

Growing the Pipeline of Diverse HIV Investigators: The Impact of Mentored Research Experiences to Engage Underrepresented Minority Students

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Abstract Structured, mentored research programs for high school and undergraduate students from underrepresented minority (URM) backgrounds are needed to increase the diversity of our nation's biomedical research workforce. In particular, a robust pipeline of investigators from the communities disproportionately affected by the HIV epidemic is needed not only for fairness and equity but for insights and innovations to address persistent racial and ethnic disparities in new infections. We created the Summer HIV/AIDS Research Program (SHARP) at the San Francisco Department of Public Health for URM undergraduates as a 12-week program of hands-on research experience, one-on-one mentoring by a senior HIV investigator, didactic seminars for content and research methods, and networking opportunities. The first four cohorts (2012–2015) of SHARP gained research skills, built confidence in their abilities and self-identified as scientists. In addition, the majority of program alumni is employed in research positions and has been admitted to or is pursuing graduate degree programs in fields related to HIV prevention. While we await empirical studies of specific mentoring strategies at early educational stages, programs that engage faculty who are sensitive to the unique challenges facing diverse students and who draw lessons from established mentoring frameworks can help build an inclusive generation of HIV researchers.

Keywords Mentor · Undergraduate research experience · Career development · Underrepresented minority · HIV

Introduction

The National HIV/AIDS Strategy calls for addressing and eliminating HIV disparities in the US in response to the disproportionate impact the epidemic has had among heavily affected groups, such as Blacks and Latinos [1, 2]. Many point to the need to diversify the HIV research workforce as underrepresented individuals stand to contribute important insights that can help narrow the gap in new infections and improve HIV-associated health care for racial and ethnic minorities [3, 4]. Enhancing the early mentoring of emerging scientists from underrepresented minority (URM) communities—including ethnic minorities and socioeconomically disadvantaged individuals—may limit the attrition observed at later stages of the academic pipeline [5–7]. To accomplish this, several groups have created innovative models and training programs that aim to strengthen the mentoring competencies of senior investigators and to increase sensitivity to unique challenges facing investigators from diverse backgrounds [8–14].

Enhanced mentoring of diverse post-doctoral fellows and junior faculty is needed to reduce the loss of URM investigators as they transition to academic independence. However, to diversify the future biomedical research workforce attention also must be paid to the opportunities afforded to those at earlier stages of training. Structured mentored research, particularly at the undergraduate and post-baccalaureate levels, can influence future education and career trajectories [15–19, 23]. A meaningful mentored research experience during these highly formative years

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can influence students' early impressions of science and cement lifelong passions to generate new knowledge.

Data from recent studies suggest undergraduate research experiences have been effective in increasing persistence in science and intention to pursue graduate school. One of the largest examined a longitudinal sample of 4152 aspiring science, technology, engineering, and mathematics (STEM) majors who completed the 2004 Freshman Survey and 2008 College Survey [20]. Compared to matched controls who did not participate in an organized research experience, students had greater intention to pursue graduate school enrollment, and this was particularly pronounced for Latino and Black students. In addition, a longitudinal study of students from 25 four-year institutions who participated in the National Institutes of Health (NIH)-funded Research Initiative for Science Excellence (RISE) minority training program showed they were more likely than propensity score matched controls to persist in their intentions to pursue a scientific research career [21]. Since 1989, the Myerhoff Scholars program at the University of Maryland has engaged hundreds of high achieving URM undergraduates to prepare them for advanced science and engineering degrees. Through a combination of mentored research, participation in study groups, and requiring scholars to mentor and tutor other students, over 85 % earned science or engineering bachelor's degrees, with 87 % going on to graduate or professional programs. Compared to students who were invited to participate in the program, but declined and attended other institutions, Myerhoff scholars earned similar grades and graduated at similar rates, but were more than twice as likely to earn a science or engineering bachelor's degree and over five times more likely to enroll in post-college graduate study [22]. At the post-baccalaureate level, the National Institute of General Medical Sciences has been supporting recent URM college graduates at over 41 grantee institutions since 2001 with the goal of preparing eligible individuals for entrance and completion of rigorous Ph.D. training programs in the biomedical sciences. Post-baccalaureate Research Education Program (PREP) scholars typically participate in mentored discovery research projects, engage in programs of study to enhance their academic standing, work closely with peer groups, and take advantage of scientific writing workshops and graduate school application information and assistance. While PREP programs did not have formal control groups, Hall et al. found that the Ph.D. attainment rate was 38 % for the first cohort of scholars (2000–2006), a rate that is approximately six fold higher than a comparison group of under-represented biology baccalaureates [23].

