

Another lesson pertains to mentor expectations. Nearly all mentoring faculty, graduate students, and post-doctoral fellows understand and appreciate their scholar's background and the challenges this may present. However, in a few cases to date, the mentor wrongly assumed their scholar should be able to function like a first-year PhD student, which is unrealistic for most scholars on Day One. That said, we can and do realistically expect that nearly all scholars will function near or at this level by the end of the program. To keep faculty expectations realistic, we provide mentor training workshops at the beginning of SARE and DDP. We provide case studies (anonymized examples of real situations we encountered) for mentors to discuss as a group, our philosophy being that we all seek to learn from past experiences and improve our mentoring skills. Mentor training has improved mentor-scholar relationships, as indicated in end-of-program mentor reflection meetings and exit interviews with high school scholars.

Our collective multifaceted effort to be responsive and holistic can be transformative for high school scholars. To illustrate this, in multiple years we accepted a few high school scholars with lower GPAs (ranging from 2.1 to 2.5) who were recognized by the partnering organization as having great untapped potential. After experiencing our intensive research and mentoring, about half of these scholars achieved a GPA of 3.5 or higher in their next year of high school. Even for scholars who come to us with GPAs of 3.5 or higher, many routinely show an increase in academic performance upon returning to school. We suspect that our outsized impact on the lower-GPA scholars comes from three factors: intensive mentorship, holding them accountable, and the scholar's

Table 6. Lessons learned.

Challenge	Strategy for resolution	Impact
Mentoring Mentor expectations may not match program expectations	Train mentors at the start of each program cycle, and review program expectations with them.	Helps reduce mentor-mentee strain; improves scholar performance and satisfaction of both mentors and mentees.
Scholars lack basic information needed to advance to next phase of career	The CSM management team must listen for cues that indicate scholars are not on track. This is especially important at the high school level, where scholars may receive variable college/career counseling. We are involved in scholar development and make calls to prospective colleges if needed.	Helps ensure scholars advance to the next level and find the best situations to help them flourish.
Knowledge gaps Academic topics	Developed an academic curriculum to meet scholars' needs.	Ensures scholars develop key academic skills. We document considerable academic improvement in single summers; multiple high school scholars raised their GPA by a full point the following year.
Life skills (e.g. financial literacy, navigating administrative processes)	Many scholars had large gaps in financial 'literacy', and/or limited knowledge of the college application process. We have experts from area banks and our university's Office of Admissions meet with scholars.	Scholars gain improved understanding of key life activities, which may lead to better decision-making in future.
Overall lesson	Impact	Impact
Scholars must be at the center of all program components. This requires regular cross-communication between all stakeholders. The CSM management team must respond immediately as needs arise.	Scholars feel a part of the academic community; they become empowered and inspired to succeed as key skills develop. Many scholars did not realize personal success was possible until they participated in CSM.	

realization that we believe in them, their abilities, and their potential. Over the summer, they begin to recognize these features in themselves. As one scholar commented, "As the weeks went by, I became more confident. Not only did I become more assertive in my passion for science but also my mistakes. I realized that in order to learn, I had to fail. Accepting failure and criticism was one of the biggest lessons that being in SARE has taught me." Another pointed out, "Calculus was easy after spending a summer in SARE." We conclude that their experiences and practice in multiple areas of scientific competence increased their confidence that they could achieve what was previously unimaginable. Another scholar, whose family was homeless just before she entered high school, was recognized for her scholarship at the city-wide level and is now a STEMM major at a four-year college—an extraordinary transformation for her and her family.

Conclusions

The CSM Initiative is helping students from under-resourced backgrounds pursue careers in STEMM. This program attempts to be proactive, customized, and personally responsive in training and empowering scholars at successive phases of their education with outcomes that are transformative. By focusing on the unique needs of scholars from under-resourced backgrounds, we are nurturing a new generation of professionals who will contribute to innovation and excellence in healthcare and biomedical research. Our collective and achievable effort in initiatives such as this will also help lift their families and future generations out of poverty.

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