A Pilot Project Exploring Possible Novel Ways of Delivering Relevant Education for Radiation Oncology Nurses During Covid-19 Social Distancing

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Dedication and Acknowledgements

I have been fortunate to have been an oncology nurse for 25 years at this writing, and I have been involved in radiation oncology since the beginning. My patients have taught me so much about life and what is truly important.

I have had the good fortune to work alongside amazing professionals. Without the example, input, and expertise of so many, this project would not have been possible. Special thanks to the Oncology Nursing Society and the Oncology Nursing Certification Corporation for their leadership and vision for oncology nursing.

The literature on RO education has been transformed over the past decade through the hard work and generosity of Dr. Dan Golden and the Radiation Oncology Education Collaborative Study Group. Without them, I would have had little to build on. Thanks to Dr. Kathryn Lawrence for all the support. Thank you to Mary Ellyn Witt, Kate Martin, Dr. Jenna Kahn and ROVER, Dr. David Carpenter, Dr. Yvonne Mowery, Olivia Franek, Anna Rodriguez, Theresa Brown, Hutch Allen, Dr. Horatio Thomas, and the cancer center nursing staff who agreed to be my subjects. Thanks, in particular to Drs. Marina Moskalenko and Sameer Nath for their taking the lead on this topic.

To my wife, Katie: Thanks for everything.

Abstract

Background: The first needs assessment in the USA reported that RO nurses lacked standardized, structured education and certification programs for onboarding and continuing education. Survivorship care is an increasing need for all nurses. All RNs may work with late radiation side effects.

Purpose: Explore the education needs and improve the education of radiation oncology specialist nurses.

Methods: Utilizing online survey software, anonymous limited demographics were collected. An adapted version of a needs assessment survey was administered to RNs at a single academic medical center RO department in an IRB-exempt QI project. A pre-post test design was utilized, and RNs were asked to provide feedback on a self-study video curriculum developed for this project.

Results: Over half of respondents were oncology certified, and nearly half had ≥5 years RO experience. Moderate confidence was expressed regarding common technologies and duties, including radiology, disease sites, combined modality therapy, and coordination of care. Regarding acute toxicity management, RNs reported the highest confidence with prostate/genitourinary, and sarcoma cancers; with lower scores across hematologic and pediatric cancers. Regarding late side effect management, the highest scores were observed among prostate/genitourinary, sarcoma, and breast cancers; with lower scores for skin, CNS, GI, hematologic, and pediatric cancers.

Conclusion and Recommendations: These results highlight the need for a formalized curriculum and can help to target educational needs while guiding education materials development. This study can inform the much-needed development of education for all RNs.

Background and Significance

Radiation oncology (RO), the use of ionizing radiation to treat or palliate disease, is one of the most common modalities for cancer treatment (American Cancer Society [ACS], n.d.). The National Cancer Institute (NCI) reports that 50-60% of people with cancer will be treated with radiation at some point during their cancer journey (2021a). However, most registered nurses (RNs) receive no training on RO in school despite nearly 130 years of history of the modality. Increasingly care is becoming more complex and multidisciplinary, requiring intensive coordination and navigation (Mitin, 2023). Significant numbers of patients are treated acutely with radiation, and there are increasing numbers of cancer survivors who were treated with radiation. Yet, there is no credential available for American RNs in RO, and no clearly defined scope of practice. Nursing education in this discipline is rare at the local, state, and national levels. Prior literature found that RN working in RO were lacking in experience, training, and onboarding education (Moskalenko et al., 2021). There is a scarcity of research on this topic, but there are recent developments in RO medical student and resident education that could form a beneficial foundation for RN education.

Cancer remains the second highest cause of death in the United States, with a projected 1,958,310 new cancer cases and 609,820 cancer-related deaths in 2023 (Siegel et al., 2023). North Carolina alone will account for 67,690 of these new diagnoses, and 20,400 of these deaths (Siegel et al., 2023). It is anticipated that the most prevalent top three new case diagnoses for women, not including skin cancer, will be Breast (31%), Lung and Bronchus (13%), and Colon and Rectum (8%) (Spiegel et al., 2023). For men, the anticipated top three cancer diagnoses, not including skin cancer, will be Prostate (29%), Lung and Bronchus (12%), and Colon and Rectum (8%) (Spiegel et al., 2023). In both cases, the top three diagnoses account for roughly half of all anticipated cases. These top three most prevalent diagnoses for both genders are commonly treated with RO, as well as several other malignancies and some benign conditions as well (Mitin, 2023)

There are thousands of radiation treatment facilities in the United States (Bates et al., 2021), hundreds of thousands of patients who receive radiation therapy every year (Mettler et al., 2020; Halperin et al., 2008), and millions of radiation-treated cancer survivors (Bryant et al., 2017). Modern radiation therapy employs many disparate techniques, including external beam therapies from radiation-emitting devices, radioactive materials in brachytherapy, and radiopharmaceuticals. Increasingly this modality is being used in conjunction with surgery and systemic therapies like chemotherapy, immunotherapy, and hormone therapy (Mitin, 2023). RNs in this field need to have a broad base of knowledge but have a poorly defined scope of practice and limited training opportunities.

To answer to unmet nursing education needs, an online and asynchronous journal club for RNs in the RO department was previously developed. The facility where this project was implemented otherwise only offered a single hour of radiation oncology education at the time. Moreover, no nursing organization offered sufficient continuing education (CE) credits to meet the continuing competence requirements of the multiple organizations overseeing nursing practice. Nursing staff members were not permitted to meet in person during the COVID-19 pandemic, which created an additional barrier to providing regular education. To comply with social distancing requirement, articles were posted online and staff participated individually when it was convenient for them to do so (Hillson et al., 2022a). While this early project was able to successfully provide monthly relevant CEs for staff, it was hypothesized early on that the nurses might benefit from a better-developed foundation of knowledge. For example, one national research initiative, radiation dose-de-escalation for human papillomavirus-related head and neck (H&N) cancer, required significant background information not covered in nursing training (White et al., 2020). This single-site DNP QI pilot project was an initial attempt to increase the available educational resources for nurses in this specialty.

Purpose

This pilot project sought to develop an RO self-study online asynchronous curriculum (Appendix D) for RNs in RO at a single-site large academic medical center. The goal was to improve orientation to the specialty for RNs new to RO, and to improve resources, knowledge, and confidence in the delivery of care for existing RNs in RO.

Review of Current Evidence

The literature search involved multiple approaches. Searching the *International Journal of Radiation Oncology, Biology, and Physics* (Red Journal) returned 157 results from the last 5 years. Most mentioned nursing in a perfunctory fashion, and many articles were from outside the United States. In the end, seven articles were chosen.

PubMed was searched using the key words “nurse” or “nursing,” “radiotherapy or radiation therapy,” “training” or “education,” and “America” or “United States.” This returned 105 results for the past 5 years.

Literature searches for the last five years were done for both the University of North Carolina at Greensboro library and the Duke University Medical Center library using the terms ("radiation oncology" or "radiation therapy" or "radiotherapy") AND ("nurse" or "nursing").

As the project was as much about andragogy as it was about RO, an additional search was done of PubMed and CINAHL using "nurse" or "nursing", "online," "education" or "training," and "self study" or "self-study" or "self paced" or "self-paced" or "asynchronous." This search gave 371 articles published in the last five years, and so the additional filter of "oncology" was added. This brought the number of articles to review down to 79, but RO was found to contribute little to these articles.

A search was done of the archives of the Red Journal using the terms "nurse" and "education" or "training." Within the past 5 years, there were 24 results generated but most only mentioned nursing in a very perfunctory fashion.

Given that the intention was to review articles that focused on delivering online education on post-nursing training advanced skills and topics, the search involved reviewing articles on a case-by-case basis. Articles on education from other professionals like advanced practice providers (APP), medical students, certified medical aides (CMA), and radiation therapists were evaluated to determine if the material could contribute to this project. Articles were included if they were in English and focused on the education and practice of RO. A preference was given to American studies that addressed the RN role in RO, but articles were included from other countries if the topic was considered relevant to this project. As an example, Kim et al. (2018) noted an increase in radiology and interventional radiation-based procedures in Korean hospitals, increasing the risk of radiation exposure to their nurses. This was felt to be comparable to the lack of education on radiation safety in nursing education, with implications for safety and regulatory compliance worldwide (Kim et al., 2018).

Finally, culture and geography were felt to have no bearing on medical physics and radiobiology. With the vague definition of the role of RNs in RO in the USA, information from other nations may better inform what this role could and should be in this specialized setting. For example, a review of Canadian and United Kingdom journals found that researchers discussed measures to decrease RO patient anxiety and improve collaboration with patients for improved psychosocial well-being and patient symptom management during radiation therapy (van Beusekom et al, 2019; Lee et al., 2020).

