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Design and Success of a 21st Century Cancer Education Program at the University of Louisville

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Abstract

Cancer incidence, morbidity, and mortality in the Commonwealth of Kentucky are among the highest in the nation. The University of Louisville was the recipient of a National Cancer Institute (NCI)-funded cancer education program grant in 1975 under the leadership of Dr. Norbert Burzynski. A new and totally redesigned performance-based University of Louisville Cancer Education Program was funded by NCI in 2011 to recruit and motivate outstanding undergraduate and health professional students to pursue further training and careers in cancer research. Here, we describe the strategy, design, methods, implementation, and accomplishments of our twenty-first century performance-based cancer education program. Our program will meet or exceed all of its 5-year performance goals, including the total number students ($n = 156$) and under-represented minorities ($n = 53$) who successfully completed the program under the mentorship of cancer research-intensive faculty members of the James Graham Brown Cancer Center (JGBCC). The mentored research program is complemented with professional development and enhancement activities, including cancer research seminars presented by faculty members actively engaged in research centered on the diagnosis, treatment or prevention of cancer, creation of individual career development plans, exploration of cancer research careers, and acquisition of professionalism skills. Student interests towards cancer research significantly increased after completion of the program compared to baseline ($P = 0.02$). Based on quantitative and qualitative analysis of various components of the curricula, the trainees favor practical, engaging, and interactive activities aligned within professional career goals and objectives. For instance, the trainees prefer two 30-min small group discussions on “Navigating Careers in Cancer Research” with faculty, professional students, and program alumni. Future updates to the program include new activities that capitalize on the cross-disciplinary background of our mentors and trainees as well as a team-based approach to professional development. Our cancer education program will continue to enhance the professional development of the next generation of cancer scientists and clinicians.

Keywords

Cancer education; Cancer research and training; Summer research program; Distinction in research program

Background/Purpose

Cancer incidence, morbidity, and mortality in the Commonwealth of Kentucky are among the highest in the nation. In order to reduce the burden of cancer, new cancer researchers are needed to improve cancer detection, treatment, and clinical management modalities. Commensurate with this mission, the University of Louisville (UofL) embarked upon a strategic plan to become a premier nationally recognized metropolitan research university by 2020. The recruitment of James Graham Brown Cancer Center (JGBCC) faculty represents a major initiative towards this goal. To maintain a steady pipeline of cancer researchers, both the UofL and the JGBCC are actively supportive of cancer education programs geared toward the training and development of twenty-first century research scholars. In 2011, UofL received a Cancer Education Program grant funded by the National Cancer Institute to recruit, educate, and motivate outstanding undergraduate and health professional students to pursue further training and careers in basic, clinical, and translational cancer research. The program aligns extremely well with UofL's 2020 strategic plan and the JGBCC's mission is to reduce cancer incidence, morbidity, and mortality particularly within the Commonwealth and the region.

Program Description

We have modeled our Cancer Education Program after successful programs such as the University of Texas MD Anderson Cancer Center [3], University of Alabama at Birmingham [5], and St. Jude Children's Research Hospital [8]. However, the distinctive aspects of the University of Louisville Cancer Education Program include (1) incorporation of a combination of peer- and faculty/professional student-based learning among all professional enhancement activities; (2) cross-disciplinary and highly interactive learning; (3) incorporation of a Distinction in Research Career Track for medical students interested in extended research experience and professional development during the last 2 years of medical school; and (4) emphasis of our program on student "ownership" of their cancer research project. Rather than assigning participants to an already existing cancer research project, each of our cancer education program students in large measure selects the faculty mentor and develops their own cancer research project in collaboration with their mentor. To optimize the research project success, scholars present their "own" cancer research project as the cumulating experience and acquire skills to communicate the purpose and findings of their cancer research project at local and national scientific meetings (supplement video <http://video.louisville.edu/vod/tvprod/QC/Interviews2.mp4>).

The Cancer Education Program is an annual 10-week experience beginning in late May. The first day of the program begins with an intensive orientation in which students receive a welcome address by UofL senior leadership. The session follows with comprehensive information about key aspects of the program, including student and faculty expectations, program schedule, subsistence pay allowance and schedule, accommodations, and social activities. The opening day also includes detailed instruction and discussion on the responsible conduct of research, research integrity, and recording research data in laboratory notebooks. In addition, students receive information on the dates, times and locations of comprehensive research integrity and compliance training needed for the students' cancer

research projects. Prior to a student initiating a cancer research project, the Cancer Education Program verifies approval of all projects by appropriate IRB, IACUC, and biosafety committees. Facilitated by a grand meet/greet luncheon at the University Club, students in our program meet students and leaders of other UofL summer research programs with whom they frequently interact throughout the duration of the program.

