Youth Enjoy Science Program at the Case Comprehensive Cancer Center: Increasing Engagement and Opportunity for Underrepresented Minority Students

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The Youth Enjoy Science (YES) Program at the Case Comprehensive Cancer Center is a National Cancer Institute (NCI) R25-funded training grant, designed to increase the pipeline of underrepresented minority (URM) students entering college and pursuing biomedical research and health care careers in the Cleveland Metropolitan and surrounding school districts. The three components of the program include: *Learn to Beat Cancer*, engaging middle school students and their families; *Research to Beat Cancer*, designed for high school students and college undergraduates; and *Teach to Beat Cancer*, focused on enhancing science, technology, engineering, and mathematics (STEM) teaching capacity among high school teachers. This study focuses on *Research to Beat Cancer*, which, in 2018 enrolled 36 URM students as paid summer scholars. Students were assigned to a faculty mentor, were taught laboratory safety, responsible conduct of research and the scientific method, and then immersed in full-time laboratory cancer research during an eight-week period. Twice each week, students participated in Lunch and Learn Seminars where faculty members provided combined motivational and scientific guidance lectures. In a capstone poster session at the end of the program, students presented their research to peers, medical and graduate students, family members, faculty, community members and leaders. Students' perceptions of the program were reported using descriptive statistics and qualitative thematic analyses. Twenty-four of the 2018 YES students (67%) and 19 (53%) mentors completed the online post-program survey. Opportunity was a major qualitative theme from student and mentor responses. Future research will investigate the long-term impacts of YES, including college enrollment.
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Introduction

The Youth Enjoy Science (YES) Program is a NCI, R25-funded training program designed to engage and excite underrepresented minority (URM) students. The long-term goal of the YES program is to increase the number of URM in the biomedical research and health care professions. Currently, there are eight NCI-sponsored R25 YES programs, each with its own unique approach. The YES program at the Case Comprehensive Cancer Center (Case CCC) at Case Western Reserve University (CWRU) aims to engage students from the Cleveland Metropolitan and surrounding school districts to help prepare them to enter college and pursue cancer-focused biomedical research and health care careers.

The underrepresentation of historically disadvantaged populations, including racial/ethnic minorities, in biomedical research and health care delivery is a national concern, as is evidenced by the NCI's continued support for research education programs for URM students. The YES program at the Case CCC is focused on Cleveland, Ohio, where the URM population is 51% African American and 10% Hispanic.[1] In contrast, among the overall population in Northeast Ohio, 15% of residents self-identify as African American and 4% as Hispanic.[1] About 35% of the population in Cleveland and 49% of children aged <18 years live in poverty.[2,3] Like

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many other large racially/ethnically diverse and economically challenged urban school districts across the United States, the Cleveland Metropolitan School District (CMSD) is faced with numerous academic challenges. In 2014, the overall academic performance of CMSD rated 602 out of 608 districts in Ohio.[4] By the end of the 12th grade, only 35% of students had passed the science portion of the Ohio Proficiency test.[5] Overall, four-year and five-year graduation rates are 75% and 80%, respectively.[6] The city of Cleveland and the CMSD are engaged in multiple initiatives to improve these statistics, including expanding and replicating existing high performance districts and charter schools, refocusing and strengthening mid-performing schools, and developing new magnet schools and advanced placement proposals.

The initiation of the NCI's YES program in 2017 presented the opportunity to close the gap between programs serving URM post-secondary students and those at the K-12 level.

Many schools of medicine and schools of public health in the United States offer academic enrichment programs that support URM students; however, such pipeline programs are frequently designed for students who are at the undergraduate or graduate level. To date, the majority of research education pipeline programs have served already high-achieving, racial/ethnic minority students in their undergraduate or graduate years.[7,8] Far fewer programs reach students in secondary or high school to assist them through the educational pipeline. The 2007 Academic Competitiveness Council report on educational programs indicated that of the 105 federally sponsored STEM education programs in 2006, only 18% focused on K-12 education while 77% focused on postsecondary education.[9] The initiation of the NCI's YES program in 2017 presented the opportunity to close the gap between programs serving URM post-secondary students and those at the K-12 level.

