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Early Cancer Research Education for Underrepresented Middle School Students: A Case Study of Experiences from Youth Enjoy Science Programs

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ABSTRACT: Cancer is the second leading cause of death in the United States, and marginalized communities are disproportionately affected. There is a significant need to address cancer disparities and the determinants of health that are associated with those disparities. Increasing the diversity of the cancer research workforce is a potential mechanism to address health disparities. The National Cancer Institute's Youth Enjoy Science Research Education Program provides funding to engage middle school, high school, and undergraduate students from underrepresented student populations in cancer research education programming, conduct cancer education outreach to communities, and provide cancer research curricula to kindergarten through grade 12 educators. The ultimate goal of these programs is to motivate, prepare, and support students in pursuing cancer research careers. Herein, we describe how three academic institutions with YES Programs – the University of Kentucky, the University of Nebraska Medical Center, and Case Western Reserve University – provide cancer education programming to middle school students. Descriptions of each institutions' programing are provided. Common and unique elements were determined through an evaluation of the three programs. Although each program was developed independently, they have more common than unique elements. We provide insight into the development of middle school programs for other academic institutions.

INTRODUCTION

Cancer is the second leading cause of death in the United States (US) and is expected to result in 609,360 deaths in 2022 (American Cancer Society, 2022). With a projected incidence of 1,918,030 cancer cases in 2022, cancer is a major public health concern and area of research (Siege et al., 2022). Marginalized communities, such as racial/ethnic minorities and rural populations, are disproportionately affected, leading to significant disparities in cancer mortality and incidence (National Cancer Institute, 2020a). Overall, age adjusted all site cancer mortality rates are 152.4 per 100,000 U.S. persons, 153.4 for Whites, 226.1 for Appalachian Kentuckians, 173.6 for Blacks, 139.5 for American Indian and Alaska Native (AI/AN) and 109.7 for Hispanics (National Cancer Institute, 2020b; Rodriguez et al., 2018). Although AI/AN age adjusted cancer mortality rates are lower than the overall US population, specific AI/AN communities experience significant cancer disparities that vary by geographic region and cancer type (Melkonian et al., 2019). Colorectal cancer incidence is significantly higher in AI/AN communities than white populations, with the Indian Health Service (IHS) Northern Plains region having double the rates of the Southwest region; rates for colorectal cancer and breast cancers are increasing amongst AI/ANs. Prostate cancer incidence is high amongst AI/AN males (Islami et al., 2022).

A lack of culturally and racially congruent care (Palmer Kelly et al., 2021) and research (Valantine and Collins, 2015) are factors that limit our ability to address cancer disparities. Moreover, rural and racial/ethnic minorities are significantly underrepresented in science, technology, engineering, and mathematics (STEM) education (National Science Foundation, 2020). The evident need for increased underrepresented minority (URM) students to enter and diversify the research

workforce requires a concerted effort by the federal government, academic institutions, kindergarten through 12 education, and communities (Valantine and Collins, 2015).

The National Cancer Institute (NCI) Youth Enjoy Science (YES) Research Education (R25) grant provides funding for institutions to engage underrepresented middle school, high school, and undergraduate students in cancer research education programs, conduct cancer outreach with underserved communities, and provide cancer research curricula to kindergarten through 12 educators (National Cancer Institute, 2021a). The goal of the YES grant is to support educational activities that enhance the diversity of the biomedical, behavioral, and clinical research workforce. Accordingly, YES programs can help to increase the capacity of the research workforce and address cancer disparities by developing diverse researchers with unique perspectives that are currently underrepresented (Islami et al., 2022) and prepare a health professions workforce that is culturally congruent and responsive in care (Wilbur et al., 2020).

There is significant evidence to support the impact of interpersonal factors, such as interaction with educators or peers, on early career decisions in students (Akosah-Twumasi et al., 2018). In particular, middle school students who have started career-education planning are more prepared for college and pursuing their desired careers (Turner and Lapan, 2005). Thus, middle school is a critical time to introduce students to cancer research careers and provide cancer research education. Three academic institutions – the University of Kentucky, the University of Nebraska Medical Center, and Case Western Reserve University – have developed their YES-funded programs to target middle school students for cancer research and education programming (Table 1). The purpose of this case study is to describe each program and evaluate common and unique elements across the three programs. In particular, the UK program is tailored to the surrounding rural Appalachian population, the UNMC program to the AI/AN population and the CWRU program to the Cleveland area African American population. Through examining tailored approaches, the overall goal is to provide insight into key program elements of cancer education and research programs at the middle school level for underrepresented groups.