As one of the first assigned tasks, participants devise a cancer project with their faculty mentor suitable for presentation at the end of the 10-week summer session. We believe the requirement to have students develop their cancer research project (within the parameters of ongoing research within the faculty mentor's research laboratory) fosters an immediate sense of ownership of their project. Active engagement of students in the conceptualization and design of their research project is a significant improvement compared to other research programs in which faculty mentors define research projects from which students may select. We strongly encourage many of the trainees to engage in a longitudinal mentored cancer research experience that extends into the remainder of their undergraduate and/or professional academic program. Medical, dental, and pre-medical/dental students are encouraged to consider a dual research degree (e.g., MD/PhD and DMD/PhD). In addition, UofL medical students are encouraged to enroll and complete requirements for the "Distinction in Research Program" from the School of Medicine. The "Distinction in Research (DIR) Certificate" is awarded with the medical degree to trainees who complete a 10-week summer research program such as the Cancer Education Program and continue to engage in research for the remainder of medical school. DIR students receive additional professional development and enrichment activities both within the program and within their faculty mentor's laboratory. They are required to propose and defend their research project in a seminar setting before the faculty and present the results of their research at a regional/national scientific meeting and/or co-author a peer-reviewed published manuscript.

The laboratory research training and mentoring are supplemented with cancer research development and enhancement activities divided into three basic categories: (1) basic, clinical, and translational research seminars; (2) acquisition of skills; and (3) career planning and exploration of cancer research careers. The cancer research seminars are presented by James Graham Brown Cancer Center faculty members and program alumni actively engaged in research centered on the diagnosis, treatment, or prevention of cancer. Cancer research presentations by program alumni who presented at national scientific meetings foster peer-based learning on how to present cancer research projects. During the career talks, we encourage program alumni to share their past and current cancer research experiences with each new class since they serve as superb role models. "Acquisition of Skills" includes how to: use library resources; LinkedIn; organize, design, and compose abstracts, poster presentations for scientific meetings, and write personal statements for application to graduate and professional schools. Career Planning & Exploration of Cancer Research Career Development Plans include creating individualized career development plans", informal career talks, and table discussions on "Navigating Careers in Cancer Research". Following a highly engaging 1-h lecture on "Creating an Individualized Career Development Plan", trainees are empowered to revise their 1-year cancer research career plan, including academic goals, research dissemination, and presentation of their research project at local, national, or international scientific meetings. The JGBCC sponsors "The Incredible Journey"

career talks in which faculty share how they came to the JGBCC and a career in cancer research. We have additional talks on diverse professional degree programs, including RN/PhD, MD/PhD, MPH, and DMD/PhD. Navigating Careers in Cancer Research offers trainees an opportunity to interact and network with program alumni, professional students, post-doctorates, clinicians, and faculty who share their insights on “women in science” as well as survival skills needed to pursue cancer research career paths in academia, industry, government, community outreach and education, and professional degree programs (supplement video <http://video.louisville.edu/vod/tvprod/QC/RoundTable2.mp4>).

Based on quantitative analysis of the various components of the Cancer Education Curriculum, “Creating Individualized Career Development Plans”, “Navigating Careers in Cancer Research”, and “How to Write Personal Statements for Professional School” were the best activities when compared to lecture style topics on scientific writing and poster presentations. These activities were highly favored because the trainees believed the activities were practical (i.e., aligned within professional career goals and objectives) and highly engaging among faculty and students. In addition, we learned the best components of the program actually involved regular scholar and faculty/lab mentor interaction and active learning. We added three new and cutting edge activities that are engaging, interactive, and practical. These three activities include a 90-Second Elevator Pitch Contest, a highly interactive lecture entitled “EMOTE: Learn how to connect with your audience”, and “Creating New Research Dissemination Tools”. The common denominator among all the activities lies with the cross-disciplinary and peer-based learning. We capitalize on the diverse education and training background of our scholars in public health, medicine, nursing, dentistry, and their lab/faculty mentors and professional students/post-doctoral fellows engaged in basic, clinical, population-based, and translational cancer research. Such diversity provides a wealth of knowledge and different perspectives on how to approach and master public speaking and scientific writing using new and highly interactive approaches.