YES at Case CCC: Background

The Case CCC, based at CWRU, is a matrix partnership organization, supporting all cancer-related research and efforts at CWRU, University Hospitals Cleveland Medical Center and the Cleveland Clinic. The YES program was built upon the pre-existing successful high school student-targeted Scientific Enrichment and Opportunity (SEO) program and an NCI-funded Continuing Umbrella of Research Excellence (CURE) award to provide a systematic and sequentially implemented approach to: 1) engage URM middle school students in the Cleveland area, their families, and teachers to become knowledgeable about cancer, risk reduction, and health disparities – and excited about cancer research opportunities; 2) attract promising URM students attending Cleveland area high schools and colleges/universities to engage in cancer education and research immersion opportunities at the Case CCC, designed to encourage and facilitate their pursuit of careers in cancer research and health care; and 3) provide specific research and educational opportunities for Cleveland area teachers to enhance their cancer research-related knowledge, curriculum development and educational skills, and their enthusiasm to promote health education and careers in cancer research. Accordingly, the YES program has three major components: 1) *Learn to Beat Cancer (LTBC)* engaging middle school students and their families; 2) *Research to Beat Cancer (RTBC)* engaging high school and undergraduate students and; and 3) *Teach to Beat Cancer (TTBC)* focused on enhancing STEM teaching capacity of high school teachers. This article describes the elements and outcomes of the RTBC component of the program, which, in 2018, enrolled 36 URM students as paid summer scholars using an apprenticeship model.

YES at Case CCC: Program Description

At the beginning of each calendar year, students from area high schools are invited by emailed announcements and application forms to high school principals, guidance counselors and science teachers who

then distribute them to students. Through word-of-mouth about the reputation of the SEO and YES programs, we also receive multiple applicants from regional high school students. Applicants are required to be at least aged 14 years and to have a grade point average of 3.0 or higher. In addition to personal identification information, the application requests a personal statement on career goals, interest(s) in science and cancer, reasons for wanting to participate in the program, as well as a broad question on the last book an applicant has read and whether and why they would recommend it to their friends. Applicants are also asked to provide their GPA, high school transcript, and two letters of recommendation (from their science teacher and guidance counselor). Applications are reviewed and individually ranked by a group of high school guidance counselors and medical school faculty, who meet to determine the final list of students to be accepted.

Before starting the research immersion program, each student is assigned to a faculty mentor and laboratory based on the interests described in their application. For example, students indicating an overall interest in cancer research would usually be assigned to a laboratory conducting cellular, molecular, or genetic cancer research. Students indicating an interest in a particular type of cancer, usually because of a family experience, would be assigned to a laboratory focusing on research related to that organ (eg, breast cancer or lung cancer). Students interested in pursuing a career in a particular discipline, such as neurosurgery, might be assigned to a neuroscience or brain tumor research lab. To the extent possible, all laboratory assignments are developed to build on and enhance student interest.

At the start of the summer, students and their families are invited to attend a morning orientation and motivational program. This introduction includes an overview of the benefits of a summer research experience, including learning about biomedical science, career possibilities, and potential connections with faculty who may serve as long-term mentors, role models, and advisors. Given the objectives of the program, the keynote speaker is an accomplished faculty member who also identifies with an underrepresented minority group. Students are asked to consider predictors of academic success, such as intrinsic motivation, and a personal goal of obtaining a professional or graduate degree. Discussions also include the importance of increasing the pipeline of URM scientists and clinicians, as one mechanism to address health disparities. Finally, the students are challenged to consider how they might better serve the needs of the community at-large and are encouraged to fulfill that commitment during and after completing their training. Although not subject to formal evaluation, this segment of the program was followed by widespread acclaim from both the students and their families.