Articles were excluded that focused exclusively on the education of other professionals like physicists, radiation oncologists, radiologists, radiation therapists, RO residents, or other specialties like nuclear medicine. Articles specifically focused on radiation disaster management, patient education, and side effect management were excluded unless discussing an intervention contributed to by nurses.

Prevalence of radiation therapy

The National Council of Radiation Protection and Measurements (NCRP) estimated that in the USA from 2006 to 2016 there were one million courses of radiation therapy conducted each year for approximately 800,000 patients annually (Mettler et al., 2020). In 2016 it was estimated that there were over 3 million cancer survivors treated with radiation, or 29% of all cancer survivors (Bryant et al., 2017). It was projected that there would be 4.17 million radiation-treated cancer survivors by 2030 (Bryant et al., 2017). In an earlier study, Halperin et al. (2008) performed one of the few SEER database searches by modality and found that there were 1.4 million new cases of cancer diagnosed annually, with 643,000 patients receiving radiation, 649,000 receiving chemotherapies, and 180,000 receiving both. In NCI's *Radiation Therapy and You*, it was reported that 60% of people with cancer receive radiation therapy (2021a). These statistics are not easily updated, and the choice of modality varies greatly by the actual disease. It is reasonable to anticipate that these numbers have increased.

To put these statistics in perspective, comparisons can be made to other health statistics. The CDC (2022a) reports that 805,000 Americans have a heart attack every year, with 605,000 having their first heart attack. 697,000 died of heart disease in 2020. These numbers are comparable to the number of patients who receive radiation therapy annually (Halperin et al., 2008; Mettler et al., 2020). However, there are substantial differences in our profession's responses to these numbers. There is training on ECG interpretation for all nurses but not for radiation in medicine; Nurses may in fact be surprised to learn that radiation therapy predates ECG (Salam, 2019; Smith, 2022). Nurses and nursing students are commonly required to take cardiopulmonary resuscitation; Moskalenko et al. (2021) found radiation oncology was seldom mentioned in nursing training, and Linet et al. (2021) noted there is a dearth of training on this subject in medical training as well.

For a second comparative example, the CDC (2021a) reported that 687,000 patients in 2015 were estimated to have a healthcare-associated infection (HAI). Initiatives addressing healthcare-associated infections rapidly gained national prominence, while RO remains relatively obscure despite a similar incidence. The CDC also reports that there are 300,000 older people hospitalized for broken hips annually (CDC, 2016); this is less than half the number of patients that the NCRP found were treated with radiation annually (Mettler et al., 2020). However, all nursing students will receive some orthopedics content and patient falls prevention in their training while most nurses will not receive RO education.

Radiology, Radiation Oncology, Nuclear Medicine, and Nursing

Nursing predates RO and radiology, as Florence Nightingale was born 75 years before x-rays were discovered (History, 2023). Madame Marie Curie famously trained women in radiology during the first World War (Jorgensen, 2017). Margaret Hopp is credited with being the first to identify the role of the radiation oncology nurse back in 1941 (Farmer, 1999). Despite this long-standing history, formalized curriculums and training methodologies have been lacking for RNs in RO (Moskalenko et al., 2021). This has a negative effect on the recruitment of new talent to the specialty and has been theorized to adversely affect the quality and coordination of cancer care in the larger community (Abshire & Lang, 2018; Sandhu et al., 2020; Jimenez et al., 2020; Gunther et al., 2018).

RO was a subspecialty of radiology until relatively recently, only separating from the American College of Radiology in 1998 (American Society for Radiation Oncology [ASTRO], 2023). The American Board of Radiology (ABR) is still one of the credentialing bodies, and RO still shares common history, science, and technology with radiology and nuclear medicine (ABR, 2022). These closely related subjects and radiation safety are also not part of core nursing training. Therefore, nursing radiation knowledge deficits have far larger implications than just RO itself. The lack of recognition that medical radiation has become part of the nursing role potentially affects nursing school curriculums and possibly contributed to some of the lower confidence and knowledge deficits found in our project's needs assessment (Appendix B; Figure 3; Tables 1-6) and test of knowledge (Appendix G).

Despite radiology and radiation oncology being created simultaneously and radiation oncologists being certified by the ABR, there are separate certifications for these nursing specialties. The Radiologic Nursing Certification Board (RNCB) offer a radiology nursing credential (RNCB, 2023), and there is an Association for Radiologic and Imaging Nursing (ARIN). These two groups are working parallel to the Oncology Nursing Credentialing Corporation (ONCC) which offers an oncology nursing credential (ONCC, 2023) and the Oncology Nursing Society (ONS). This potentially leads to knowledge gaps that directly affect practice as RO nursing is heavily focused on oncology but is descended from radiology and relies heavily on radiology technologies. This specialty requires knowledge from both fields. However, at the project facility only one certification will be reimbursed, so the number of nurses with multiple certifications is limited.

The prevalence of medical radiation procedures is increasing. Between 2006 and 2016, the NCRP estimated there were millions of radiographic procedures including CT scans, fluoroscopically guided procedures, and nuclear medicine examinations in the USA, in addition to an estimated one million courses of RO given to 800,000 patients (Mettler et al., 2020). In 2019, the World Health Organization reported estimates that there were more than 3.6 billion x-rays, 37 million nuclear medicine, and 7.5 million RO courses performed annually world-wide. Low-dose ionizing radiation is associated with several occupational health risks including cancers in all age groups, increased risks for cataracts, damage to the fetus and uterus, and increased risks for cardiovascular disease (Linet, 2021; Kumar & De Jesus, 2022). The most effective approach to reducing the adverse effects of ionizing radiation is reducing exposure for patients and health professionals to levels using the guidance of ALARA, As Low As

Reasonably Achievable (Frane & Bitterman, 2022). However, radiation is now an essential and inescapable tool in modern health care.

The WHO (2019) reported that inappropriate or unskilled use of medical radiation is a public health and patient safety concern and a risk for both patients and staff. Additionally, they noted that the overall incidence of errors is around 15/10,000 treatments (WHO, 2019). In the USA, this has led to calls for greatly increased radiation science content in medical school curriculums (Linet et al., 2021). There have been calls for radiation safety training policies for nurses that would be overseen by the Joint Commission (Wang et al., 2021). Nurses cannot be actively contributing partners in a culture of radiation safety when they have significant knowledge gaps.

Radiation Safety and Regulation

RNs in RO are commonly in the vicinity of radiative materials or radiation-emitting devices. Therefore, nursing shares responsibility for compliance with radiation safety protocols. The responsibility for radiation safety is inextricably tied to a basic understanding of radiation and an awareness of radiation safety regulatory practices. Radiation safety in the United States has become significantly more complex and decentralized since the 1970s (United States Nuclear Regulatory Commission [NRC], 2021). Initially, the Atomic Energy Commission (AEC) had three roles: taking control of the Manhattan Project and nuclear weapons development, the promoting of the public use of nuclear power, and the responsibility for protecting the public from radiation hazards. The agency was responsible for lobbying and safety; the AEC was disbanded by congress after intense criticisms and backlash (NRC, 2021). Since then, radiation-emitting technologies must be approved by the Food and Drug Administration (FDA), the NRC has oversight of radioactive materials, and the Environmental Protection Agency oversees environmental impact. Each individual facility has a radiation safety officer by law, and 39 of the states are "*Agreement States*," meaning that the state itself conducts radiation safety inspections instead of the federal government (NRC, 2022). Radiation safety and regulation is complex, and not covered in core nursing training. Yet, nursing does have a role to play in maintaining a work environment that is compliant with radiation safety regulations. The situation is not unique to the USA, as one Korean study (Kim et al., 2018) found that half of the nurses in their sample received no radiation safety training, and only 25% received regular education on radiation safety protocols.

Following the Fukushima nuclear reactor accident, an examination of Japanese nursing schools found radiation education to be inadequate for an effective disaster response (Horiuchi et al., 2021). The USA has not had a major radiation disaster on its' soil since the 1979 Three Mile Island (TMI) reactor accident in Pennsylvania (Maxwell, 1982). Nurses were on the frontlines as the TMI facility had 14 hospitals and 62 nursing homes within a 20-mile radius (Maxwell, 1982). The healthcare system around TMI was quickly overwhelmed as many staff abandoned their posts (Maxwell, 1982). The criticisms of American nursing and medical education on radiation raise serious concerns about the ability to respond to similar events today (Wang et al., 2021; Linet et al., 2021). There is little doubt that American nurses would be on the frontline if a radiation disaster happened in the USA again, and only a small number of nurses would have any experience working around radiation.