Table 1. *Summary of YES Middle School Programs by University and Population.*

Program	University	Population
Appalachian Career Training In ONcology (ACTION)	University of Kentucky	Rural Appalachian Kentucky Students
Indigenous Research (IResearch) Club	University of Nebraska Medical Center	Urban American Indian and Alaska Native Students
Learn To Beat Cancer (LTBC)	Case Western Reserve University	Urban Underrepresented Minority Students and Families

PROGRAM OVERVIEWS

Case 1. The University of Kentucky Markey Cancer Center and Rural Appalachian Kentucky

Context and Impact. Each area in the US experiences cancer, but none is more afflicted than Kentucky. When compared to the remaining 49 states and the District of Columbia, Kentucky experiences the highest cancer incidence and mortality rates (Centers for Disease Control and Prevention, 2016). Specifically, the Appalachian region is disproportionately affected. The entire Appalachian region consists of 420 counties, 54 of which comprise the eastern-most region of Kentucky (Appalachian Regional Commission, 2020). The 1.2 million residents that reside in this rural, impoverished region are 8% more likely to die from a preventable cancer malignancy than those living in the urban, non-Appalachian region (Blake et al., 2017).

Appalachian Kentucky consists of a unique population of mostly White, non-Hispanic or Latino individuals; 94% of the population is White and 98% is non-Hispanic or Latino (Pollard and Jacobsen, 2020). Appalachian Kentucky is 73% rural, and 25% of its residents live below the poverty level. Forty-one of the 54 Appalachian Kentucky counties have economic indicators within the lowest 10% among all US counties, making the population among the most economically distressed in the US. The median household income in Appalachian Kentucky is $36,993, which is significantly lower than the US median of $60,293 (Appalachian Regional Commision, 2021; Appalachian Regional Commission, 2015; Pollard and Jacobsen, 2020). Out of 50 states, the State Technology and Science Index ranked Kentucky 44th overall, 48th in human capital investment, 43rd in research and development inputs, and 44th in technology and science workforce (Milken Institute, 2020). Kentucky is in the bottom quartile of states awarding bachelor's degrees in science and engineering fields (National Science Foundation, 2019). Only 24% of Kentucky's population holds a bachelor's degree or greater compared to 31.5% of the general US population, and only 1% of Kentucky's population holds a doctoral degree. The education disparities are greatest in Appalachian Kentucky, where nearly 22% of the population hold less than a high school diploma compared to 12.3% of the US population. Only 14.1% hold a bachelor's degree compared to 31.5% of the US population, and less than 1% of the Appalachian Kentucky population holds a doctoral degree (Pollard and Jacobsen, 2020).

The cancer disparity in Appalachian Kentucky results from various health, behavioral, and socioeconomic factors. First, the Appalachian region is extremely rural, which leads to decreased access to healthcare facilities and services (Crosby et al., 2012). Appalachia's rurality is also tied with poverty, which prevents many citizens from visiting the doctor for routine checkups (Charlton et al., 2015). Appalachia also has an economic dependence on the tobacco cash crop.

This dependence, which promotes a culture of tobacco use within the region, results in increased smoking rates (Centers for Disease Control and Prevention, 2019) and lung cancer incidence (American Cancer Society, 2021). Lastly, Appalachian Kentucky sees some of the lowest education levels, ranking 45th in the country in terms of educational attainment (McCann, 2020). This lack of education contributes to low levels of cancer literacy. Cancer literacy is defined as a person's ability to understand and make appropriate cancer-related decisions based on the advice of a healthcare professional (Diviani and Schulz, 2014). Increasing cancer literacy has the potential to increase participation in cancer-related activities that contribute to lower cancer rates (Rakhshkhorshid et al., 2018), especially if the efforts are focused on youth.

To address these issues, the University of Kentucky (UK) Markey Cancer Center developed the *Appalachian Career Training In ONcology (ACTION) Program* as an NCI YES program to provide a culturally centered cancer education and training paradigm for students from Appalachian Kentucky. The program immerses high school and undergraduate students from the region in cross-disciplinary mentored research projects, cancer care observational experiences, and cancer education and career development activities. It also provides hands-on community outreach activities (McConnell-Parsons et al., 2021). As part of ACTION's outreach activities and with the goal of increasing cancer literacy, a cancer curriculum was created and targeted towards Appalachian middle and high school students. The curriculum consists of three lessons that each teach different cancer-related topics. In order to engage students and cultivate learning, lessons include interactive activities, discussion questions, and instructional PowerPoint presentations. Pre-tests and post-tests are used to assess students' knowledge, determine curriculum effectiveness, and receive teacher feedback for future adjustments.