90-Second Elevator Pitch Contest

Trainees compete for the best 90-second elevator pitch about their research projects. This interactive and fun learning activity better prepares trainees to present high-impact and concise presentations of their research projects to both scientists and non-scientists within 90 s. Cancer Education Program alumni or faculty/lab mentors serve as role models and offer excellent 90-s elevator pitches of their previous summer research projects.

Emote: Learn how to Connect With Your Audience

The concept of emoting one’s voice helps to empower trainees to connect and engage their audience with fascinating and innovative and significant aspects of their research projects to scientists and non-scientists. This activity improves the delivery and effectiveness of their invited talks and oral poster presentations at scientific meetings. Trainees have the opportunity to emulate skills learned during the 90-s elevator pitch contest at local/national/international scientific meetings. Prior to presenting at scientific meetings, trainees receive constructive feedback on their practice talks or elevator pitches by peers and faculty/lab mentors.

Creating new Research Dissemination Tools

Trainees create a new research dissemination learning module to guide scientific writing and presentations using a flipped classroom approach. Trainees gather information related to scientific writing and oral presentations from freely available NIH podcast videos, consultations with faculty/lab mentors or previously published abstracts, manuscripts, or posters previously published by Cancer Education Program alumni. Knowledge acquired is discussed in team-based and peer-based learning groups. Each team, consisting of 4–6 members, develops a detailed outline on various components of scientific writing or talking blocks (e.g., abstract, introduction, research objectives, hypothesis, rational, clinical impact, innovation, conclusion, future direction, and discussion). Each small group selects one team leader to share what they learned with the other Cancer Education Program students. Faculty/lab mentors and Cancer Education Program alumni help guide table discussions to optimize group participation and the preparation of a written document to guide research dissemination activity during and after the completion of the 10-week program. Concepts learned are reinforced by (1) mentor/peer-based constructive input; (2) a lecture on “How to Compose an Award Winning Abstract”; and (3) practical experience preparing and/or delivering abstracts/posters for scientific meetings and manuscripts for scholarly journals.

The cumulating event of the program involves a required oral poster presentation that describes the background, research objectives, hypothesis, methods, results, innovation, and clinical relevance of student’s cancer research project (supplement video <http://video.louisville.edu/vod/tvprod/QC/PosterExhibit2.mp4>). Each student presents their research poster to faculty judges at either the annual University of Louisville Summer Undergraduate Research Conference or the annual Research!Louisville Conference (a weeklong, city-wide celebration of research). Teams of 2–5 faculty members evaluate student oral poster presentations of their cancer research using a Likert scale, ranging from 1 to 5 (1 = unsatisfactory and 5 = outstanding). The posters are judged on several categories, including scientific merit, organization, communication skills, potential impact on target population, and innovative ideas. The students with the highest evaluation scores, summed across the various categories, receive Norbert J. Burzynski Outstanding Professional and Undergraduate Student Awards. To date, all participants in the Cancer Education Program have completed their cancer research project, submitted their research abstract, and presented their research poster at a local/national/international scientific meetings. Links to every abstract and every poster is available on the program website (<http://uofl.me/nci-r25>). Students are invited to present their research findings at national and international scientific meetings. These meetings offer strategies on navigating careers in cancer research, networking opportunities for future collaborations, and opportunities for trainees to apply/compete for travel awards. As described later, program alumni have received prestigious travel awards to present their research at numerous national and international scientific meetings.

An important emphasis of the training program resides within the faculty mentor’s laboratory group. Trainees are expected to present their findings at weekly laboratory meetings with graduate students and postdoctoral fellows. This dynamic interaction informs as to expectations of graduate and postgraduate research training. Trainees are introduced to

the different thematic research programs in the James Graham Brown Cancer Center and encouraged to also participate in activities of the programs other than the home of the faculty mentor and project.

Program Faculty

Program faculty holds appointments in the colleges of Arts and Sciences, Dentistry, Engineering, Medicine, Nursing, Public Health & Information Sciences, and Social Work. The scientific programs of the James Graham Brown Cancer Center are summarized below.

Therapeutics/Diagnostics

Researchers in this program identify molecular targets and pathways necessary to develop the next generation of cancer therapeutics and diagnostics. A unique structure-based strategy is used to accelerate the clinical testing of promising drug candidates. Traditional drug design often means random testing of hundreds to thousands of compounds. Given a candidate drug's precise structure, JGBCC scientists use a rational approach to select and test the more promising candidate molecules.