Given the widespread appreciation for the diversity gap in the biomedical workforce, the federal government, private foundations, and other sponsors will undoubtedly

continue to support a host of opportunities that engage early stage trainees. However, as recently advised by Linn et al. [24], the field would benefit from more robust evidence on what factors were most influential in increasing the diversity of students entering graduate school and retaining them in research careers. They point to a dearth of empirical studies comparing different mentoring models and their ability to guide URM students into STEM graduate studies and careers. For example, the Posse Foundation has pioneered a team-based model to identify promising inner city high school scholars to combat isolation and the perceived mismatch between expectations and reality that many URM students cite as reasons for why they leave science [25]. While college achievement and graduation rates approach 90 % overall for the Posse scholars who go on to participate in programs at 26 universities across the country, few studies have formally assessed individual versus team level mentoring and support—a key element in the program's success. To the extent that diversity in the HIV workforce could be affected, as far as we are aware, no programs have reported on mentored research opportunities for high school or undergraduate students with explicit outcomes on career paths in HIV research.

Through the lens of a model summer program developed to attract URM undergraduate students to HIV research, this article explores theoretical frameworks that can guide the mentoring approach as well as relevant contextual factors that influence diverse students as they weigh future training and career options. We also discuss opportunities and challenges in recruiting URM students and evaluating the outcomes of such programs. Finally, we suggest future directions for our program and others as we refine educational interventions to increase the inclusiveness and diversity of the HIV research workforce.

The Summer HIV/AIDS Research Program

The Summer HIV/AIDS Research Program (SHARP) is a multi-component, inter-disciplinary, 12-week mentored summer research experience based at the San Francisco Department of Public Health (SFDPH) and supported through an R25 research education award [26]. SHARP aims to attract undergraduate students to careers in HIV prevention research, with recruitment focused on communities disproportionately affected by HIV, including racial, ethnic and sexual minorities (e.g., transgender persons) and on economically disadvantaged persons. Unlike most programs of its kind which are usually hosted by universities or academic health centers, SHARP highlights the potential to pursue research careers in public health settings where studies are implemented and findings applied in close partnership with community stakeholders. As a health

department in one of the early HIV epicenters, the SFDPH attracted researchers working on a wide range of federally-sponsored, investigator-initiated and clinical trial network-associated studies. Many of the SFDPH researchers are faculty at the University of California, San Francisco (UCSF) and leverage close ties with the University community to introduce SHARP scholars to post-doctoral trainees and a wide range of research and learning opportunities such as symposia and clinical shadowing. Although not a common site for pipeline programs, health departments present an opportunity to increase exposure to research careers outside of academia in an era of fewer university-based tenured track positions [27].

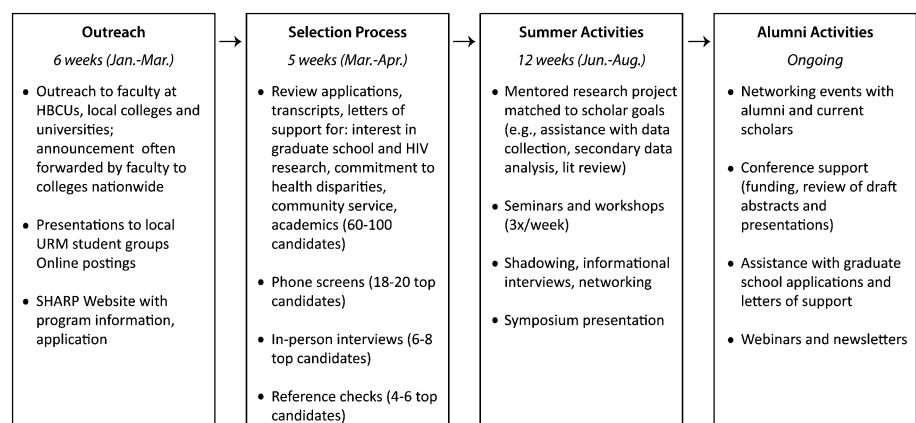
The components of SHARP are depicted in Fig. 1. Four to six scholars are selected to participate each summer; four cohorts completed the program through 2015. An independent, but closely mentored, HIV-focused research project is the cornerstone experience. These projects primarily focus on describing HIV disparities and identifying novel biomedical and behavioral interventions to mitigate them among highly affected populations, including men who have sex with men (MSM), particularly MSM of color, transgender individuals, and substance users. To identify candidates for the program, SHARP investigators and staff pursue a wide range of outreach activities that involve contact with faculty at local partner colleges, including several Historically Black Colleges and Universities (HBCUs), online postings, and presentations to URM student groups. Prior to applying for the program, prospective scholars are encouraged to review the SHARP website (sharpinternship.org) to learn more about potential research topics and participating mentors. Through a formal application and multi-stage selection process, including face-to-face interviews, candidates from across the country describe their research interests, share their competency-building goals and provide transcripts and letters of recommendation. No minimum GPA is required to be considered for the program, and evidence of candidates' personal commitment HIV/AIDS