Program Content Details. The first curriculum lesson is designed to introduce students to cancer, covering basic cancer biology and diagnosis. It also dives into the Kentucky cancer crisis by explaining which states are most afflicted by cancer. The second lesson discusses cancer risk factors, such as age, alcohol use, tobacco use, and obesity. It also gives students a three-step plan that is designed to help them alleviate their cancer risk. Finally, the third lesson focuses entirely on cancer treatments. Covering both common and modern cancer treatment types, this lesson can be kept as one long lesson or divided into two parts. It is also available in a short version. The curriculum PowerPoint presentations have been equipped with several additional aspects that make implementation easier for teachers. First, the lessons have embedded, interactive activities that promotes students' critical thinking and reasoning skills. Second, each lesson contains a detailed teacher's guide. Third, all lessons contain an embedded pre- and post-test, which will allow both teachers and ACTION personnel to assess the effectiveness of the curriculum and make changes in the future. Lastly, each lesson has been pre-recorded with a voiceover (guided by ACTION personnel) set to the PowerPoint presentation. These recordings allow the teachers to play the voiceover in class if desired, as opposed to teaching it to students themselves.

Part of the goal of the curriculum is to impart cancer education knowledge to both teachers and students. In doing so, they are trained to be change agents in their families and communities by empowering them to share the information they learn with those they love. Early evaluation of these efforts indicate that cancer education curriculum does motivate Appalachian Kentucky students to share what they learn with friends and family (Hudson et al., 2020). Engagement with family and the community more broadly is, thus, happening more indirectly through this approach. Since its creation in 2020, the curriculum has reached between 10 to 30 Appalachian Kentucky middle and high school students per session depending on class sizes.

Studies have shown that curricula are more effective when geared towards specific situations (Theall, 2012). As a result, these lessons have been tailored to Appalachian Kentucky. Appalachian Kentucky has a distinct culture and set of educational and healthcare needs, and each lesson was created with these cultural considerations in mind. Furthermore, the lessons are aligned with Kentucky academic health and science standards. An article about the creation of curriculum has been published in the Journal of Appalachian Health (Hudson et al., 2021), and the curriculum has already been further adapted since that publication in response to teacher and student feedback.

Evaluation Plan. The UK cancer curriculum comes equipped with Research Electronic Data Capture (REDCap) pre- and post-test surveys that assess students' knowledge, comfort levels, and interest in the material (Harris et al., 2019). Another set of REDCap surveys collect feedback from the teachers regarding factors such as ease of program delivery and student engagement. All survey results will be analyzed by Markey Cancer Center researchers and used to improve the program.

Case 2. The University of Nebraska Medical Center and Urban American Indian and Alaska Native Community.

Context and Impact. In the US, the American Indian and Alaska Native (AI/AN) population grew 86.5% from 2010 to 2020, and the AI/AN population is younger than the general population (USA Facts, 2021). In 2019, the AI/AN population had the lowest rates (16.1%) of educational attainment of a Bachelor's degree and second lowest rates (81.5%) of high school graduation compared to all other races or ethnic-

ities (American Community Survey, 2019). Median household income in 2019 was $44,497, the second lowest by race or ethnicity (American Community Survey, 2019). Furthermore, in 2019, 18.5% of families lived in poverty, which is the highest rate amongst all races or ethnicities (American Community Survey, 2019). These statistics demonstrate the critical need for researchers to investigate the impacts of social determinants on health.

Prior to settler colonialism, Nebraska was home to the Omaha, Ponca, Pawnee, Kansas, Otoe, Missouri, Arapaho, Cheyenne, Dakota Sioux, Yankton Sioux, and Lakota Sioux nations (Nebraska Department of Education, 2021). Today, the four tribes of Nebraska are acknowledged as the Omaha, Ponca, Santee Sioux, and Ho-Chunk (Winnebago) (Nebraska Department of Education, 2021). In 2019, the AI/AN population for the state was 17,673 (United Sates Census Bureau, 2020). The University of Nebraska Medical Center (UNMC) is located in the largest city in the state, Omaha, Nebraska, and in the IHS, Northern Plains region. As of the 2020 Census, Omaha, Nebraska has a population of 486,051 with 0.6% percent of the population identifying as AI/AN alone (United Sates Census Bureau, 2021a).

AI/ANs experience significant cancer disparities that mirror persistent disparities in wealth, education, and other illnesses or diseases (Jones, 2006). Over the past 20 years, cancer death rates have declined for all racial/ethnic groups except AI/ANs (White et al., 2014). Factors, such as bias and discrimination in cancer care, limited participation in cancer research due to a history of research abuse, structural racism limiting access to vital cancer care resources, and a lack of representation of AI/AN professionals and worldviews in healthcare and research, are some of the challenges that are faced when addressing cancer disparities seen in AI/AN communities (Association of American Medical Colleges, 2019; Idoate et al., 2021; National Science Foundation, 2021; Tuck and Yang, 2014; Warne et al., 2012; Zestcott et al., 2021).