Cancer Prevention and Control

This program uses a combination of epidemiological and outreach approaches to reduce cancer risk, detect cancer early, and increase the number of people who survive cancer. Physicians need new tools to identify patients who have a high risk of developing cancer and/or may benefit from available interventions and aggressive treatment strategies. At the same time, physicians also need a profile of factors that protect a patient from cancer progression or predict successful recovery after chemotherapy.

Cancer prevention and control research often uses large data sets from population-based studies to determine the genetic factors, environmental effects, lifestyle choices, and biomarkers that relate to cancer development and prevention. The identification of risk factors predictive of a patient's likelihood to develop cancer can help guide decisions to tailor the most effective regimen to prevent or treat disease. The program is closely integrated with the JGBCC Kentucky Cancer Program, a national leader in cancer control and education. Through a network of 13 regional offices, the Kentucky Cancer Program promotes cancer prevention measures and serves as a bridge between scientists and the public, bringing the latest discoveries to the community through clinical outreach sites.

Tumor Immunology

Decades of research suggest a person's immune system may undergo activation and attack cancer cells. Paradoxically, inflammation mediated by the immune system can create a micro-environment that promotes cancer development. Tumor immunology research seeks to understand and manipulate this complex interplay to create new cancer prevention and treatment approaches. The research goals of this program are to activate host immunity against cancer cells and to suppress inflammatory induced cancer.

Clinical Trials

After rigorous testing in animal models, new diagnostics and therapeutics (some discovered by our Cancer Center research programs) are screened for safety and efficacy in humans using early-phase clinical trials (phases I, II, and III). A strong clinical trials program ensures that Kentuckians have access to cutting-edge anti-cancer agents without having to leave the state. Our clinical trials program for cancer patients has achieved national recognition as a major trial site for large pharmaceutical companies including Genentech, Amgen, Bristol Myers Squibb, and Merck as well as the National Cancer Institute. On average, we have over 100 open clinical trials and 750 cancer patients who actively participate in clinical research. We help to translate basic discoveries into clinical benefits for our patients. Moreover, we use astute clinical observations to create innovative ideas to test in our laboratories.

Program Participants

The total number of applications has increased dramatically over the first 5 years of the program with over 100 new applications in 2016. We target rising junior and senior undergraduate students considering graduate studies in the biomedical or public health sciences. Students complete an online application describing their major and academic performance, previous research experiences, and a personal statement on current long term goals and how their participation in the University of Louisville Cancer Education Program will assist their career plans. Criteria for selection include (1) USA citizenship; (2) an academic record suggestive of future success in graduate or health professional schools; (3) research experience (preferred but not required); and (4) a personal statement and letters of recommendation reflective of the candidate's strong interest in cancer research and training. We strive to achieve diversity in the race/ethnicity, gender, institution, and academic majors for our participants. Students were accepted from the following 33 universities and colleges:

- Auburn University
- Campbellsville University
- Cheyney University of Pennsylvania
- Clemson University
- Cornell University
- Drexel University
- Duke University
- Earlham College
- Emory University
- Goshen College
- Howard University
- Indiana University
- Massachusetts Institute of Technology

- Michigan State University
- Middle Tennessee State University
- Mississippi State University
- Morehead State University
- Roosevelt University
- Spelman College
- St Louis University
- SUNY-Binghamton
- University of Alabama
- University of Chicago
- University of Cincinnati
- University of Houston
- University of Louisiana-Monroe
- University of Louisville
- University of Kentucky
- University of Notre Dame
- Washington University
- Western Kentucky University
- Wheaton College
- Yale University

We recruit trainees from the UofL health professional schools (Medicine, Dentistry, Nursing, and Public Health & Information Sciences) as well as undergraduates from all other schools. Our recruitment strategies for professional students are integrated with the student summer research programs of the School of Dentistry and the School of Medicine. Our recruitment strategies for undergraduate students are integrated into UofL's Summer Research Opportunity Program (SROP). SROP has established procedures for recruiting undergraduate trainees from UofL as well as from under-served/underrepresented student populations from regional colleges and universities.

Decisions on faculty mentors are made in consultation with the student. Prospective trainees are encouraged to view our program's website to secure archived abstracts and research posters from all past students to identify potential mentors to contact for additional information on available cancer research projects within their laboratories. Students rank the faculty mentors and their research program for which they have interest. This student ranking together with information on the student's long-term objective is used by the program directors and the internal advisory committee to "match" trainees with faculty mentors. All of our student participants successfully completed the 10-week program.