prevention is weighted heavily during the selection process. Accepted scholars work closely with mentor teams to carve out a feasible project to which they can meaningfully contribute over the summer. The projects culminate in capstone oral and poster presentations at the SHARP Research Symposium, attended widely by SFDPH leaders and staff. Scholars also work with mentors to submit abstracts for national conference presentations and manuscripts to peer-reviewed journals. In addition to their one-on-one mentorship and hands-on learning, SHARP scholars participate in weekly seminars that delve into quantitative and qualitative research methods, the responsible conduct of research, good participatory practices in biomedical HIV prevention research, HIV disparities, bio-behavioral prevention methods, and scientific writing and presentation skills. Clinical shadowing opportunities are made available to those interested in graduate degrees in medicine, nursing, and psychology. After the intensive summer experience, scholars maintain their connections with the program through their fellow scholars from their cohort, and through their mentors who assist with manuscripts and abstracts and who are asked to provide letters of support for graduate school applications. They receive electronic newsletters, participate in webinars, and take advantage of online and face-to-face networking opportunities with the incoming cohorts. Alumni are also eligible to apply for funding to present at scientific conferences.

Theoretical Underpinnings

Ultimately, the goals of any program that strives to attract URM students to future careers in research must be to increase students' awareness and understanding of scientific methods and to solidify a student's identity as a researcher. Research training and experiences alone, however, are insufficient to sustain long-term interest in research careers. Several investigators point to the

Fig. 1 Outreach activities, selection process, and program components of the Summer HIV/AIDS Research Program (SHARP) at the San Francisco Department of Public Health. *HBCU* historically black colleges and universities, *URM* underrepresented minority



relevance of key social and environmental determinants that affect goal setting, motivation, and retention in academic programs [28–30].

SHARP is grounded in Social Cognitive Career Theory (SCCT) [31] which posits that students' career-related goals are driven by their sense of self-efficacy and their outcome expectations about their envisioned career (Fig. 2). As Baaken et al. aptly describe, self-efficacy encourages students to ask, "Can I do this?" whereas outcome expectations focus on the question, "If I do this, what will happen?" [32]. To bolster self-efficacy, programs should provide multiple opportunities for students to achieve success during training while evoking positive feelings as they contemplate future research careers. SHARP accomplishes this through scheduled works-in-progress sessions where scholars can receive encouragement and constructive feedback about their research from mentors and peers. Scholars also have the chance to present their work publicly at the Symposium, where they receive recognition from leaders from across the SFDPH. The SHARP coordinator and program investigators meet regularly with scholars to provide ongoing social and moral support and to ensure their program-related needs are met in a timely manner. Outcome expectations are bolstered by early and frequent contact with successful role models, particularly those from underrepresented backgrounds at different career stages. SHARP hosts several networking events to expose scholars to URM doctoral and postdoctoral trainees from UCSF with whom the SFDPH collaborates closely in HIV prevention research and training.

Finally, SCCT requires that key contextual and environmental influences are considered. With these influences in mind, SHARP program staff and mentors consider the unique attributes and backgrounds of each individual scholar so that they can tailor the experience accordingly.