The Undefined Role of the Nurse in Radiation Oncology

Although nursing in RO is a growing field, this group of nurses is still trying to establish their role. The role of the RN in clinical trials is well established, and this crosses over in RO research. However, acute treatments have become more complex and integrated with other modalities (Mitin, 2023). The number of cancer survivors has increased (Office of Cancer Survivorship [OCS], 2022; Siegel et al., 2023). Patient care needs have expanded, and nurses in RO now require a working knowledge of the larger continuum of care. In response, the role of the RN in RO has continued to evolve and has become more integral to the changing oncology environment. This is especially true for the advanced practice provider (APP) in RO (Martin et al., 2020; Bruinooge et al., 2018; Estep, 2021; Skubish et al., 2021), as it has been determined that interprofessional education was an unmet need that could improve communication in the RO environment (Schultz et al., 2021).

Continuing Education Requirements

Continuing education is mandatory for RNs, and this is enforced by several entities. The NCBON (2022) requires 15 CE every two years, and non-specialty certified RNs need to obtain 36 CE every three years for a facility to be given COC accreditation (COC, 2022). To maintain their credentials, certified oncology nurses (OCN) require a potentially higher number of nursing continuing professional development (NCPD) credits every four years based on an Individual Learning Needs Assessment (ILNA) score (ONCC, 2022). The CEs and NCPDs can overlap and be used for multiple organizations. However, the limitations on CE offerings were such that RNs in RO needed to obtain CEs that were not directly related to their daily practice to meet these mandatory standards.

Role Delineation for RO RNs Internationally vs United States

The USA does not have RO nursing standards of practice, nor has the role of a nurse in RO been clearly defined. Rather, ONS has provided the generalist *Oncology Nursing: Scope & Standards of Practice* (Lubejko & Wilson, 2019) which makes only incidental mention of any treatment modalities. Staying strictly with American sources in developing a RO nursing curriculum is challenging with this lack of guidance. Other nations, however, do have national standards in this specialization. International materials can provide guidance and knowledge that is lacking in America in this specialty.

For example, the Canadian Association of Nurses in Oncology/Association Canadienne des Infirmieres en Oncologie ([CANO/ACIO], 2018) has had RO nursing-specific national practice standards and competencies since 2006. This initiative was aimed at improving access and standards nationwide while promoting national excellence in practice, education, research, and leadership (Nowell & Campbell, 2020). Canadian-developed oncology standards have been utilized by CANO/ACIO in international initiatives in several countries including Latin America, Rwanda, and Kenya (McQuestion et al., 2021b). The provincial government-sponsored British Columbia Cancer Agency ([BCCA], 2018) also has its own separate accredited RO nursing course, as do other Canadian provinces.

Additionally, the International Atomic Energy Agency (IAEA) released a syllabus for the education and training of nurses in RO in Vienna in 2009 (IAEA, 2008). The authors noted that the need for this curriculum was driven by increases in the incidence of cancer, shortages of equipment, radiation protection infrastructure, and a need for qualified staff. The IAEA recommended all RNs in RO have a baccalaureate education and a 12-to-16-week course that prepared the nurse for the provision of clinical care, education, and leadership (IAEA, 2008).

In like manner, the Cancer Nurses Society of Australia ([CNSA], 2022) has a RO nursing specialist practice network. The Australian government has partnered with eviQ Education to create a national self-study online program offering targeted nurse education modules on RO, titled the Radiation Oncology Nursing Knowledge and Skills (RONKAS) framework (Cancer Institute of New South Wales, 2019). This ensures national standards of RO nursing training and resources that are always accessible to the individual nurse. Of note, in Australia, there are both basic and advanced RO courses for all health professionals working in RO, as well as free clinical resources for staff and patients. American nurses are lacking in this level of leadership and national standards.

Learning styles

The education materials offered by ONS, CANO, and RONKAS were noted to all have a self-study and remote learning component. The decision was made to continue in this vein with this project. While individual nurses may have a preferred learning style, COVID-19 restricted in-person and group education, and learning the educational platform software posed practical challenges for this DNP project. Additionally, the absence of funding affected the choice of presentation software used.

The research of Mangold et al. (2018) found that most nurses preferred visual learning despite age, gender, or experience. This informed the decision on the pedagogy for the instruction, as the presentations used visual depictions of common disease findings and side effects. Correspondingly, as RO treatment planning extensively uses radiology imaging, there were many opportunities for visual aids to be part of lectures. Links were provided in curriculum presentations to the Radiological Society of North America (RSNA) and American College of Radiology's RadiologyInfo.org, ASTRO's RTAnswers, and ROECSG's Introductory Radiation Oncoloy Curriculum (IROC) YouTube videos. ASTRO provided slides with free images for this project as the author is an associate member. A professional medical illustrator generously allowed the use of her images for free as this was a student project.

Recent Innovations in Education

One recent educational innovation is the use of shorter videos. Elsevier publishing has created Osmosis, a subscription service with over 2000 medical topic videos. Osmosis' YouTube channel boasts an audience of over 3 million, and the Osmosis YouTube channel has had 135,826,692 views since 2015 (YouTube, n.d. a). The format keeps topics separate into smaller videos and manageable chunks. This allows for rapid, responsive updates when there are new developments in the changing face of healthcare. Another example is the Technology, Entertainment, and Design (TED) talks. TED is an organization that provides podcasts of 18-minute duration or less on a wide range of topics. The TED YouTube channel has 22.6 million subscribers, and since December 2006 has had nearly 2.5 billion views (YouTube, n.d. b). The CDC (2021b) offers a free online curriculum of short videos, *Radiation Basics Made Simple*, and this covers radiation and responding to radiation emergencies. The NRC and FDA similarly have YouTube channels with informative videos on radiation, and webpages with information geared towards the public. ROECSG has a very informative YouTube channel on RO, but not specifically on RO nursing. Being able to address disparate but relevant topics on-demand in short videos was felt to be an ideal approach to providing a resource to RNs in the department.

Indeed, it was found that the project facility’s own Radiation Protection Division was also using brief, targeted videos on specific radiation procedures and subjects.

Barriers to creating a program with nurse-only input

One theme noted in the literature was that radiation oncologists have been collaborating with nurses in either nursing education research or the provision of education on this specialty, or both (Moskalenko et al., 2021, Moskalenko et al., 2019, Chang et al, 2019; Choflet, 2017; Voigt 2021). Five articles were found where physicians, as a whole or in part, developed or delivered the curriculum, and another article named two physicians involved in researching the knowledge bases of RNs in RO. Given the limits on credentials and education opportunities, physician involvement may represent a reliable strategy to ensure that the education provided is high quality (Moskalenko et al., 2021; Chang et al., 2019; Hayden & Connolly, 2019; Lowther et al., 2019; Bakker et al., 2017; Holtzman et al., 2018). Indeed, the Scope & Standards of Oncology Practice call for collaboration with the interprofessional team to improve outcomes. This is a clear example of when nursing and patient outcomes could benefit from the input of the larger RO team (Lubejko & Wilson, 2019).

Some examples in the literature demonstrate a lack of training, education, and knowledge. One study found a minority (15.6%) of palliative care and general oncology nurses reported receiving any formal training in RO during their nursing training (Hayden & Connolly, 2019). Approximately one in four nurses in this study reported receiving some RO training after graduation. Despite the specialist nature of the nurses who completed the surveys, only around half of the respondents had even visited a radiation therapy department. When the respondents were given an objective test of knowledge, they had poor awareness of the indications for, and effectiveness of radiation therapy (Hayden & Connolly, 2019).

In like manner, Tuschihashi et al. (2017) explored nursing training and confidence related to caring for patients undergoing radiation therapy. They found that 80% of nurses in the one large hospital had cared for patients receiving radiation therapy, but only 17% of surveyed nurses received any RO training as nursing students. The hospital where Tuschihashi et al.'s (2017) study took place had no radiation therapy education program, and general oncology education targeted seasoned nurses who were more senior on the clinical ladder. In the absence of a thorough understanding of the course of treatment, the nurses were found to be unable to manage or anticipate common side effects appropriately. When these nurses were confronted with emotionally challenging or medically complex patients, the lack of knowledge contributed to a lack of self-confidence. Difficulties caring for radiation therapy patients were reported by 40% of nurses in the study. Less than two years of experience as a nurse was closely associated with reports of challenges in caring for RO patients (Tuschihashi et al., 2017).

Theoretically, the lower levels of confidence that RO nurses reported to Hayden and Connolly (2019), Moskalenko et al. (2021), and Tuschihashi et al. (2017) may be founded on a lack of knowledge. Two studies used pre-tests to evaluate the baseline RO knowledge of nurses participating in their respective studies (Chang et al., 2019; Hayden & Connolly, 2019). In both studies, a significant knowledge deficit was noted. Chang et al. (2019) administered a pre-curriculum test on palliative radiation therapy and found mean scores of 71.4% ±11.3% among their nursing staff. Post-test scores following education improved to 80.2% ± 9.0%. In like manner, Hayden and Connolly (2019) administered a one-time test of basic palliative RO knowledge to oncology nurses and palliative care nurses. The mean scores were 60.73%, with the oncology group scoring slightly worse. However, both palliative care and oncology nurses were motivated to learn more about this modality, with 94.8% stating they would benefit from more education (Hayden & Connolly, 2019).