Program Evaluation

Our evaluation plan is designed to measure the degree to which undergraduate and professional students who participate in the program are motivated to pursue further training and/or careers in cancer research. We evaluated student experiences using a blinded and electronic survey. The survey included questions regarding interest in the field of cancer research before and after the Cancer Education Program as well as perception of the quality of the faculty/lab mentor, program curriculum, and the overall program. In terms of the program curriculum, trainees report on their satisfaction with the various presentations/activities. All answers are recorded as typed responses to open-ended questions or ranked using a Likert scale, ranging from 1 to 5. Evaluation scores of 1, 2, 3, 4, and 5 corresponded to qualitative values of “poor”, “could be better”; “neutral”, “good”, and “excellent”, respectively. Improvement in the level of interest in cancer research before and after the completion of the program is assessed using the Wilcoxon signed rank test. Differences in the frequency of categorical data are assessed using the chi-square test of homogeneity. The Cancer Education program was approved by the University of Louisville Human Subject and Protection Office as qualifying for exemption according to 45 CFR 46.101(b), under Category 1: Research conducted in established or commonly accepted educational settings, involving normal educational practices.

We use the Pre- and Post-SURE III survey of Lopatto [11], a standardized assessment/measurement tool, to compare our program performance against others across the country. Dr. Robert Chamberlain provides external evaluation of our program’s performance against our approved benchmark goals. As former Director of the Cancer Prevention Education and Teaching Program at MD Anderson and currently Research Professor of Epidemiology at the University of Nebraska, Dr. Chamberlain has extensive experience in evaluating outcomes from comparable cancer educational and training programs.

Our process evaluations involve development of and revising existing objective questionnaires, subjective interview tools, as well as data and interview information derived from students, research mentors, and staff. Our outcome evaluations determine the extent to which the students fulfill the objectives of the program using both qualitative and quantitative measures. These objectives include presentations of research findings at regional and national scientific meetings and acceptance of trainees into cancer graduate and residency programs. This data is aggregated and compared to data collected using the same instruments at specific intervals and at the end of the project period. Evaluation also includes measures reflective of factors related to project sustainability, such as exit and postgraduate interviews and University commitment and support. Moreover, summative evaluation is used to evaluate progress as well as to improve assessment tools.

Student trainees are tracked from the time they enter the program until the completion the program, enter residency or other postdoctoral training, and/or obtain permanent employment (goal of 15 years). We also monitor and evaluate research publications of current and past participants over this 15-year period through citations in PubMed and Medline databases. We use LinkedIn to track cancer research education, training, and career progress. We continue to review best practices for student tracking as published by the NIH and the AAMC.

Program Accomplishments

The University of Louisville Cancer Education Program exceeded all of its goals in the initial 5-year program (Table 1). Our program alumni continue the cancer research training within various professional degree programs as summarized below.

- Twelve in PhD programs [e.g., John Hopkins University, UofL, University of South Carolina];
- Fifteen in MD Programs [i.e., Columbia University, James H. Quillen College of Medicine/East Tennessee State University, Johns Hopkins University, St. Louis University, UofL, University of Kentucky (UK)];
- Four in MD/PhD Programs (e.g., UofL, UK)
- Two in PharmD Programs (Lake Erie College of Osteopathic Medicine, UK)
- One each in Masters of Public Health Programs (UofL), Masters of Science in Social Work Programs (UofL), Masters of Science (Purdue University)

Moreover, destinations of medical/dental students who participated in the 1st and 2nd year of the NCI Cancer Prevention Program include residency or training programs at the following institutions:

- General Surgery (UofL, University of Illinois)
- Preliminary Medicine (UofL, Virginia Mason Medical Center and Dermatology at Rush University Med Center, George Washington University and Radiation-Oncology at Georgetown University Hospital)
- Radiology-Interventional, Vanderbilt University Medical Center.
- Pediatrics (UofL, University of North Carolina Hospitals, All Children's Hospital at Johns Hopkins Medicine)
- Plastic and reconstructive surgery, University of California, Davis
- Diagnostic Radiology, University of Pittsburgh Medical Center
- Radiation Oncology, UK
- Ophthalmology, Medical University of South Carolina
- Otolaryngology, Indiana University School of Medicine
- Internal Medicine, UofL
- Orthopedic Surgery (UofL, University of Alabama at Birmingham Medical Center)
- Urology, Akron General Medical Center at Northeast Ohio Medical University,
- Preliminary Surgery at University of Texas Health Science Campus
- Internal Medicine, Vanderbilt University Medical Center