The YES research education program at the UNMC was created to address the need for increased representation of AI/AN healthcare and research professionals specific to cancer. This is achieved through curriculum workshops for teachers serving AI/AN student populations, outreach to rural and urban AI/AN communities, and programming that provides research experiences for AI/AN students in grades six through undergraduate. The UNMC YES Middle School Indigenous Research (IResearch) Club provides middle school students (grades six through eight) with Native American ancestry the opportunity to participate in on-going, schoolyear-long research projects. There is a focus on learning cancer biology, prevention, treatment, and research based in Indigenous pedagogy and gain early exposure to various cancer-related research and health careers. This program was developed in 2019 in partnership with a Title IV-funded Native American education program, Native Indigenous Centered Education (NICE), in Omaha, Nebraska. The research projects were developed based on interest identified by the urban AI/AN community through a Community Readiness Assessment conducted by the YES program, the NICE program, and the students themselves.

Program Content Details. Activities include environmental health research projects focused on measuring International Agency for Research on Cancer (IARC) classified carcinogens (Group 1-2) in water, air, and soil. The club curriculum focuses on understanding how exposure to contaminants in the environment can contribute to cancer risk. It aligns with Indigenous worldviews in which the natural world is viewed in relationship with all beings (Cajete, 2000) and environmental values that are eco-centric and non-materialistic, emphasizing how focusing on protecting the environment will in turn protect one's health and culture (Magallanes-Blanco, 2015). The program also acknowledges the historical and present existence of environment contamination on tribal lands and the fact that environmental conservation is, thus, a key element to self-determination and an exercise of Indigenous rights (Gratani et al., 2016).

Following the scientific process, students 1) develop a research question, 2) conduct background research, 3) create a hypothesis, 4) test their hypotheses, 5) analyze and interpret data, and 6) communicate their results. Students hear from guest speakers to provide background research and engage in hands-on, active learning experiences. Students engage in school group discussions to construct hypotheses reflecting on and informed by content learned as background research. Students learn Environmental Protection Agency (EPA) or other standard sampling methodology to sample for contaminants to test their hypotheses. Results are interpreted as a group and compared to relevant regulatory limits, and students communicate the study and its results through poster presentation. In addition to science learning objectives, the IResearch club content is integrated with cultural education delivered by the NICE program with an equal balance of time provided to both curricula. IResearch club curriculum integrates cultural education facilitated by Indigenous education and research faculty and educational consultants on the UNMC YES team. Since program inception in 2019, an average of 34 middle school students have participated in the IResearch Club program every schoolyear. All participating students identify as AI/AN. There are slightly more female (56.4%) participants than male (41.6%), and 2% of students reported a different gender identity (e.g., transgender, genderqueer, non-binary, two-spirit).

All program activities are conducted during in-school advisement times or in out-of-school field trips on college campuses. Out-of-school field trips include community partner organizations that support AI/AN students in increasing

college preparedness, preparation for high school transition, and development of life skills and resilience. These clubs are also recognized pre-college American Indian Science and Engineering Society (AISES) chapters. Through their participation in these chapters, students can create a research poster to submit to the National American Indian Science and Engineering Fair (NAISEF) Junior Division to represent the American Indian Science and Engineering Society (AISES) chapter. The overall aim of the UNMC YES is to ultimately increase the number of Native Americans in health professions and research in cancer-related fields through early exposure to these careers.

Evaluation Plan. Evaluation of students' experiences, knowledge of cancer and Indigenous culture, and interest in cancer-related health professions and research careers is collected using an online survey hosted in Microsoft Forms. Microsoft Forms is the preferred method of data collection through school-provided devices of the partner school. Students who do not have access to reliable internet or internet accessible devices can complete these surveys in paper form to later be entered manually by YES personnel. Responses are collected at the end of the schoolyear until the beginning of the following schoolyear.

Student participation in IResearch club meetings is documented for each event in a database that facilitates tracking of student participation in UNMC YES programming at the high school and college level. Matriculation to college can be obtained through the National Student Clearinghouse database utilizing student date of birth and full name including middle initial to determine the impact of participation in UNMC YES programming on matriculation into a health research field.

Case 3. Case Western Reserve University, Case Comprehensive Cancer Center and Underrepresented Minority Students in a Large Metropolitan Area.