Interprofessionalism

Schultz et al. (2021) hypothesized that a lack of understanding of professional roles could lead to communication barriers, disorganized patient care, an unclear chain of command, and less efficient management of the facility. Other groups like medical physicists have noted that the academic medical center environment now depends on communication between a growing number of professions in the department: radiation therapists, dosimetrists, physicists, residents, attending physicians, medical assistants, and nurses (American College of Radiology [ACR], 2018). Interprofessional education has improved healthcare and patient outcomes (Schultz et al., 2021). RO is a multidisciplinary work environment, and that makes interprofessional communication necessary. Even so, studies have shown that interprofessional education has been limited in RO (Winter et al., 2021). The broad base of nursing education and the wide-ranging nursing role offers tangible benefits to a field often not understood by non-radiation oncologists (Dennis & Duncan, 2010; Martin et al., 2019). However, well-designed nursing curricula in this specialty will require the input of RO content experts to ensure an accurate baseline shared understanding of a complex treatment modality.

One potential approach to improve interprofessionalism is improved socialization into the specialty. While nursing is a female-dominated profession, RO itself has traditionally been more male-dominated. In 2017, the Society for Women in Radiation Oncology (SWRO) was created to highlight and celebrate the women of RO (Masters, 2019). SWRO soon started the social media campaign, #WomenWhoCurie to increase the visibility of Madame Marie Curie, the seminal pioneer of RO and radiation physics who overcame so much institutional sexism (Hillson, 2022c). Celebrating the greater moments in RO history is an important step in socializing nurses into the specialty.

Coordination of Acute Radiation Therapy in a Multidisciplinary Health Care Environment

Increasingly radiation therapy may be combined with other cancer treatment modalities like surgery or systemic therapy, concurrently or adjuvantly, with either curative or palliative intent (Mitin, 2023). This requires both the nurse in radiation oncology and the nursing staff of the outside departments to understand the overall management and coordination of care to ensure the best outcomes. As part of their needs assessment, Moskalenko et al. (2021) asked nurses what education topics they wanted to learn about, and over half of their respondents wanted to learn more about treatment modalities and medical oncology. These subjects are integral to coordinating multidisciplinary care for patients, and this demonstrates the RO RNs in their study wanted to know more about the patient's larger cancer journey.

Knowledge of other treatment modalities that patients may receive at the same time is foundational to improved oncology patient navigation. This includes addressing barriers to quality care, providing accurate education and useful resources, as well as timely and correct referrals. The ONS' *2017 Oncology Nurse Navigator Core Competencies* states that barriers can vary substantially depending on the phase of care and the patient's diagnosis. This in turn affects shared decision-making, advance care planning, and palliation of the patient's symptoms (ONS, 2017).

However, Moskalenko et al. (2021) found that only 5% of RNs had RO content in their curriculum during their nursing training, 92% attended a nursing school with no affiliated RO department, and not a single nurse reported having a required RO clinical experience in nursing school. Additionally, frontline RNs in RO have reported spending only 2% of their time on continuing education (Moore-Higgs et al., 2003), which presumably further limits understanding of patient needs and coordination of care.

For example, during radiation treatment common health conditions like diabetes or hypertension can be exacerbated by treatment toxicities which the RN in RO must be prepared to address. Implanted devices like pacemakers and defibrillators can be damaged by radiation therapy treatments (Bitterman et al., 2018), requiring close monitoring and coordination of care. Exposing continuous glucose monitors and insulin pumps to linear accelerators is not recommended by many of the manufacturers of these devices due to concerns of damage; this requires monitoring the patient and the device for discrepancies (Hillson, 2022b). Procedures within the department may require conscious sedation and intravenous (IV) contrast, which means the RON must be proficient in managing anesthesia recovery and allergic reactions. The scope of the frontline nursing duties is very broad in the project department.

The project's facility treats inpatient and outpatient, adult and pediatric, and all genders. RO patients are treated with definitive or palliative intent for a wide range of malignancies or benign conditions (Halperin et al., 2019). Radiation oncologists may have a particular subspecialty, and then they and the RO nurses would coordinate care with specific teams of other medical professionals. For example, a radiation oncologist may have a sub-specialization in H&N cancer, which means that the patient's care is coordinated closely with medical oncology, otolaryngology, infusion center nurses, dieticians, speech-language therapists, and many others. A radiation oncologist who specializes in brain tumors will be coordinating with a different larger care team. An RN in RO may be simultaneously assigned to multiple providers and therefore needs knowledge of a wide range of treatment techniques, side effects, and familiarity with the larger teams for each disease site.

The deficiency in nursing training in RO has implications outside of the RO department. As multi-modality treatment is increasing (Mitin, 2023), the potential likelihood that any nurse outside of the RO department may be called upon to look after patients currently receiving radiation and contending with acute radiation toxicities increases. The absence of training available to RO nursing translates into a lack of available training and resources for any nurse who might be caring for a patient who is receiving radiation therapy. Consequently, this also applies to resources and training to help manage former radiation patients as well.

The Expanding Role of Survivorship in RO

It is a requirement of the ACR accreditation process that radiation oncologists should have regular, ongoing follow-up plans for their patients (Albus, 2022). Long-term side effects of radiation therapy can be life-long and life-changing. In males and females, the lifetime probability of developing cancer is approximately 40%, and the 5-year survival rate has increased to 68% (Siegel et al., 2023). It is estimated that cancer survivors account for 5.4% of Americans or 18.1 million people (OCS, 2022). Through various factors, including improved screening and therapy, the number of cancer survivors is projected to increase to 22.5 million by 2032 and to 26.0 million by 2040 (OCS, 2022). In 2016, it was projected that there would be 4.17 million radiation-treated cancer survivors by 2030, with 2.01 million radiation-treated breast cancer survivors and 627, 000 radiation-treated prostate cancer survivors (Bryant, 2017). This means that with more patients living longer after diagnosis, there is an increasing likelihood of non-RO staff being required to look after patients with chronic radiation therapy toxicities. There is a wide range of health professionals who may be treating patients who have previously undergone radiation therapy and are now suffering from long-term, chronic side effects.

For example, H&N cancer survivors who received radiation therapy (Haddad & Limaye, 2023) can commonly experience dry mouth, impaired speech, impaired swallowing, trismus, dental complications, osteoradionecrosis, lymphedema, fibrosis of the neck muscles, and impaired nutrition as well psychological distress. Thyroid dysfunction and carotid artery stenosis may require years of follow-up (Haddad & Limaye, 2023). Primary care for these patients should be multifaceted, but few health professionals outside of RO are trained to anticipate or screen for chronic findings that may not become apparent for months or years. Nurses in radiation oncology may be called upon to educate their peers and represent the specialty, but this will be a challenging task without specific training through a well-designed curriculum.

Concurrent Systemic Therapy with Radiation Therapy

As an example of coordination of care issues, some chemical agents are given to increase the sensitivity of cancer to radiation therapy. This is termed *radiosensitization.* One of the most common agents used as a radiosensitizer is cisplatin, a platinum-based chemotherapy (McQuestion et al., 2021a). This drug has greatly improved outcomes in gynecology and H&N cancers when used concurrently, but it has an extensive side effect profile.

Cisplatin is known to potentially cause acute renal failure, severe and delayed onset of nausea and vomiting, and electrolyte disturbances including magnesium and potassium wasting

(McQuestion et al., 2021). The resulting uncontrolled nausea and vomiting can manifest as malnutrition, weight loss, or falls. Family members and patients need their home anti-emetic regimen reinforced, the patients need to be assessed for safety, and nurses may be the first ones assessing that a prescribed treatment is insufficient. Patients at risk of dehydration need to be quickly assessed, lab work needs to be drawn, evaluated, and fluids and electrolytes administered. If the electrolyte depletion is significant enough, the patient may require hospitalization, close cardiac monitoring, and aggressive supplementation (McQuestion et al., 2021a). In some cases, patients may experience neuropathy and hearing loss, and these symptoms can become permanent if the chemotherapy is not adjusted or changed to another drug (McQuestion et al., 2021a). The nursing role in RO is heavy on assessment of the patient and their resources, education of the patients and their support people, and communication with all relevant providers. This includes referrals to speech therapy for communication and swallowing challenges, dieticians for nutritional assessment and support, social workers for the provision of additional resources, and family medical therapists for emotional support.