Student Program Evaluations

Since the program began in 2011, there is a significant cumulative improvement in the level of interest in cancer research comparing participants' evaluation scores before and after the Cancer Education Program (Wilcoxon Signed Rank Test $P < 0.0001$). There was a nearly two-fold increase in the proportion of trainees who rated their cancer research experience as excellent after the Cancer Education Program compared to baseline scores (chi-square P value = 0.0015). Following the completion of Cancer Education Program, student interest towards cancer research increased significantly ($P = 0.02$) after completion of the program compared to cancer research interest at the onset. Furthermore, a majority of the students perceived the overall program (86.5 %), quality of the faculty mentor (88.5 %), helpfulness of lab mentor (86.3 %), and program curriculum (84.4 %), overall program (86.4 %) experience as "good to excellent" (Fig. 1). The trainees really appreciated their mentored research experience, program overall, and the program, based on selected students' comments summarized below and in Table 2.

- "I liked the low key and unstructured (Navigating Careers in Cancer Research) discussion with a small group. I especially liked hearing about how to incorporate research into a clinical practice."
- "The curriculum was well suited to the undergraduate participants. My mentor spent lots of time with me, but still allowed me to work independently and have influence over the research direction. Having never worked in cancer research before, I am definitely more interested now, particularly in the translation aspect of research."
- "My mentor and everyone else in the laboratory were very patient with me when I first started this program. I had no prior research experience, but they were very willing to help me. I had no interest in research before this program, but I decided to stay with the lab and continue with my project into the academic year."

Communication and Dissemination of Cancer Research

Students are required to present a research poster describing the background, research objectives, hypothesis, clinical relevance, innovation, methods, results, and discussion of their research project. Students are strongly encouraged and funded to present their research findings at national and international scientific meetings. In the first 4 years of the program, cancer education program graduates presented their research at over 35 national and international scientific meetings, including but not limited to the International Endocrine Society, Society of Toxicology, Keystone Symposia on "Cancer Pathophysiology: Integrating the Host and Tumor Environments", American Association for Cancer Research, International Workshops on Arylamine N-acetyltransferases, Academic Surgical Congress, Keystone Cancer Conference, Biomedical Engineering Society, National Student American Institute of Chemical Engineers, and Society for the Advancement of Chicanos and Native Americans in Science. In addition, several of our trainees published their research findings in scholarly journals [1, 2, 4, 6, 7, 9, 10, 12–19].

In summary, the University of Louisville Cancer Education Program consistently recruits highly competitive undergraduate and health science professional students from UofL and other colleges and universities across the country. The program surpassed all of its 5-year performance goals. Student and peer feedback continuously improves our cancer education efforts to train the next generation of cancer scientists and clinicians.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.
Student survey results for the University of Louisville Cancer Education Program

Table 1**Student outcomes in University of Louisville Cancer Education Program**

	5 year goal	Progress at year 4
Number of participants who complete the program	115	121 (156) ^a
Number of student participants who complete and present their research project	100	121 (156) ^a
Number of participants from underrepresented minority groups who complete the program	37	34 (53) ^b
Number of student participants who continue in cancer research and/or training	25	58
Number of medical students who pursue "Distinction in Research"	–	31 ^c
Number of female participants who complete the program	66	49 (69) ^d
Number of undergraduate student participants who have enrolled in MD/PhD programs	–	4
Number of undergraduate student participants who have enrolled in PhD graduate programs	–	14
Number of undergraduate student participants who have enrolled in health professional (MD, DMD, PharmD) programs	–	17
Number of undergraduate students participants who have enrolled in Master's graduate programs	–	3 (MPH, MSSW, MS)

^aAn additional 35 students were accepted for the 2016 class. To date, 100 % of enrolled students have completed the program and presented their research project. Thus, it is anticipated that a total of 156 will successfully complete the program through year 5.

^bAn additional 19 under-represented minority students were accepted for the 2016 class, resulting in an anticipated total of 53 through year 5.

^cAn additional eight medical student participants from the class of 2013 received a Distinction in Research (DIR) designation along with their medical degree awarded May 2016, resulting in a 2-year total of 31 DIR designations.