Recruiting Diverse Students

In order to reap the benefits of mentored research, URM students need to know that these opportunities exist. Unfortunately, studies have documented that students have limited awareness of mentored research options when applying to college [33] or fail to take advantage of them once there [34]. In addition, Bangera and Brownell [35] point to the fact that approximately half of students nationally begin their undergraduate education at community colleges [36] which often lack research infrastructure and hands-on opportunities. Because these schools traditionally attract a large proportion of URM students, research programs that are seeking diverse students should actively engage community colleges. SHARP partners with a large local community college to advertise the summer opportunity; approximately 10 % of the 75 or more candidates who apply each year come from this recruitment source. From our first four cohorts, 19 of the 20 scholars who shared their race/ethnicity and socioeconomic background (95 %) report being a member of an underrepresented group (Table 1).

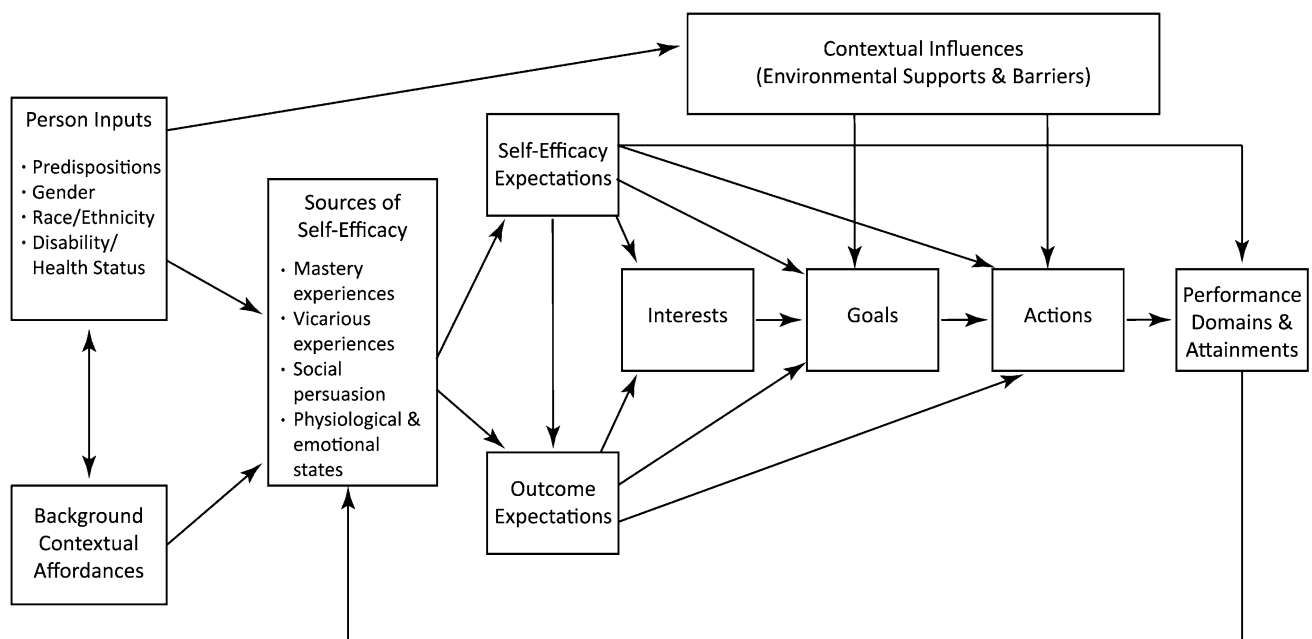


Fig. 2 A representation of constructs and processes underlying Social Cognitive Career Theory: adapted from Lent et al. [31]

Programs must also acknowledge that students from diverse backgrounds, many of whom are under significant financial pressure to work during college or during the summer to afford school, often cannot pursue volunteer research experiences. While SHARP is a paid summer internship, it still may be inaccessible for nontraditional students who are supporting families, or cannot afford to relocate to the San Francisco Bay Area for the summer based on its high cost of living and limited housing options. Supplemental stipends to support students from outside the region are likely needed to ensure national reach, especially as we seek to partner more closely with the network of HBCUs heavily concentrated in the Southeastern US. In addition, students from disadvantaged backgrounds may be dissuaded from considering graduate studies in STEM fields altogether as they contemplate the prospect of accruing substantial student debt to obtain their degree [37]. To mitigate this, programs should reinforce the importance of investing in their future and highlight federal loan repayment options, particularly for those who may go on to become clinician scientists interested in conducting NIH-funded health disparities research or who come from economically disadvantaged backgrounds.