One of the most dangerous conditions caused by cisplatin (and most chemotherapies) is *myelosuppression*, a condition that requires rapid nursing assessment and intervention for patient survival. *Myelosuppression* occurs when toxic effects on the bone marrow can lead to thrombocytopenia, anemia, and neutropenia several days after the chemotherapy has been administered. Neutropenic fever, or infection when the body's ability to fight off infections is impaired, is a potentially lethal oncologic emergency (Wingard, 2022). The patient runs a greater chance of presenting to RO with this finding because treatment is five days a week whereas medical oncology appointments are only one day a week. Additionally, as these treatments are provided on an outpatient basis the assessment may be done by the RN in RO by telehealth. The patient’s survival depends on quick action, no matter which department the patient presents to first (Wingard, 2022). In the project facility, education on chemotherapy was provided to the medical oncology departments and not to the RO nurses. Additionally, existing reference materials seldom mention which agents are radiosensitizers. Unfortunately, the nursing staff in the project’s RO department are currently not taught about chemotherapy or any expected side effects. The knowledge deficit could conceivably be a barrier to the RO nurse making informed assessments, effectively intervening, and accurately communicating to the necessary team members.

It is important to realize that the nurse in RO is often the frontline contact with the patient, the first to assess the symptoms, and one tasked with communicating to the other necessary medical professionals. The project facility has RNs in RO seeing patients in weekly on-treatment visits; twice weekly for weight checks and brief assessments; weekly meetings with RO staff, medical oncology staff, and multiple therapy groups; and providing the initial point of contact and performing triage in the department’s infusion bay. The RN is responsible for communications to the attending physicians and residents. The RN in RO is, in part, responsible for ensuring timely communication with medical oncology to facilitate the decision to modify or even potentially hold chemotherapy doses (McQuestion et al., 2021a). RNs assessments, communications, and interventions can prevent permanent harm to the patient, and even prevent patient deaths.

Additionally, the inadequacy of systemic therapy knowledge also presents safety concerns for nurses as many cancer-fighting drugs are present in body fluids. Koulounti et al. (2019) noted that chemotherapies are mutagenic and teratogenic and associated with nurses experiencing anorexia, nausea, alopecia, and weakness if they are not using adequate personal protective equipment. For example, cisplatin is known to be present in sweat, urine, saliva, emesis, and stool for five days following administration (Eisenberg, 2022). Nursing is at the frontline providing direct patient care and, while excreta is presumed less than actual direct drug exposure, nurses and ancillary staff are at risk of getting exposed (Eisenberg, 2022). This means that the RNs in RO require education on personal protective equipment and minimizing personal exposure risks. Additionally, some chemotherapies run by continuous infusion (Brant, 2019), and this means that while chemotherapy spills are an uncommon event in a RO facility, the possibility exists. Finally, some concurrent chemotherapy regimens like temozolomide and capecitabine are now available in pill form and so the RN in RO has a role in providing and reinforcing patient education as well arranging for blood tests and monitoring (McQuestion et al., 2021a).

Disparities in Radiation Oncology: Financial toxicity, Rural versus Urban, and Race

Santos et al. (2023) wrote, "Ultimately, the answer to reducing mortality from cancer and other serious illnesses in underserved populations lies not in the next "Moonshot" cure, but in improving access to basic, "on-the-ground" care" (p. 773). There is a growing body of literature showing a complex interplay of social determinants of health (SDOH) affecting cancer outcomes including race, socioeconomic status, and access to treatment (LaVigne et al., 2023). Recently, there is an acknowledgment of "radiotherapy deserts" in America that have higher death rates and fewer radiation oncologists (LaVigne et al., 2023). These areas are disproportionately rural with a higher percentage of Black Americans (LaVigne et al., 2023).

Yusuf et al. (2022) found breast cancer radiation-receiving patients had increased risk for financial toxicity depending on their marital status, medication cost, employment type, and type of surgery. Black women with breast cancer were found to be significantly more likely to have their radiation treatment delayed, omitted, or given in a less timely fashion compared to Caucasian women (McClelland et al., 2020). Rural radiation therapy patients with delays in treatment were found to have a substantially higher mortality rate compared to urban residents who were otherwise similar in terms of marital status, employment status, and age (Morris et al., 2022).

As an example of geographic disparities, Appalachia, which is a system of mountains in the eastern and northeastern US, has just under 10% of the entire US population. Yet, this region has higher lung, cervical, and colorectal death rates than the rest of the country (McClelland et al., 2018). These disparities are attributed to poverty, low levels of education, and a reduced number of quality screening and radiation treatment facilities (McClelland et al., 2018). While access to radiation therapy has improved for Americans, 1.8% of Americans live over 50 miles away from the nearest treatment facility (Maroongroge et al., 2022). Patient issues related to SDOH and barriers to health care are within the nursing scope of practice, but the most useful interventions will require an accurate understanding of the modality.

Recent Initiatives in RO Education

Oncology education, and RO education in particular, has only recently become a focus of research. The first literature review for undergraduate medical education only happened in 2009, and the authors found that the caliber of oncology education was insufficiently preparing medical students (Dennis & Duncan, 2010). A national needs assessment was performed and found that only 50% of RO residents reported receiving a formal introductory curriculum and that many residents felt underprepared to begin their studies (Gunter et al., 2018). A structured didactic component to complement the clinical experience gained during a radiation oncology rotation was also noted to be lacking (Oskvarek et al., 2016).

With the intention of correcting this issue, a pilot program including didactic and lecture curriculum first rolled out in 2012 (Gunther, 2018), and this led to the creation of the multinational and interprofessional Radiation Oncology Education Collaborative Study Group (ROECSG). After the lectures and didactic components, those who received the curriculum reported feeling moderately prepared for beginning their training (Gunther et al., 2018). Students who attended ROECSG institutions were subsequently shown to have performed better during their rotation than those who attended an institution that did not follow the ROECSG curriculum (Golden et al., 2018). IROC was developed and trialed with 236 residents, and significant improvements were noted in the improved confidence of the respondents, as well as significant improvement in scores on a pre/post-test (Jimenez et al., 2020). The ROECSG curriculum is focused on actual radiation therapy treatment design and delivery. It does not address common nursing roles like concurrent systemic therapy, coordination of care, navigation, and survivorship. However, non-radiation oncologists are openly encouraged to participate (Rosenberg et al., 2022).

With the start of Covid-19, a second successful initiative was the implementation of the Radiation Oncology Virtual Education Rotation (ROVER) for medical students (Kahn et al., 2018). Virtual live didactic education panels with case-based discussions were moderated by residents and faculty, and medical students reported increased in perceived knowledge of radiation oncology (Kahn et al., 2018). ROVER 2.0 was subsequently developed for radiation oncology residents following the same format, and most attendees rated the sessions as having value (Sandhu et al., 2022).

A parallel body of literature is starting to be developed for APP in RO (Martin et al., 2021). A recent needs assessment for an introductory RO curriculum was trialed conducted by Martin et al. in 2021 and found that even after onboarding, 44.6% of respondents reported a lack of confidence in clinical skills and knowledge. Additionally, 59% reported that onboarding was affected by unclear goals and expectations. Most respondents (86.1%) expressed that they believed an online introductory curriculum would be of value.

Another parallel project, RO medical assistant training for RO has been studied by Sinha et al. (2021). There had been no CE or didactic training for this group of health care workers, and so a curriculum was developed. CMA participants reported a significant increase in feeling empowered, and there was a sustained demonstrable improvement in clinical knowledge. Notably, RO patients also reported an improvement in perceived empathy (Sinha et al., 2021).

We feel that these efforts to improve the caliber of the introduction of RO to other professionals and students offers a substantial opportunity to RNs. Even though the focus of these curriculums is partly outside the scope of nursing practice, the curriculums developed were some of the earliest attempts to communicate this complex specialty to non-oncologists. All of these groups were contacted during this project. All of these projects were conducted by ROECSG affiliates. Both ROECSG and ROVER were openly welcoming to nursing when approached regarding this project, and both made their curricula available for review.

Challenges to Providing Continuing Education

The traditionally smaller number of nursing staff, and a high volume and rapid turnover of patients make it challenging to take a nurse out of staffing for education. The primary nurse model utilized at the project facility further challenges the ability of one nurse to cover another. Different nurses may work with different diagnoses with different care teams and different acute and survivorship patient needs. Additionally, the RO department where the project was implemented was only one site out of eight in a large multi-state health system. Having in-person education would mean that some staff members would have to travel significant distances. Not all sites offered the same treatments or technologies, so the baseline knowledge required was not the same for all nurses in the same department. The radiation protection state government oversite is different for each state. This creates a barrier to providing a valid curriculum for all department nurses when the facilities are so significantly different from each other.