Context and Impact. Case Western Reserve University (CWRU) and the Case Comprehensive Cancer Center (Case CCC) are major research institutions located in Cleveland, Ohio. Cleveland has a population of 376,594 with an ethnic composition that is 49% Black, 40% White, and 12% Hispanic. Cleveland has been identified as being one of the poorest large cities in the U.S. with a median household income of $30,903 and poverty level of 32.6%. Only 33% of the population over age 25 are high school graduates and 11% have bachelor's degrees or higher (Census Reporter, 2021; United Sates Census Bureau, 2021b). The city of East Cleveland, immediately adjacent to the CWRU School of Medicine and the Case CCC, is even more economically depressed and academically challenged. The population of East Cleveland is 20,451 with a composition of 93.5% Black, 1% Hispanic, 4.6% White with a median household income of $21,883 and an overall poverty rate of 37.4% (Biggest US Cities, 2021; Public School Review, 2021).

In addition to being both economically and educationally challenged, the cities of Cleveland and East Cleveland are afflicted by significant health care and cancer disparities. The age adjusted annual incidence for all cancers for the Case CCC 15 county catchment area is 485 cases per 100,000 persons compared to the national average of 448. The predominant cancer diagnoses are lung-bronchial, breast, colorectal and prostate. In Cuyahoga County, where both Cleveland and East Cleveland are located, the age adjusted cancer mortality rate was 173.1 per 100,000 residents compared to 152.4 per 100,000 for the US. The age adjusted cancer death rate for African Americans is even more striking at 195 per 100,000 compared to 166 per 100,000 for Non-Hispanic Whites (National Cancer Institute, 2021b, 2021c).

The Case CCC YES Program provides a sequentially integrated educational and research approach consisting of three components 1) Learn to Beat Cancer (LTBC), focused on providing education and research opportunities for middle school students and their families; 2) Research to Beat Cancer (RTBC), focused on providing cancer research immersion opportunities for URM high school and undergraduate students, as well as engaging their interest in pursuing careers in cancer research; 3) Teach to Beat Cancer (TTBC), providing special research and education opportunities for teachers of URM students to enhance their understanding of cancer, promote their use of cancer-based curriculum modules, and stimulate their participation in cancer risk reduction activities (Qua et al., 2020). The Case CCC sponsored LTBC component of the YES program primarily targets students from the surrounding Cleveland and East Cleveland areas.

Program Content Details. The LTBC program focuses on engaging Cleveland area middle school students, families, and teachers in exciting active learning. The program includes hands on participatory education programs to increase student knowledge about cancer, introduce them to strategies for risk reduction and disparity elimination, acquaint them with cancer center members, and excite them about the possibility of pursuing careers in cancer research and cancer care. To implement these strategies, we have developed a series of 13 age appropriate, active versus passive learning opportunities. These experiences are designed to convey principles of basic cancer clinical and translational strategies and stimulate inquiry in a series of seven workshops per year.

The sequential education and outreach programs are presented on Saturday mornings starting in February. The workshops are designed to introduce cancer research and care to students and their families to become knowledgeable about cancer, involved in risk reduction and disparity elimination, and excited about pursuit of cancer research opportunities.

The first four workshops focus on introduction to cancer, cancer disparities, cancer prevention, and cancer therapeutics. These four workshops are repeated each year. The latter three workshops focus on specific cancer types rotated on a three-year cycle. In addition to learning about different cancer types, students and families are encouraged to participate in developing strategies for cancer prevention including eliminating tobacco use, HPV vaccination, avoiding UV radiation, exercise, healthy eating, and avoiding obesity.

Each workshop is presented as a 3.5-hour program divided into seven, 30-minute blocks with five 30-minute educational sessions, a middle 30-minute refreshment session, and a final rap session. The five 30-minute learning sessions in each workshop typically focus on 1) understanding cancer science, 2) case presentation and discussion, 3) disparities, prevention and risk reduction, 4) ongoing research presented by a faculty member, and 5) student team research project development. Rather than utilize passive lecture type presentations, all learning sessions are designed to emphasize active/hands-on participatory learning using educational games, physician role playing, and hands-on learning modules. Some examples of activities to engage students and their families include drawing cellular components and comparing them to school functions, building balloon lung models, chest x-ray reading, using tabletop models to detect breast masses, and tumor-versus-immune cell hide and seek games with increasing complexity of hiding places in successive rounds designed to illustrate principles of tumor cell sanctuaries. Since inception in 2018, these workshops have been regularly attended by 12 to 18 students each along with variable numbers of family members.