Supporting Mentors

Many of the competencies required to successfully mentor doctoral, post-doctoral, and early career faculty equally apply to the high school and undergraduate levels. Effective mentors should possess strong communication skills including a willingness to clarify expectations of the mentor/mentee relationship over time (the individual development plan, or IDP, is an excellent tool to facilitate these conversations), to offer honest and timely feedback, and to acknowledge diversity and differences between the mentor and mentee [8, 11, 13]. Unlike post-doctoral trainees or junior faculty who are already committed to an academic path and possess a core scientific knowledge base, mentors working with students at the high school or college levels should adopt a framework of knowledge integration which focuses on developing good research practices, expanding knowledge, understanding the nature of science, and developing a science identity [24]. This model is inherently more time intensive for mentors, and requires them to provide high levels of scientific and psychosocial support needed to ensure their mentees apply to graduate school [20]. Not surprisingly, many faculty are wary of committing the additional time required by these students [38]. To ensure students receive sufficient oversight during their research experiences, SHARP has adopted a model where senior faculty are encouraged to assemble mentor teams that include junior faculty and

Table 1 Cohort demographics, program inputs and outcomes of the 20 Summer HIV/AIDS Research Program (SHARP) scholars, San Francisco, 2012–2015

Cohort Demographics	<i>N</i>
Gender	
Male	10
Female	8
Transgender	1
Decline to state	1
Race/ethnicity	
Black/African American	5
Latino	4
Asian/Pacific Islander	8
White	1
Other	2
Program inputs	
Number of scholars funded	20
Participating scholars not funded by SHARP	8
Program staff ^a	4
Primary mentors	11
Secondary mentors	8
Average number of seminars organized each summer	24
Professional development workshops per summer	3
Works in progress/peer mentoring sessions per summer	8
Networking events per summer	5
Clinical shadowing placements	6
Program outcomes	
Scholars successfully completing the summer program	20
Professional outcomes	
Authored publications ^b	16
Delivered abstract-driven presentations ^c	6
Honors, awards, and leadership roles ^d	6
Employed in health or research-related field	7
Graduate education outcomes	
Scholars who intend to apply to graduate school at program completion	19
Applied to a graduate program and awaiting acceptance	1
Accepted to a graduate program	2
Matriculated in a graduate program	5
Currently completing college degree	5

N number

^a Includes two co-principal investigators, a program coordinator and alumnus scholar

^b Published and in progress manuscripts from SHARP Projects authored or co-authored by 16 scholars

^c Abstract presentations from six scholars

^d Scholars who have participated on executive boards of community organizations, obtained fellowships, or served in other leadership positions

research staff. This team-based approach facilitates regular meetings with students over the summer while preserving time for senior faculty to focus their mentoring and teaching on scientific methods and to provide individualized coaching to the students—a factor that is closely linked to higher student retention in scientific fields [39].

As mentioned previously, mentoring for diversity is a key goal of these programs. Building a mentor's skill begins with enhancing his/her self-knowledge about unconscious biases and the negative impact that microaggressions may have during a URM student's formative experience in the research setting. However, mentors may be unaware of these impacts. A recent study of mentors working with undergraduates in the research laboratory context found that most did not perceive that racial and ethnic discordance with their mentees affected their mentoring relationships [38]. Thus, confronting the concept of color-blindness is an important step in understanding the potential for prejudices to play out in the mentoring relationship and negatively affect the performance of URM students [40]. In addition, mentors should be sensitized to the possibility that undergraduate student performance in STEM fields can be negatively influenced by stereotype threat which refers to the risk of confirming a negative stereotype about one's social group [41]. Finally, mentors can work with students to increase their awareness of the tensions between their cultural norms and those that exist in the scientific community [38]. Consistent with this point, several SHARP scholars appreciated the opportunities they had to share their critiques of the research establishment. Some scholars highlighted their personal struggle with the concept of the mentee-driven process whereby mentees are encouraged to be assertive about their views and needs regarding project- or authorship-related issues. The SHARP mentor orientation incorporates self-assessments and case-based discussions to highlight many of the issues above that may affect a URM scholar's experience in our program and beyond. Mentors have suggested that additional training and support in mentoring for diversity would be helpful.