These barriers are potentially not be specific to this one location. Chang et al. (2019) created a series of nine 30-minute lectures with only two lectures every month. Lectures covered topics like radiation therapy planning and delivery, special cases in radiation therapy, and management of commonly treated cancers. At the end of the study, despite the low time commitment, the researchers noted barriers to attendance and staff turnover without further elucidation (Chang et al., 2019). Finally, social distancing requirements further challenged the feasibility of classroom learning and had negative effects on staffing levels. (Sandhu et al., 2020). This led to fewer experienced nurses in several fields and likely RO as well (Sandhu et al., 2020).

Lack of nursing and provider knowledge affecting referrals

Two studies (Hayden & Connolly, 2019; Schone, 2017) explored the knowledge of radiation therapy of frontline care providers as part of a strategy to reduce barriers to patient referrals and a strategy to improve patient care. An effort was made to better disseminate information in communities and remote areas on best practices and guidelines. However, neither study was able to demonstrate that improved knowledge of frontline providers led to an increase in referrals.

Addressing knowledge deficits improves patient care and expands the role of nursing

Studies demonstrated how nurses with additional RO-related training were able to improve the quality of care significantly. In one study (Holtzman et al., 2018), RO nurses participated in training sessions with physicians on optimizing cancer pain management. Afterward, nurses had weekly meetings with patients actively undergoing radiation therapy. On follow-up, the researchers noted a 50% relative reduction in the pain scores of patients undergoing radiation therapy.

In the same way, following physician and psychologist-led education, a group of nurses followed gynecologic radiation therapy patients during treatment and at regular intervals following the completion of RO therapy (Bakker et al., 2017). This nurse-delivered sexual rehabilitation and survivorship program had patients demonstrating 94% compliance with rehabilitative exercises. After a year, most patients reported pre-diagnosis levels of sexual functioning (Bakker et al., 2017).

In another supportive measure, Kawamura et al. (2019) developed a scoring system using dosimetry data to successfully predict skin reactions in RO patients. Such tools can greatly inform frontline staff about specific anticipated patient side effects. This, in turn, can increase targeted and proactive interventions to improve patient outcomes. Care can be improved even when the frontline care nurse may not have the training to interpret the complex physics of the treatment plan by having accurately guided assessments.

The use of artificial intelligence (AI) to increase the contributions of nursing is controversial. Hunyh et al. (2020) explored AI and its potential application to treatment planning. The hope was that this would make higher quality care available throughout the world by providing better guidance to remote and developing areas. However, it was their belief that the role of nursing would not be affected as the nursing profession is more focused on people than technology.

However, Hong et al. (2021) demonstrated that an increased use of AI can help to direct care and expand the nursing role. In an interesting study, researchers created an AI, SHIELD-RT, and tested its ability to predict which patients during treatment would be at higher risk for needing an acute care visit (Hong et al., 2021). Those patients who were deemed to be at higher risk were randomized into two groups, with one group being seen twice a week and the control group being seen the usual once a week for an on-treatment visit. Those patients who were randomized to being seen twice a week were seen once by their attending physician, and the second weekly assessment was conducted by one member of a team consisting of a second attending physician, a RO resident, two nurse practitioners, or a specially trained RO nurse with a BSN.

As a result of the SHIELD-RT protocol, significantly fewer patients receiving the twice-weekly assessment schedule were admitted to either the emergency department or hospital for radiation treatment toxicities both during and after treatment. The two most common reasons for those who were admitted were neurologic changes and malnutrition. Nearly one-third of admissions and acute care visits were for reasons that were determined to be potentially preventable, with preventable reasons for acute care visits significantly less in the intervention arm (Hong et al., 2021). Preventable visits included findings like anemia, dehydration, diarrhea, nausea and vomiting, pain, and sepsis, and these were defined according to criteria set out by the Centers for Medicare and Medicaid Services. Subsequent economic analysis showed that the cost of care was significantly reduced as well (Natesan et al., 2021). These studies would seem to indicate that the role of the RO nurse can be expanded and optimized for better patient outcomes with more guidance, training, and education.

The First Radiation Oncology Nursing Needs Assessment in the United States

Many of the great milestones in radiation in medicine first occurred in the United States, including the very first radiation therapy for breast cancer in the world (Smith, 2022), and the first fluoroscopy (King, 2012). Memorial Sloane Kettering began low voltage x-ray therapy only six years after Wilhelm Röntgen announced the discovery of x-rays and started radium therapy the same year that Marie Curie defended her doctoral thesis (Chu, 2011). The United States would become a major benefactor for Curie’s research when President Warren Harding and the forerunners of the American Association of University Women gifted her an ounce of radium (Gould, 2013).

Despite over a century of American history involving radiation in health care, research into RO nursing education in the United States is limited, and in fact actually lags behind other countries. As one example, the first study examining perceived education needs and training for nurses in RO was only published in 2021 by Moskalenko et al. Therefore, there were a limited number of studies to draw on for the purposes of our project.

Moskalenko et al. (2021) found that 97% of RO nurses reported learning on the job, with 56% reporting on-the-job training provided by fellow nurses and 39% of their education provided by residents and attending physicians. Experience was also limited, with only 21% or approximately one in five respondents reporting more than ten years of RO experience (Moskalenko et al., 2021). Only 5% had any RO training at all in school, and only 49% had received any onboarding training (Moskalenko et al., 2021). This study paints a picture of RO nurses with no credentials, limited experience, and significantly limited RO training mostly provided by other nurses who were presumably products of the same systemic barriers. Nonetheless, 100% of respondents stated they were responsible for educating patients and coordinating their care (Moskalenko et al., 2021). The nurses in this study reported they were also responsible for pending orders, psychosocial assessments, and taking a history and physical.

For their needs assessment, Moskalenko et al. (2021) used a 5-point Likert scale to grade self-reported individual RN confidence to care for specific disease sites. Responses were reported as (median [interquartile range]). Breast (4 [3-4]), prostate (4 [3-5]), and central nervous system (CNS) were associated with the highest nurse-reported confidence. H&N (3 [2-4]), gynecologic (3 [2-4]), and lymphoma (3 [2-4]) were associated with lower confidence regarding providing care. Finally, nurses were asked about education topics of interest. Over half of the respondents expressed interest in learning more about the treatment modality, cancer biology, effective management of treatment toxicities, and medical oncology (Moskalenko et al., 2021).

The nurses surveyed by Moskalenko et al. (2021) were from three major academic centers. It is possible that the nurses from smaller practices would have responded to the survey questions differently. Some technologies are geographically more prevalent than others (Bates et al., 2022; Bates et al., 2021; Dean et al., 2019; National Association for Proton Therapy [NAPT], 2023). It is possible that these findings do not reflect the demographics, education, and needs of all American nurses in RO.

Conceptual Framework

This project focused on developing a curriculum (Appendix D) and andragogy for a group of practicing professional nurses in a RO department. The principal theory that was utilized was *Andragogy*, or Knowles Theory of Adult Learning (KTOAL). Malcom Shepard Knowles developed this theory in 1980, to demonstrate how learning occurs during the adult years (Merriam, 2002). Knowles defines andragogy as the art and science of adult learning (Merriam, 2002). As adult learners, each of the nurses in the project facility had already completed their core nursing training and were already licensed and practicing.

As such, Knowles' andragogy is based on a set of expectations. First, these learners are expected to be self-directed and will have a strong sense of self. Secondly, they all had prior nursing experiences that they were able to draw upon. Thirdly, the expectation is that both experienced practitioners and learners will want to immediately apply their new-found knowledge to the problem-solving and challenging patient care issues to which they are already seeking solutions. Fourthly, it is important for the student to understand the value of the education was practical, relevant, and necessary; The prospective student is expected to want to know why their latest education mattered. Finally, adult education is often driven by internal factors and is often a matter of choice (Spies & Bothma, 2015). Pedagogical learning is traditional classroom instruction where the teacher is in charge, and the students simply absorb what they are ordered to receive. However, not all adult learners clearly fit the description that KTOAL presents (Spies & Bothma, 2020). As an example, in a subspecialty with so few education opportunities, some nurses may not be independent learners, and the experiences that they have to draw on may not be related to this subspecialty. In the context of this DNP project, the target group was practicing registered nurses, and therefore, it was expected that core nursing knowledge could be built upon for the purposes of edification leading to expertise. A well-designed curriculum was anticipated to start with the least complex and then proceed to greater complexity (Spies & Bothma, 2020).

Modules were created that were divided up by topic, giving staff the opportunity to focus on relevant information and problem-solving related to specific subjects. Videos were available online and on-demand to allow for flexibility for when the nurses were ready to review them. This let staff be self-directed learners and facilitated access to the relevant information that they personally needed during their clinical practice. Ideally, information that had already been acquired or was not relevant at that moment was possible to skip over, and that in turn would allow for better focus on the knowledge that was being sought.