^dAn additional 20 female students were accepted for the 2016 class, resulting in an anticipated total of 69 female students through year 5.

Table 2**Student survey comments regarding the University of Louisville Cancer Education Program**

As a first-generation Latino college student, I want to continue to pursue my dream of earning an MD/PhD and contribute to the scientific community through research and discovery.... I want to ameliorate the lives of other families who struggle with cancer." "Just as the physician works to heal patients, I plan to work in creating better treatments for combating cancer. After receiving a medical education, I plan to work at the James Graham Brown Cancer Center with the intention of advancing the health of the entire global community.

This summer, I've learned more about the cancer research career path in CEP than I could have ever learned in class. Exposure to real life experience and testimony helped me clarify my career goals exceptionally, more than I imagined. Thank you both for making this possible!

The curriculum was well suited to the undergraduate participants. My mentor spent lots of time with me, but still allowed me to work independently and have influence over the research direction. Having never worked in cancer research before, I am definitely more interested now, particularly in the translation aspect of research.

It was very helpful that the curriculum incorporated various aspects of writing a scientific paper, and how to compose a scientific poster. I learned a lot about clinical research, and am interested in continuing that style of research through my career.

It increased my interest because I thought I would hate research when in reality I found it to be interesting and engaging. I was able to apply coursework to actual science, which made me appreciate my education even more.

The experience helped to ease my worries about writing papers.

The curriculum did a good job in really laying out the foundation of what scientific writing and a manuscript should look like. It broke down writing and scientific investigation into manageable parts.

My mentor was very hands on and taught me many techniques first hand. He was very encouraging and supportive of any techniques I wanted to learn and explained the advancements of the field of molecular biology. Since it was my first research experience, he was a great mentor and has really made me love research and the experience.

The curriculum was what I enjoyed most about the program. Most of the lectures were extremely helpful and informative, and even if I didn't always understand what the presenters were talking about, it was so interesting to learn about new discoveries and techniques being used to treat cancer. My mentor was an excellent example of what I hope to one day become, and working with him was truly an honor. However, he was often very busy and was difficult to get into contact with. But being able to see cancer from different angles, including clinical and surgical, was truly amazing.

Since I was a returning R25 CEP trainee, this summer I was able to practice giving a 10 min presentation. My mentor also helped with this process. This was very helpful in preparation for an oral presentation at a conference I also attended this summer. Another positive aspect was the homework. Actually writing the introduction section was helpful for preparation of a manuscript as well as practice for the poster presentation.

This was an amazing opportunity! With my previous research experience as a technician, I was always working on bits and pieces of projects, helping out where ever I was needed. Through this program, I was able to work on a project in its entirety, creating a piece of a story about a novel compound with potential value as an anticancer therapy in breast cancer! I received top-notch insight from my mentor and got to contribute my own background experience to the project! It was great being able to contribute to a piece of the story, and I am excited to hear updates about the compound!

My mentor and everyone else in the laboratory were very patient with me when I first started this program. I had no prior research experience, but they were very willing to help me. I had no interest in research before this program, but I decided to stay with the lab and continue with my project into the academic year.

My experience during the Cancer Education Program culminated my curiosity to explore cancer research. By working alongside research professionals and medical doctors, I firmly believe that I have been exposed to how it actually feels like to be a scientist in the field. I have been granted the privilege to formulate my own hypothesis and design experiments in order to support it. My mentor certainly helped me learn the necessary techniques in order to succeed in such an academic setting.

The program did a very good job at emulating what it would be like to really work in a research lab full-time. It was an engaging hands-on experience many students never have in the world of research. My mentor was a wonderful teacher and really helped to guide me through this project while all the letting the experience be my own. My project was very interesting and I hope to continue with it in the future.

"While I may not have understood the content as well as I would have liked to, I was still able to gain experience from attending these seminars. By the end of the summer I was thinking of questions I would ask, and some of the audience actually asked the same questions I had. So attending these seminars actually helped me to think more scientifically about the content though I might not have fully understood it."

It is great practice for those like me at WKU who can't get a lot of experience otherwise.

Yes. If they were looking for a great program to really immerse themselves in biomedical research I would recommend this program and also recommend my mentor.

It provides beneficial research experience and could open new doors regarding career paths and opportunities.

I have had the most wonderful timewith the NCI-R25 Program I have been exposed to the way real scientists discover new knowledge, gained a deeper appreciation of the scientific process, learned how to communicate results in an effective way, and most importantly walked away with a very positive experience and a passion for research. I also feel much more confident about my ability to conduct research. I am so glad I chose to spend my summer in the R25 Program. I made the right decision for sure!!