Evaluating Outcomes

Evaluation of training programs for post-doctoral fellows is often based on trainees' productivity as measured by the number of manuscripts published and grants procured. Such distal outcomes are difficult to establish for high school and college students participating in mentored research programs, given they may take a decade or more to realize (i.e., proportion of program participants who are funded investigators). As seen in the table, our first four cohorts of SHARP scholars have successfully prepared

meeting abstracts and have submitted or are in the process of developing manuscripts for peer review. Proximal outcomes, such as program completion rates, graduation rates from college, as well as intent to apply to graduate school (post-program completion), and graduate school matriculation are feasible to track over the short to mid-term. All SHARP scholars have successfully completed the program, and if eligible, graduated from college. Almost all scholars (19/20, 95 %) completing the program reported intent to apply to graduate school. As of this writing, over half (8/14, 57 %) of those who obtained their college degree and intended to apply to graduate school have matriculated, been accepted, or have an application under consideration. In addition, changes in knowledge, self-efficacy and perceived gains in fundamental skills are other important proximal measures. Drawing from the Survey of Undergraduate Research Experiences [42] (Fig. 3), we found that on a 5-point Likert scale (1 = no gain at all to 5 = great gain), scholars reported 1 month after program completion their greatest gains in understanding scientific methods and domains linked to self-identification as researcher—an important predictor of persistence in research by URM students [43]. In addition, an unanticipated intermediate outcome of SHARP is success in finding work in the public health field after completing the summer program. Many SHARP scholars wish to get additional work experience prior to applying to graduate school to further hone their research skills while serving as research assistants or community engagement staff. Finally, an ancillary benefit of such programs is the ability to leverage them to enhance research experiences for other students in high school and graduate school who are interning with faculty within the department. These students and others from Bay Area universities are invited to attend the seminar series and work with mentors on HIV-related projects. SHARP scholars benefit by interacting closely with these trainees, expanding opportunities for peer mentoring. This model also allows us to train an even larger cadre of mentors who further strengthen our institution's capacity to mentor diverse students.

Discussion

Multi-component mentored research programs that are theoretically grounded and designed to build and sustain high quality mentoring for URM undergraduates can encourage diverse students to pursue future careers in research. From our experience with the first four cohorts of SHARP undergraduates, we have demonstrated that we were able to recruit and select a diverse group of scholars who successfully completed the intensive 12-week program and developed new research competencies. In the