Methods

The dearth of a nursing training curriculum in RO could affect the competence and confidence of nurses to provide high-level care to patients who are currently receiving radiation therapy or who have received radiation therapy in the past. Nursing's contributions to research and regulatory compliance could also be adversely affected. The purpose of this pilot project was to improve the education and training of frontline RO nurses in the project's department, with the expectation that this would improve patient and staff safety, patient education and outcomes, and departmental workflow. This project aimed to provide a foundation to improve interdisciplinary communication both within and outside the department.

Eight self-study video PowerPoint modules were created. These included an introduction to the department, to radiation science, radiation safety and regulatory oversight, radiobiology or the interaction of radiation with organic tissue and the grading of radiation toxicities, chemical modifiers of radiation response or concurrent systemic therapy, radioactive sources, radiation-emitting machines, radiology, and a final site-specific module on H&N cancer. Module length ranged from 6 minutes to 30 minutes. Modules were developed with the input of department specialist physicians, clinical nurse specialists, radiation therapists, medical physicists, and multiple staff members at the project facility's continuing education and professional development department (CEPD). Work on the curriculum (Appendix D) and modules started in January 2022 and was completed in August 2022.

IRB applications were submitted both to the project facility and the university school of nursing overseeing this project, and both found this project IRB exempt. For recruitment, a convenience sample of staff RNs in a single RO department was engaged by an introduction to the project was held at a staff meeting in August using an IRB-approved script (Appendix F), and an information sheet that was posted on the nurse manager's office door (Appendix F). Surveys were sent out by the nurse manager to the staff RNs of this department in August 2022. These included a limited demographics survey (Appendix A), an adapted version of the needs assessment by Moskalenko et al. (2021) (Appendix B), and a pre-test of knowledge (Appendix C). Limited demographics (Appendix A) were collected regarding RO education, oncology education, and work experience. No names, ages, or genders were requested. These surveys were disseminated using an online survey software through the project facility and sent to individual nurses by the nurse manager using password and multi-factor authentication protected emails. An email reminder to complete the surveys was sent from the nurse manager to the individual nurses with a pre-approved script (Appendix F) in September 2022. In October, eight weeks later and following approval from the facility's CEPD department, links to the education modules and curriculum (Appendix D) were sent out using the same process and security, and those modules were stored on the similarly password and multi-factor authentication protected learning management system available through the project facility. In November 2022, an additional reminder email using the same previously approved script (Appendix F) with links to surveys and education modules was sent. In December 2022, links were sent out to two additional surveys. The first was a post-test of knowledge (Appendix C) that was identical to the pre-test of knowledge. Individual respondents were not told the survey would be the same in advance. The second survey was soliciting feedback on the viability of this training method, the curriculum, and the modules themselves (Appendix E). Both December surveys and responses were available through the project facility's password protected and multi-factor authentication online survey system. All responses were confidential and anonymous, and only available through accessing the online survey software using multifactor authentication and password protection.

Design

This pilot Quality Improvement project was a mixed method, quantitative and qualitative, pre-/post-survey design. A self-study video curriculum of recorded PowerPoints was provided. Recruitment was done using a convenience sample in the summer and fall of 2022 and through the spring of 2023.

Translational Framework

The translational framework that we used was the Institute for Healthcare Improvement's ([IHI], 2022) Plan-Do-Study-Act (PDSA). This framework was originally introduced by Walter Shewhart who constructed a three-step scientific process that included a cycle of specification, production, and inspection. Dr. Deming, an American statistician, electrical engineer, and management consultant for manufacturing, worked alongside Shewhart and modified Shewhart's process. Deming constructed a new version of Shewhart's cycle which emphasized four steps of design, production, sales, and research. Although this archetype originated in the realm of manufacturing, the PDSA model has been applied to the healthcare setting among other professional disciplines (Millard, 2022).

PDSA is an applied scientific approach that uses cycles of change and evaluation continuously. RO is a dynamic field where technology is rapidly being developed, and new applications are frequently being devised. Those providing instruction in this specialty are currently evaluating the way in which medical students and residents are taught (Rosenberg et al., 2022). The PDSA tools have a history of utilization within health care and are located as part of the public domain through the Institute for Healthcare Improvement (IHI) website.

The initial phase, “Plan” involved informal discussions and team building to develop RO nursing curriculum materials. A formal needs assessment and go-live of the modules were part of the second phase, “Do”. For the third phase, “Study”, an evaluation of the knowledge gained was conducted by asking staff to evaluate the effectiveness and feasibility of the materials. The fourth phase, “Act”, evaluated the response to the curriculum and re-evaluated the curriculum content.

The whole PDSA process is anticipated to be an ongoing cyclical effort. With advancements in this specialty, changes in department protocols, and solicited staff feedback, it is anticipated that the curriculum will need regular, ongoing review and updates to ensure high caliber content.

Population

The population for this pilot QI project was full-time or part-time registered nurses (RN) providing frontline care to radiation therapy patients. All department RNs work 8-to-10-hour days, Monday through Friday with no weekend or night shifts. There were fourteen nurses who are eligible for participation. All nurses could read and write English and were computer literate with regular access to computers. One nurse transitioned to a new role during the project. It was decided that only RNs including senior staff and new hires from this one facility would be included. The exclusion criteria were staff who were not RNs, RNs who were employed in other departments within the facility, or RNs employed at other facilities that were not utilized for the DNP project. Additionally, also excluded were administrative staff, ancillary clerical staff, dosimetrists, physicists, radiation therapists, radiology technicians, certified medical assistants, and any non-clinical staff of the RO department.

Setting

The setting for the DNP project was a single radiation oncology facility affiliated with a large academic health system in the southeastern United States. The project department is attached to a 957-bed facility, and seven affiliated facilities are found in five communities in three states. On an average day,, 200 patients are being treated, and approximately 100 patients are being seen in consult, follow-up, or on-treatment visits.

Project Implementation

With permission from the authors of the Moskalenko et al. (2021) RO nursing education needs assessment, cloud-based software was used to administer an adapted version of their needs assessment survey to Registered Nurses (RN) in RO at a single academic medical center. This survey used a 5-point Likert-type scale (5 = "Extremely Confident," 4= "Quite Confident," 3= "Somewhat Confident," 2= "Not Very Confident," 1= "Not At All Confident") to explore perceived clinical strengths and weaknesses regarding providing care to radiation oncology patients with the following disease groups: breast, prostate/genitourinary, lung, sarcoma, gynecological, CNS, H&N, gastrointestinal (GI), skin, leukemia/lymphoma, and pediatrics. Respondents were first asked to grade their confidence in their knowledge and understanding for providing acute therapy, defined as under 90 days from the start of treatment. We then asked RNs to grade their confidence in their knowledge and understanding for providing care to patients more than 90 days after treatment. Respondents were also asked to grade their confidence in providing patient education and care regarding computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), external beam radiation therapy (EBRT), high-dose rate brachytherapy (HDR), concurrent systemic therapies, anesthesia recovery, radiation safety, and general cancer knowledge.

Eight education modules were submitted for approval and were rolled out in mid-September 2022. Stakeholders who had committed to the project were represented by the continuing education and professional development department (CEPD), the director of nursing research for the health system, and RO department leadership. The chief dosimetrist, lead therapist, lead physicist, a pharmacist, physician experts, and the radiation safety officer were engaged to help oversee aspects of curriculum development. Several frontline nurses in the project department were certified oncology nurses and contributors to the 5th edition of the ONS *Manual for Radiation Oncology Nursing Practice and Education* (2021), and they were approached to contribute content to the modules.

Actions taken, and what supports and resources were used to implement the plan

The project facility's software accounts were used in several ways. The project facility provided access to their online survey software which was used to develop and disseminate the questionnaires that were administered. All surveys were only available as password protected and via multi-factor authentication. A cloud-based content management system was used for communication during the development of the curriculum and modules. The facility's online Learning Management System (LMS) was used to disseminate the modules to participants. Several onsite physicians were approached for their expertise on the subject matter. Resources used to develop curriculum materials included those developed by ONS, ASTRO, CDC, NCR, FDA, ABR, ACR, and ROECSG, as well as existing textbooks within the field. Nurse educators and clinical nurse specialists for the department were engaged early on, as were nurse leaders for the department and the greater health system for IRB and materials development. The resources of the university overseeing the DNP program included IRB assistance and writing assistance in the development of materials.

Instruments

All instruments were programmed into an online survey tool software available through the health care system of the project's facility. Links to all surveys were provided through password-protected email from the project facility's nurse manager to the sample of RNs in the project department. All surveys were anonymous and confidential, and not linked to specific respondents. This involved an optional demographics survey (Appendix A), a needs assessment (Appendix B), a pre- and post- test of knowledge (Appendix C), and a post-curriculum solicitation of feedback (Appendix E). All answers were de-identified with no way to trace back answers to the respondents, and only available through a multifactor authentication and password protected online software. Respondents were told that their involvement would not affect their employment, nor would there be any financial compensation for their time. All survey responses are stored in the multifactor authentication and password-protected online software and stored de-identified.