The initial orientation and motivational program also include mentor and research team introductions, and a discussion of each lab's experimental focus. Students then write a short summary of their understanding of the lab research focus and briefly present them to the extended student group. During the second meeting, students are trained and tested in laboratory safety, and the responsible conduct of research, and introduced to the scientific method. They are then immersed in full-time laboratory research for eight weeks, followed by additional participation in research activities designed to accommodate student, family and faculty schedules. Students are integrated into the laboratory research programs at a level commensurate with their knowledge and research experience. Their activities and results are reviewed on a regular basis by their mentor and responsible laboratory personnel. At least twice during the summer, students meet in small groups with MD, PhD students to discuss techniques and results. For these meetings, each student is responsible for bringing and describing one piece of a research finding (eg, southern blot, flow cytometry, etc). This overall approach provides for deep learning of a unique scientific focus and broader focus on cancer research.

For educational enhancement, students participate in Lunch and Learn seminars twice each week, where invited faculty members: 1) briefly explain their academic discipline (eg, molecular genetics, immunology, surgery, or pathology and the requisite training requirements); 2) discuss their own training and career trajectories with particular emphasis on advantages and disadvantages of colleges and post-graduate schools they attended; and 3) their own area of scientific research and expertise. The speakers also provide contact information to the students, encouraging them to follow up on areas of scientific

research and additional information on specific colleges and universities.

Throughout the summer, students are coached in activities designed to build self-confidence. First, in preparation for the culminating poster session, students receive training in public speaking skills and scientific presentation delivery (Week 1). In Week 2 students are given a book to read on a subject matter relevant to our population, specifically focused on how individuals overcame personal and/or environmental challenges, and went on to develop successful careers. In Week 7, a book club-style discussion is led by a URM faculty leader, who also shares his/her personal experiences and obstacles throughout his/her educational journey. A new book is chosen each year and engages students on relevant issues encountered in their lives. In 2018, the book, *The Cross Over,* by Kwame Alexander was given to all participants. Students are also provided with multiple college entrance support activities. In Week 2, students are given practice ACT and/or SAT exams, which are scored and returned to them. Students then work with laboratory mentors to help them understand items that were answered incorrectly and to develop strategies for subject improvement. In Week 4, students are advised on college application processes and financial aid requests by CWRU admissions staff. Finally, multiple faculty advisors and speakers are available to discuss college selection options.

In Week 8 of the research immersion, all students participate in a capstone research poster presentation. Students work with mentors to prepare abstracts of their work, which are then published in a program booklet distributed at the poster presentation event. Throughout the eight-week period, students are engaged in increasingly complex discussions of their research project. These practice sessions lead to the capstone poster presentation session, where each student formally presents their research and future directions to an audience of peers, faculty, laboratory personnel, family and friends, as well as, university and local government officials. The capstone event includes brief motivational comments by university leadership, government and public health officials, and presentation of two awards (including a monetary prize) to students for scientific achievement and best scientific growth. Poster presentations are reviewed by MD, PhD students and scored using a standardized rubric. The formal research immersion program and capstone poster event are concluded with a celebratory luncheon.

Methods

Program Evaluation

Near the end of the 2018 YES Program, participants (students and faculty mentors) were emailed a confidential, online post-program questionnaire to evaluate the program. This was a post-program survey only. Students received a 24-item online self-administered confidential questionnaire with three email reminders to non-respondents (the questionnaire is available from the corresponding author). Survey items included both Likert scale and open-ended response items. YES mentors were sent an online, self-administered confidential 26-item questionnaire by email with two reminders to non-respondents. Mentors rated students using a five-point scale rated from poor (1) to exceptional

Table 1. 2018 YES student demographics

Demographics	2018 YES Survey Respondents, n=24	All 2018 YES Students, N=36
Grade		
High school student	18 (75%)	30 (83%)
College student	6 (25%)	6 (25%)
Sex		
Female	13 (54%)	18 (50%)
Male	11 (46%)	18 (50%)
Educational setting		
Urban	10 (56%)	7 (47%)
Suburban	8 (44%)	13 (36%)
College	6 (25%)	6 (25%)