Evaluation Plan. Each session consists of a pre- and post-test to determine student awareness of cancer and cancer biology (pre-test) and to assess student learning and increased interest in a cancer-related career (post-test). At the end of each LTBC workshop, a Likert scale evaluation is used to determine the effectiveness of the instructional format, including an evaluation of the presenters and the hands-on activities. The evaluation also provides space for free responses to garner suggestions for future workshops. During in-person workshops, students and families are invited to participate in a rap session to further clarify any questions from the group or to critique the program verbally rather than relying on written communication. For long term evaluations, student participation is recorded in a Case CCC database that facilitates tracking of students that go on to participate in the YES RTBC program in high school. Matriculation to college and choice of career pathways will be obtained through the National Student Clearinghouse database and regular follow-up with program alumni.

DISCUSSION

While each of these three programs developed independently and each is targeted to unique communities, it is striking that all three have developed common approaches to engage students as described below. These common components, as well as several unique elements, are discussed to provide a basis for those wishing to develop middle school targeted programs in cancer education and research.

Common Program Elements.

Tailored Education. One of the most striking elements shared by the 3 YES programs outlined above is content tailoring to the target population (Table 2). The programs were designed for specific populations, and each population faces its own cultural and economic differences. As a result, these factors should be considered when discussing cancer in a region. UK's YES program tailored its three-part cancer-related curriculum to Appalachian Kentucky, which has a unique cultural celebration of tobacco use, for example. To combat this, the curriculum clearly outlines how smoking

Table 2. *Summary of YES Programs' Common and Unique Elements.*

Elements	Definitions
Common	
Tailored education	Education is tailored to the student population composition.
Active learning	Students engage in learning process through discussion, problem solving, research, teamwork, and educational games.
Early research development	Students gain experience in developing research questions, developing cancer prevention strategies, and participating in science associations.
Advocacy of continued engagement	Each program provides continued support for students to pursue education and career pathways with the goal of strengthening pipelines and pathways for URM students to enter and diversify the scientific workforce.
Strengthening self-belief	Program leaders use encouragement, positive feedback, and reward students for program participation to build student confidence.
Long-term evaluation and follow-up	Continuous evaluation and tracking of student progress to measure program impact in increasing diversity in cancer research.
Community and family engagement	Each program engages and involves community and family in programming with various approaches.
Place-based education	Students engage in education that is community-based and grounded in their identity.
College and career counseling	Students engage in experiences that strengthen college and career exploration
Unique	
Student population	Each program serves a unique underrepresented student population. UK: rural, impoverished Appalachian Kentucky, UNMC: Urban and rural AI/AN, CWRU: Urban URM (Black and Hispanic)
Delivery method	Each program has developed a unique delivery for their programming. UK: in student schools, UNMC: in student schools, community groups, on-campus, CWRU: on campus at Case CCC

and tobacco use contributes to increased cancer risk. UNMC's YES program, which was created with American Indians and Alaska Natives in mind, acknowledges the historical and present existence of environment contamination on tribal lands. Thus, they emphasize the fact that environmental conservation is a pivotal element of self-determination. CWRU's YES program recognizes the cancer disparities that exist for Cleveland and East Cleveland and has developed workshops to address cancer disparities and promote prevention, treatment, and control.

Active Learning. A second element that is demonstrated in each of the three middle school YES Programs is active learning (Table 2). Active learning is defined as any variety of instructional approach where students are personally involved in the learning process, as opposed to being passive recipients of the content (University of Minnesota, 2022). While passive learning is very commonly used in higher level classrooms, actively engaging high school and middle school students in learning has been shown to improve self-efficacy and content perception (Detlor et al., 2012). One example of active learning at UK's YES Program is in curriculum lesson three, where students are asked to research a particular cancer treatment and then encouraged to teach it to another group. UNMC's YES program incorporates the scientific method, allowing students to use the steps to sample and identify a contaminant. CWRU's YES program uses physician simulation to familiarize students with developing health plans and promoting early diagnosis. CWRU's program also makes extensive use of educational games and models to engage middle school student interest. Although the specific activities involving active learning differ with each program, the three YES programs share a common goal of improving cancer-related interest and knowledge through hands-on participation.

Early Researcher Development. Another important approach that is shared between the YES programs is how they strive to develop research skills in their target audience (Table 2). UK's YES Program involves activities where students conduct independent and group research on different cancer treatments, simultaneously introducing them to how cancer is treated while also fostering research-related curiosity. It also encourages students to share their findings with peers, helping to develop their research communication skills. UNMC's YES program takes this one step further by guiding students through the development of a scholarly, research poster. Students are encouraged to submit their posters to the National American Indian Science and Engineering Fair Junior Division to represent the American Indian Science and Engineering Society chapter. Similarly, CWRU's YES program dedicates one 30-minute learning session each workshop to student research projects, which are primarily focused on developing practical strategies to eliminate perceived barriers to cancer screening and/or care. These students work to create this project in Teams, which introduces them to teamwork in the scientific setting.