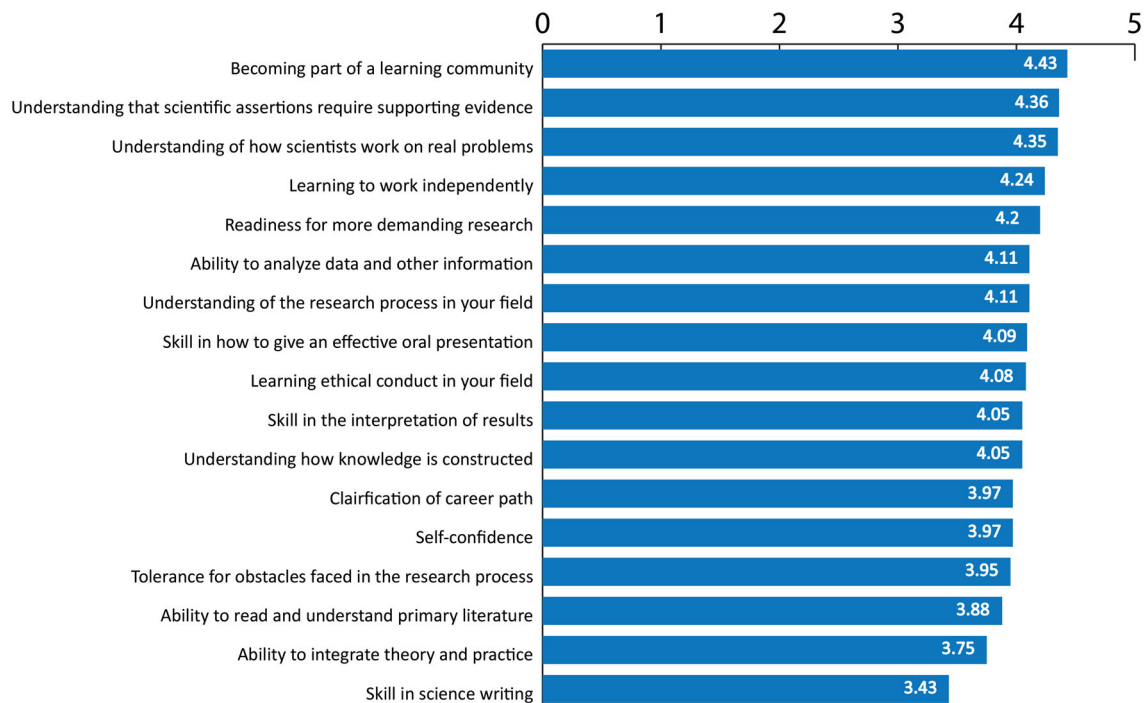


Fig. 3 Perceived gain in research skills among twenty SHARP scholars, 1 month post-program completion, 2012–2015. Means scores are provided (1 = no gain, 2 = little gain, 3 = some gain, 4 = considerable gain, 5 = great gain)

process, these students were also able to achieve measurable gains in self-efficacy and identity formation as scientists—short-term outcomes which predict persistence in research careers [43]. We also showed that participating scholars were able to present their research, prepare findings for publication in peer-reviewed journals, sought additional hands-on experience in research, and for a majority of scholars, either enrolled in graduate studies or reported their plans to do so in the near future. Mentors who participated in the program wished to enhance their mentoring skills, particularly around mentoring for diversity, and were strongly committed to the vision and goals of the program.

Despite the emerging evidence that supports the value of structured mentoring experiences in directing URM students towards careers in research, there is a risk that an increasingly constrained federal funding climate for HIV research may shift funding priorities from pipeline programs towards efforts to bolster the success of URM post-doctoral or early career faculty where the return on investment (i.e., grants funded) can be realized and documented more quickly. We argue that pipeline programs may, in fact, require *greater* investment if we are to attract individuals from URM and disadvantaged backgrounds, particularly non-traditional students. In addition, mentored research programs that are dedicated to increasing workforce diversity should have national reach to attract

prospective students, and therefore program stipends should cover travel and living expenses to ensure promising candidates receive high quality immersion experiences. A clinical trial network-based mentored research program designed to attract medical students of color into HIV vaccine science was successful in marshaling these resources which was perceived by both mentors and mentees to be instrumental in the program's early success [44].

It is important to recognize the limitations of some highly specialized mentored research experiences, like SHARP. First, such competitive programs can typically accommodate a relatively small group of students in any one year based on the availability of willing mentors and thus may be difficult to scale at any one institution. Ultimately the goal is to reach large numbers of students from URM backgrounds in order to have a sizable impact on the diversity of the biomedical workforce. Another approach would be to focus on expanding access to course-based undergraduate research experiences. Some contend that if research methods were required as an introductory college course [35], this would reduce reliance on highly selective programs such as ours. However, it is unclear whether equivalent benefits will accrue with these courses without providing the same levels of individualized attention and mentoring that are part of programs like SHARP. This research question should be explored empirically.

Our review of existing literature found that a majority of studies focused on undergraduate research experiences, while relatively few formally evaluated high school pipeline programs. Yet, many hold that we should develop a wide range of opportunities for K-12 students and carefully track career outcomes [45, 46]. Future plans for SHARP involve expanding the program to include high school students given the model's early success in catalyzing interest in HIV research-focused career paths. We also intend to conduct a controlled evaluation of SHARP by enrolling a matched comparison group to determine whether the promising outcomes achieved are due to participation in the program as opposed to a selection effect. Finally, we hope to pursue qualitative studies of the mentor-student dyad as recommended by Lev et al. to assess whether mentors' and students' perceptions of the students' research self-efficacy are truly aligned [47] and to reveal important insights into ways to enhance the mentoring experience in SHARP for both mentee and mentor.

Creation of a more inclusive biomedical workforce dedicated to reducing the burden of HIV infection locally and globally requires mentors who can serve as effective teachers and supportive role models. Mentored research opportunities during high school and college can be transformative for young individuals. To optimize these research experiences, future studies should seek to better define what constitutes effective mentoring for URM students and identify factors that may dissuade them from following a research career path. Programs that can effectively transfer skills and excitement for research in an environment that embraces cultural humility are poised to bolster the diversity of our HIV research workforce.

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