Table 2. Frequency distributions of Youth Enjoy Science (YES) participants at Case Western Reserve University summer program

Response	n(%)[a]
Interest in biomedical or cancer research	
Increased	20 (83%)
No change in interest	4 (17%)
Interest in biomedical, cancer, or health care career	
Yes	17 (71%)
No	4 (17%)
Interest in health science or health care career	
Yes	16 (67%)
No	6 (25%)
Interest in cancer research career	
Yes	10 (42%)
No	12 (50%)
Increase in knowledge	
Health and science	
Yes	20 (83%)
No	2 (8%)
Cancer	
Yes	19 (79%)
No	3 (13%)
Cancer risk factors and disparities	
Yes	17 (71%)
No	5 (21%)
Postgraduate degree interest	
MD	10 (42%)
PhD	3 (13%)
Program aspects of most interest	
Research project	17(71%)
My interaction with my mentor	15 (63%)
Lunch and Learn seminars	14 (58%)
Education workshops	7 (29%)
Poster preparation and presentation	7 (29%)

a. Percentages were calculated using 24 respondents as a constant denominator; percentages reported are actual values and therefore include missing data. Missing responses varied for each item from 1-9 missing responses.

(5). Items focused on student assessment, including ratings of the overall experience, mentorship, program highlights, and recommendations for program improvement. Survey questions were structured to align with program objectives and inform future programmatic decisions. Our study was reviewed and deemed exempt by Case Western Reserve University's institutional review board [IRB STUDY20190229].

Analysis

Data were analyzed using a mixed-methods approach. Descriptive statistics of scaled-response questions were analyzed using SPSS 25. With an understanding student and mentor experiences with the program required a categorizing analysis,[10] after reading and rereading the data sources, a study team member developed inductive analytic codes considering the data through the lens of the survey items and study aims. Using NVivo11 software, the analyst coded the data to develop understandings of student and mentor experiences and perspectives regarding participation in the

Table 3. Distribution of responses by mentors (n=19) to each item on the 2018 program evaluation survey, n(%)

Rate your student's…	Poor	Fair	Average	Good	Exceptional
Understanding research topic	1 (5)	5 (26)	2 (11)	8 (42)	3 (16)
Improvement in understanding research topic	0 (0)	2 (11)	1 (5)	11(58)	5 (26)
Enthusiasm for research topic[a]	0 (0)	1 (5)	5 (26)	3 (16)	8 (53)
Improvement in research topic enthusiasm	0 (0)	1 (5)	3 (16)	11 (58)	4 (21)
Initiative to learn	0 (0)	2 (11)	4 (21)	6 (31)	7 (37)
Improvement in initiative to learn[a]	0 (0)	1 (5)	2 (11)	8 (53)	6 (31)
Mastery of techniques taught	1 (5)	0 (0)	3 (16)	9 (47)	6 (31)
Improvement in technical aptitude	0 (0)	3 (16)	2 (11)	9 (47)	5 (26)

a. Two respondents did not provide a response to this item.

YES program. For example, inductive codes used to categorize data included those that reflected the topics of our post-program survey questions (eg, interest level, mentorship, recommendations, satisfaction, program aspects, etc.) and more specific themes that emerged in the open response questions (eg, future academic/professional plans, change in interest or academic plans, research opportunity, mentorship fit). Throughout and after recursively coding the data in NVivo11, the analyst documented emerging findings and, ultimately, developed themes that represented participants' experiences and views.

Results

Student Participants

In 2018, 69 students applied for all available programs (ie, SEO and YES). Thirty-six URM students were enrolled in the YES program. Twenty-four students were enrolled in the parallel SEO program and nine applicants were not enrolled. Of the 36 YES student participants 24 (67%) completed the online post-program survey. The majority of 2018 YES survey respondents were attending a school in an urban educational setting (n=10, 56%), were female (n=13, 54%), and in high school (n=18, 75%) (Table 1).