Community and Family Engagement. Community and family engagement in programming can be supportive of student participation. Each university had varying levels of family and community engagement in the middle school program delivery, and differences in community and family engagement varied between the universities based on the program delivery and content. UK has used a more indirect approach to engage community and families through their curriculum. Specifically, UK encourages the teachers and students that engage in their curriculum to be change agents in their families and communities by sharing what they learn. UNMC has developed a community advisory board that provides critical feedback for program activities. The middle school programming has been created in partnership with the NICE program through a Community Based Participatory Research (CBPR) approach. Using CBPR, UNMC and NICE have developed mutually beneficial goals, revised program activities in iterative and cyclical processes, prioritized the cultural identity of our partner program and its students, and shared the dissemination of program activities and results (Israel et al., 2017). UNMC utilizes a place-based education approach which is critical in meeting students where they are at, strengthening their identity, and engaging students in community-based research (Smith, 2007). CRWU involves the community directly by inviting families to attend every Saturday session with their students. This has been a successful method for engaging families in programming with most students having family consistently present in workshops.

College and Career Counseling. College and career counseling are important components to strengthen middle school students' college readiness and provide career exploration. UK has leveraged multiple strategies to promote college readiness including offering a college readiness workshop, as well as having career counselors from the university career center and admissions officers from university admissions engage with students. UNMC partners with community-based programs to assist in providing students college and career counseling. UNMC YES's program brings in guest speakers in relevant research and health professions to speak with students emphasizing different career opportunities that exist. Out-of-school field trips are spent on varying college campuses, and these field trips include a college tour. These experiences provide early exposures to college to assist in strengthening self-belief of students. At CWRU onsite workshops, middle school students are given opportunities to act as physicians by evaluating and providing advice to simulat-

ed patients with cancer. During these sessions, students are provided with Physician Jacket printed T-shirts and given stethoscopes to keep. Donning the T-shirts always provides a moment of family pride with all members taking out their cell phones to take pictures. Medical students also lead tours of campus facilities and hold rap sessions with middle school students to further encourage career pursuits.

Additional Common Elements. In addition to the elements described above, the programs share several additional common aspects that may be useful to those creating middle school programs (Table 2). For example, each program endeavors to provide opportunities that strengthen students' self-belief through positive attitudes and encouragement. By providing students with enthusiastic feedback, these programs help students gain the confidence necessary to pursue a career in STEM. In addition, each program advocates for future student engagement. Because the goal of these programs is to create the next generation of researchers, they encourage students to continue seeking cancer-related activities following program completion. Where the opportunities are already in place, it is ideal for middle school students to continue through the pipeline to a similar program throughout their high school and undergraduate careers, such as at UK, UNMC, and CWRU where middle school students are encouraged to join each institution's high school program. Finally, all programs are implementing long-term evaluation plans that will be used to improve the program for future cohorts, and to track future student success to evaluate the effectiveness of these programs. For all three programs, the long-term evaluation of student matriculation into health science research fields includes the use of the National Student Clearinghouse database and surveys to student participants as continuous follow-up (e.g., annually). To utilize the National Student Clearinghouse database, it is critical to have full name, including middle initial, collected at student enrollment in program. Pertinent information that is collected from students in follow-up surveys are health and research professions interest, contact information (e.g., name change, address, phone, email), and school information from high school to university. The UK YES program will also be implementing surveys to assess teacher use of program materials.

Unique Program Elements.

Student Population. While it was discussed above that each YES program was tailored to its student population, one stark contrast between these programs is the population for which they were created (Table 2). Although all three targeted populations are underserved, each population has specific demographic characteristics that make their YES programs unique. Appalachian Kentucky is 94.3% percent non-Hispanic white citizens, many of which live in extremely rural communities (Pollard and Jacobsen, 2021). While the population surrounding UNMC is majority white (United Sates Census Bureau, 2021a), the program continues to target underserved American Indians and Alaskan Natives living in or near Omaha, Nebraska, which is a large urban and suburban area. The population of Cleveland and East Cleveland are 49% and 93.5% Black citizens, respectively, all of whom live in the heart of a sprawling urban region. As with many aspects of healthcare, differences in racial composition and urbanization are important considerations when creating health education programs.