Since participating in the 2015 UofL NCI Cancer Education Program I have accepted a full time position as a Research Coordinator for the Department of Otolaryngology - HNS and Communicative Disorders, University of Louisville School of Medicine. The department is located in

the James Graham Brown Cancer Center, and current research studies include examining quality of life, circadian disruption, stress, their relation to psychosocial outcomes, and overall relationships of these variables to cancer outcomes in patients with head and neck cancer; participants are recruited from the multidisciplinary Head and Neck clinic affiliated with our department. Additionally, I am also working a few hours a week at the Biobehavioral Lab on Belknap campus, managing their wetlab's IBC documents and performing ELISA assays for quantification of salivary cortisol with regard to their current study focusing on lung cancer patients. Our department will be mentoring several new students from the 2016 NCI CEP program and 2016 SROP program. I will be helping to oversee their involvement with both our current research as well as multidisciplinary efforts. I am eternally grateful for the experience this program has given me, the personal growth that it has afforded me, and for the ways it has motivated me to continue my love of research within a cancer framework. I feel that I am in a position that will allow me to affect positive change, and I look forward to new collaborations and ventures between our department and this program.

I graduated from Wheaton College (IL) last Sunday summa cum laude with a B.S. in Biology and a B.A. in Spanish. My participation in this research program along with my academic achievements in my biology courses allowed me to receive departmental honors in biology. I'm currently preparing to move to Bethesda, MD to work as an IRTA (Intramural Research Training Award) fellow at the NIH. The Cancer Education Research Program was an incredibly formative experience and I look forward to gaining additional research training at the NIH prior to applying to medical school. As a result of this program, my passion for oncology research and practice grew tremendously. It was a pleasure to work with a brilliant, kind and compassionate oncologist who has an incredibly multifaceted role as a researcher, clinical physician and medical educator. I have become increasingly dedicated to breast cancer research and pursuing a future career in academic medical oncology. My interest in cancer research sparked numerous cancer-focused projects in my final two years of college. In a biology research course, I conducted a project studying DNA-damaging mechanisms and apoptosis in *C. elegans* and wrote a literature review on targeted antibody therapy for the treatment of HER2-positive breast disease. I also engaged the topic in a senior thesis examining the ethics of phase I clinical drug trials in breast cancer patients after the development of Herceptin. It is my desire to continue passionately pursuing cancer research and achieve my goal of combining clinical practice with cancer research.

I graduated with a B.S. in Psychology today from UofL undergrad. I will be attending University of Louisville School of Medicine for an MD degree. I am also interested in completing the Distinction in Research program that they have there. There are so many exciting things going on. I've heard of some of my summer research colleague's recent achievements and I have to say- the caliber of the students in the NCI-R25 program and the work they do is humbling and absolutely astounding!! So keep doing what you do Dr. Hein, you rock!

Student statements regarding the navigating careers in cancer research

I liked the low key and unstructured discussion with a small group. I especially liked hearing about how to incorporate research into a clinical practice.

It was nice to be able to talk to people in the field on a small group basis. they offered insight that might not have been received if it was given within a larger group

I liked that we were able to informally connect and ask questions to professors and individuals in the fields. I really enjoyed their insight and guidance.

The thing I appreciated most about the speakers was their incredible blunt honesty. They told me what I needed to hear. After this discussion I actually have a clearer direction about continuing after I get my doctorate. I will be in touch with Dr. Clark in the future to continue the conversation that was started at this event.

I loved that the groups were small enough that everyone was able to contribute and ask questions. It was also a great way to meet potential collaborators and hear about their experiences.

I thought it was very well structured and the open ended discussions allowed the students to ask questions that pertained to them!

It made me think about how to I can get involved with community outreach and preventative care education as a medical student

I really enjoyed the table discussions, especially "Women in Science". Dr. McNally gave us a lot of advice and pointers on how women can be successful in the science field.

I appreciate the fact that the presenters' contact information was shared with the R25 cohort, in order to encourage follow-up conversations and possible future collaborations.

I liked that it offered us the opportunity to network with people who have a lot of experience in their respective fields.

I liked gaining knowledge about academia that is usually not discussed in a normal academic/research setting.

I really enjoyed the discussion about jobs in government. It opened my eyes to another job opportunity.