Quantitative Survey Responses

Most students reported an increased interest in biomedical or cancer research at the end of the program (Table 2). Most reported an interest in pursuing a career in biomedical/cancer research or health care. Pursuing a career in health science or health care in general was endorsed by two-thirds of students, and over 40% reported that they wanted to pursue a career in cancer research. Most students reported increased knowledge regarding health and health science, cancer, cancer risk factors and cancer disparities. All high school student respondents indicated that they definitely planned to attend college, and the majority of respondents planned to pursue an MD or PhD postgraduate degree.

Students reported strong endorsements of key aspects of the YES curriculum on their desired career-related futures (Table 2). When asked about program characteristics of greatest interest the hands-on research project was the most highly endorsed, followed by the mentor interactions, the Lunch and Learn seminars, and the educational workshops and poster presentations. Additional qualitative comments supported this trend and highlighted the opportunities presented through the YES Program. Regarding the research project, one student said, "I was grateful that I was able to do hands-on research in my lab. I appreciated having the autonomy to perform my own assays and I appreciated the opportunity to use my critical thinking skills to analyze my data." Another student highly valued the opportunity to engage in research presentations: "It gives me the opportunity to face my fear of public speaking by giving a presentation of my research at the end of the program and participate in the lab meetings." A third student expressed the importance of collaboration and group sessions: "The Lunch and Learn sessions are a highlight because we get to hear from experts in the biomedical fields. We not only hear about their research, but how they got to where they are."

Fifty-three percent of URM student mentors completed the post-program survey. The majority of mentors reported their students showed increased knowledge of biomedical/cancer research. More than one-third of mentors recommended that their student be recognized for an achievement award in scientific growth and 26% recommended an award for scientific merit. Mentor ratings on student performance are shown in Table 3. Mentors responded that more than half of all students had a "good" to "exceptional" understanding of the research topics. Mentors reported that: most students displayed "good" to "exceptional" improvement in their level of understanding at the end of the YES Program; "good" to "exceptional" enthusiasm for research; and demonstrated increased enthusiasm by the end of the program. Strong initiative-taking toward learning was rated "good" to "exceptional" for most students and the majority showed increased initiative-taking. Mastery of techniques was identified as "good" to "exceptional" for more than three-fourths of students, and most demonstrated improvement in technical aptitude.

Qualitative Survey Responses

Open-ended student responses aligned with the quantitative results and identified a broader theme found throughout our analysis: opportunity. Opportunity encompassed research experience, academic interests, and future career paths. Students, all of whom were URM and many of

Figure 1. 2018 YES student qualitative responses

This word cloud is a visual representation of textual data whose importance is visualized by way of their size. A word cloud visually interprets qualitative data and is useful in quickly gaining insight into the most prominent words in a given text (by visualizing the word frequency n the text as a weight list). The word cloud surveys and displays the 500 most common words from student responses.

whom attended urban schools, grew to embrace YES because they valued the direct hands-on opportunities they experienced in the YES Program. This is reflected in direct quotations and a visual representation of textual data whose importance is visualized by way of their size (Figure 1).

> "This program opened up new ideas and opportunities for me and my interest in medicine has only increased. Having lab experience and gaining information about cancer and potential therapeutic strategies has been amazing."

> "Having the opportunity to participate in this experience in the first place was a highlight. Before my acceptance into the program, I never even thought it possible for someone like me to have an opportunity like this."

A second distinction of opportunity (future opportunity) also emerged from student responses. Through YES, URM students recognized the future academic and professional opportunities available to them in the biomedical/cancer research fields. Students expressed their excitement and readiness to partake in science careers in the lab as well as motivation to obtain advanced degrees.

> "...this program has paved the way for me to pursue a successful career in science. I know now I want to be a doctor."

> "Working in my lab made me explore questions about the medical field that I didn't realize I had, and I'm even more excited to continue on my pre-medical path."