Delivery Method. An important difference among the YES programs is the method in which the materials are delivered to the students (Table 2). The UK YES program is designed to be distributed to Appalachian Kentucky teachers, who will then administer the cancer-related curriculum in their classrooms. This delivery method allows for flexibility on the part of the creators, who do not have to be present to disseminate the information, and on the part of the teachers, who can teach it when most convenient. If the teachers are not comfortable or able to teach the material, they can use lectures pre-recorded by program personnel to allow for additional flexibility. UNMC's YES program uniquely mixes in-school and out-of-school meetings. In-school meetings allow for curriculum instruction by UNMC YES program personnel, while out-of-school meetings are day-long events with sessions led by guest speakers and presenters. This delivery method permits a variety of instructional styles, ensuring all students, no matter their preferred learning style, are able to glean information from the program. Finally, CWRU's YES Program is implemented in the form of in-person workshops on Saturday mornings on the CWRU campus. This venue allows for participation by family members along with middle school students. The workshops are reviewed, revised, updated, and delivered by first and second year CWRU medical students supervised by YES faculty. This delivery method provides for instructors who are easy for middle school students to identify with based on age and/or cultural characteristics. It further allows for frequent changes to workshop content and structure, while also providing medical students with pivotal leadership education experiences. Importantly, it is an opportunity for the middle school students to visit campus and begin envisioning themselves as college students. Finally, these onsite meetings serve to introduce family members to the facilities and faculty of the Case CCC.

Limitations. The implementation of these programs was stunted by the COVID-19 pandemic, so many of the ongoing efforts and areas for future work are centered around adaptations to suit the new post-pandemic educational standards. UK, which struggled to disseminate the curriculum to will-

ing Appalachian Kentucky teachers during the COVID-19 pandemic, continues to reach out to schools to identify teachers interested in using the curriculum. That said, some teachers did implement the curriculum virtually during the pandemic. Future goals include receiving additional direct teacher feedback and incorporating the curriculum into more schools. The UNMC YES program adapted their in-person meetings with students online as previously described. As schools shifted back to in-person instruction, program delivery has been resumed in-person while still maintaining adaptations that facilitate participation of AI/AN students. With the advent of the pandemic, CWRU adapted its program to continue Saturday morning delivery using remote communication technology. This approach limited use of hands-on activities, which will be resumed when in-person meetings are restored. However, virtual tools were used to develop new activities using drawing and polling functions on the software to engage students.

CONCLUSION

Introducing students at an early age to cancer education and research is crucial for creating the next generation of scientists and physicians in the field. UK, UNMC, and CWRU used R25 funding to create YES programs targeting middle school students to achieve this goal. Interestingly, the evaluation of these programs through this case study found that they had more common than unique elements. The programs have multiple elements in common, such as a tailored approach to education, active learning techniques, early researcher development goals, community and family engagement, and college and career counseling. In addition, each program also advocates for continued student engagement throughout the year or future pipeline programs, strengthens students' self-belief and self-confidence, and evaluates program implementation and student success. These programs also have unique elements, such as demographic, implementation, and evaluation differences that help them reach their target population effectively and influentially. We recommend these aspects to other institutions seeking to target middle school students because they allow the programs to introduce students to cancer research in a culturally relevant and memorable way. In evaluating these programs, we stress that rather than focusing on quantitating learned subject matter, it is important to engage students to participate in cancer prevention activities and most important, to pursue careers in cancer related professions and to diversify the workforce. Accordingly, evaluations of each program's effectiveness in this regard are long range and ongoing. Thus, the ultimate value of these YES programs targeted to middle schools will be demonstrated by the number of students that pursue cancer research and care professions, contributing to workforce diversity, and elimination of cancer health disparities. By increasing the use of these programs and continuing to update their materials, R25 YES programs have the potential to improve the cancer outlook in regions across the US and within communities experiencing significant disparities.

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ABBREVIATIONS

ACTION: Appalachian Career Training In Oncology; AI: American Indian; AISES: American Indian Science and Engineering Society; AN: Alaska Native; CBPR: Community Based Participatory Research; CCC: Comprehensive Cancer Center; CWRU: Case Western Reserve University; EPA: Environmental Protection Agency; HIS: Indian Health Service; IARC: International Agency for Research on Cancer; IResearch: Indigenous Research; LTBC: Learn to Beat Cancer; NAISEF: National American Indian Science and Engineering Fair; NCI: National Cancer Institute; NICE: Native Indigenous Centered Education; REDCap: Research Electronic Data Capture; RTBC: Research to Beat Cancer; STEM: Science, Technology, Engineering, and Mathematics; TTBC: Teach to Beat Cancer; UK: University of Kentucky; URM: Underrepresented Minority; US: United States; YES: Youth Enjoy Science

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