> "...this opened my eyes. Now I can see and appreciate the different sciences and possibly see myself following a biomedical path in the future."

Mentor-written comments provided further evidence of opportunities gained through the YES Program. This third type of opportunity illustrates the intertwined opportunities that exist within the YES Program. These opportunities are not explicit curricular aspects of YES, rather these are opportunities that arise from being in an academic research institution. Mentors reported that several students had learned advanced lab techniques, statistical analyses, and software programs.

> "She was reading publications we provided her with and mastered the SnapGene software on her own."

> "He not only learned how to manipulate genome-scale expression data, but also learned R programming from scratch."

Additional opportunities presented to students through YES included writing strategies, conference attendance, peer discussions, critiques, and collaborations, basic science/research gap identification, literature review methods, and even publication skills.

> "Her efforts have resulted in her being included as an author in one of our lab's manuscripts."

> "There was a conference in Cleveland during the summer. It was optional for her. She attended a good part of the 3 days. She was engaged and had follow up discussions with me and the lab members about some of the presentations."

The YES research immersion program affirms the value of engaging learners using a wide array of educational strategies and multiple instructional methods in terms of increasing knowledge, skills, and attitudes about science, and increased awareness of science as a career possibility.

Discussion

Our program builds upon and enhances successful pipeline programs developed to identify and encourage URM students to enter careers in medicine and science.[11-14] The YES research immersion program affirms

the value of engaging learners using a wide array of educational strategies and multiple instructional methods in terms of increasing knowledge, skills, and attitudes about science, and increased awareness of science as a career possibility. Immediate immersion in a research-mentored program can be a successful strategy to stimulate highly productive outcomes without the need for extended introductions or boot camps. Given the opportunity, students from disadvantaged backgrounds have the capacity and drive to excel in science, particularly, areas of cancer research where they master both concepts and cutting edge technology. These opportunities reinforce their realization that they can contribute to this important endeavor. For example, some of the students, upon entering the program, had a limited understanding of the concept of a gene. However, within a short time period, they were able to cut and paste genes, then evaluate and target their function. For these students, this appeared to be a transformative experience.

Another important component of the program was introducing students to a laboratory-based research family, and the realization by the student that these scientists are ordinary people with professions to which the students could aspire and achieve. Another aspect of the laboratory immersion, students were encouraged to identify at least one role model, from either the laboratory family or faculty speakers.

Research examining the long-term outcomes of the YES program is needed to accurately demonstrate its impact on URM students and the opportunities it presents. The true outcomes of our programs will be measured by whether participants choose careers in science and medicine. Initial findings are positive, and demonstrate the feasibility, acceptability, and immediate program outcomes. From a subset of eight YES high school participants, who were in their junior year in 2018, we are aware that all have been accepted into institutions such as Case Western Reserve University, Cornell University, Harvard University, Johns Hopkins University, Kenyon College, The Ohio State University, University of Pennsylvania, The University of Notre Dame, The US Naval Academy, College of Wooster and the University of Dayton, where they are majoring in biology, biochemistry, molecular biology, chemistry, and neuroscience as part of a pre-med track, while one student is planning on pursuing a research PhD. Another student, although he was very successful in his research project, indicated that he learned research was not for him; he is pursuing an entrepreneurship major leading to a business degree.

Conclusion

We suggest that program outcomes be measured broadly. Insofar as students realize a new vision for their future, identify caring role-models and mentors, connect with like-minded peers and develop a deeper appreciation for science and scientific methods, the knowledge gained may have true long-term positive consequences for their lives, and the community.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Papp, Junk, Berger; Acquisition of data: Qua, Junk, Berger; Data analysis and interpretation: Qua, Papp, Berger; Manuscript draft: Qua, Papp, Junk, Webb Hooper, Berger; Statistical expertise: Qua, Papp; Acquisition of funding: Berger; Administrative: Papp, Junk, Webb Hooper, Berger; Supervision: Webb Hooper, Berger

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