Prior to providing access to the education modules, eight optional questions covered limited demographic information, education history, certifications, and duration of practice in nursing, oncology nursing, and RO nursing (Appendix A). One question was added to the demographics section to give the individual respondents the option to provide this information or not. This section was anticipated to require under five minutes to complete. A second question involved 11 choices of potential sources of RO knowledge, and respondents were asked to select or not all responses that represented what they perceived as their sources of knowledge (Appendix A).

Permission was obtained from Drs. Marina Moskalenko, MD and Sameer Nath, MD to use and modify their previously developed and validated online needs assessment survey (Moskalenko et al., 2021) for our pilot project (Appendix B). As examples of how and why the survey was adapted, the original survey touched on prostate brachytherapy which is a procedure that the project facility is not currently performing, but the original survey did not ask about sarcoma care which is a particularly labor-intensive RN role in the project department. We did use a five-point Likert scale to evaluate nursing confidence with providing care as the original study had done. However, we used the five-point Likert scale for assessing confidence in providing care for RO patients with either acute toxicities or late radiation reactions. Finally, we added a five-point Likert scale block of questions to assess nursing confidence regarding systemic therapy, coordination of care, and radiology procedures as these were perceived to be a significant part of the role of the RN in the project's RO department. This brought the number of Likert questions for this project to forty-eight. RNs in RO were asked to grade their confidence by "Not At All Confident," "Not Very Confident," "Somewhat Confident," "Quite Confident," and "Extremely Confident." An additional one question involved nine possible responses that RNs were asked to select or not as representative of their duties (Appendix B). It was anticipated that the needs assessment survey would require twenty to thirty minutes to complete.

A knowledge-based test was utilized that had 20 multiple-choice, select-all-applicable, and true/false questions (Appendix C). This was used both as a pre- and a post- test; respondents were not notified in advance that the pre- and post-tests were identical. The individual staff members were not tracked, and so there was no way to provide a direct pre- and post-comparison. The tests of knowledge were anticipated to take respondents twenty minutes or less. Emails (Appendix F) soliciting participation were sent through the RO facility's password-protected email system through the project facility's nurse manager, and access to the surveys were also password protected using the RO facility's online survey software account.

After the education had been released for months for nurses to study on their own, a final six question post-curriculum question survey was released on the same password-protected online survey tool. Participation was solicited by the nurse manager via the same password-protected multifactor authentication email system. This survey used *yes/no/maybe, yes/no*, and free text solicited feedback on the course (Appendix E; Table 8.). A single *yes/no/maybe* question asked respondents if they felt that the curriculum modules increased their RO knowledge, if they felt that the knowledge was useful, if they felt better prepared to provide patient care with the information provided, and if they liked the self-study format. The survey included one *yes/no* question asking if there was any material that was too complex, with an option to provide clarification by selecting all that apply if the response was "*yes"*. In a second *yes/no* question, it was asked whether the material was too easy and if the answer was "*yes*" also offering the possibility of clarification using free text (Appendix E; Table 8). A final free-text question was provided to let the respondent give feedback of their choice. This survey was expected to only take two minutes.

Timeline and critical milestones

January 2022 to June 2022 – study and curriculum development

July 2022 recording of curriculum

August 2022 attended staff meeting using a pre-approved script (Appendix F). This was followed by an initial-email soliciting participation via multifactor authentication and password-protected employee email sent by the nurse manager to the department staff in August 2022. An information sheet (Appendix F) was posted on the nurse manager's office door.

September 2022 first reminder email sent using multifactor authentication and password protected employee email by the nurse manager. (Appendix F)

October 2022 approval obtained for curriculum (Appendix D) and links were sent out using multifactor authentication and password protected email by the nurse manager.

November 2022 second reminder email sent using multifactor authentication and password protected employee email by the nurse manager. (Appendix F)

December 2022 surveys sent out for post-intervention tests of knowledge (Appendix C) and post-curriculum feedback (Appendix E)

January 2023 data analysis

IRB approval

Two separate IRBs were submitted for this project, one to the UNCG School of Nursing and the other to the project site facility. Both entities deemed this QI project to be IRB exempt. Participants were informed that their responses would be kept confidential and anonymous. Limited demographics were optional, and did not include age, gender, race, or degrees obtained as this was a small enough facility that this could lead to directly identifying individual nurses. All survey responses were anonymous, and no personal identifying information of the participants was obtained or attempted. The surveys were available only on a multifactor authentication and password-protected online site, supported and secured by the project facility.

Moreover, the information was not shared with the project site management. Only with UNCG School of Nursing faculty who had CITI training were actively involved in data analysis. The collected data was stored on a password-protected computer, that was either in the possession of the principal investigator, or secured in a locked area. The data was not viewed in a public place such as a coffee shop or other venue where others could easily see the information. Considering that the department staff were being sampled, none of the staff members had access to any project data information. Pre- and post- response rate data were not collected, nor were attempts made to track how often the provided modules were viewed by the sample participants. Participation was voluntary and had no effect on participant's job performance evaluations or income. No financial compensation was offered to the staff as an incentive to participate in the education or in the pre and post surveys.

Steps implemented

Several groups were identified as necessary for the planning and implementation of the project. The medical director of the project facility was engaged early on, as it was clear that the dearth of available nursing resources meant that we would need to have some specialist involvement for accuracy in content. Three members of the radiation safety division of the project facility were communicated with by email, as were two members of the medical physics department. One member of the radiation safety division provided a video on eye plaque brachytherapy, an RO procedure that our nurses have incidental involvement in scheduling and patient education, but which is not performed in the department. The chief dosimetrist, and the chief therapist as well as the two lead therapists were engaged for guidance in the development of the curriculum. The clinical nurse specialist and nurse educator were involved in the ~~actua~~l approval and recording of the education video materials. The director of nursing research and evidenced-based practice (EBP) was an enormous help with the project site IRB process. One radiation oncologist was approached to provide a module on gynecologic radiation oncology. Members of the facility's CEPD were involved in reviewing the modules and providing links for the LMS system. Online surveys and tests of knowledge were developed with input from a radiation oncologist and the chief radiation oncology resident. Not directly related to this project, ONS was regularly communicated with regarding the education of RNs in RO. The one editor for the 5th edition of the ONS *Manual for Radiation Oncology Practice and Education* was asked to review content. The director of ROECSG was also generous with his input. Permission to use artwork used in some modules was done directly with the artist. Permission to use images involved contacting several authors.

How data were collected

Data collection was done from August 2022 to January 2023 via project facility online survey software that required multi-authentication and password protection. Respondents were volunteers in a single-site radiation oncology department of the project site, attached to the academic medical center. The nurse manager in the radiology/oncology department distributed multifactor authentication password-protected emails to the staff, providing them with the opportunity to participate in the surveys.

All information collected from respondents was anonymous and kept confidential. Demographics were limited, did not involve gender, age, race, or degree obtained, and were optional. The demographics results were collected as represented in Appendix A, and reported in Table 7, using 5-point Likert scale, number of respondents, percentage of sample, and median with interquartile range. Likert scale questions from the needs assessment (Appendix B) were collected via the same online survey tool software available through the health care system of the project's facility.

Data Analysis

After collection of data, results from quantitative and qualitative data, a frequency analysis was calculated, through Excel software. Descriptive statistics were utilized to summarize and organize the data. Qualitative data was reviewed and considered for feedback on the necessity of this project. Likert scale questions from the needs assessment (Appendix B), and survey responses were reported using number of respondents and percentage of the sample, as well as median and interquartile (IQR) range (median [IQR]) in Tables 1 through 6, and throughout the text in the results section. Additionally, these responses were plotted on bar graphs using Excel software (Figures 1 through 3). Test of knowledge scores were reported as sample average score, range of scores, and number and percentage of correct responses.

Results

RNs at a single-site academic medical center RO department were surveyed with a 100% (*n*=14) response rate. 93% of respondents (*n*=13) agreed to fill out demographics (Table 7). Scores were reported as number of respondents and percentages of the sample, or median and interquartile range, or both. Respondents were 61.5% (*n*=8) oncology certified nurses (OCN), and 15.3% (*n*=2) had completed the ONS/ONCC radiation therapy certificate course. Most respondents (84.6%, *n*=11) attended schools without affiliated RO departments and without RO clinical experiences, though RO content was included in some nursing school curriculums (23.1%).

Most were experienced RNs (Table 7), with 15.3% (*n*=2) reporting having practiced for 0-4 years, 46.2% (*n*=6) reporting having practiced for 5-9 years, and 38.5% having practiced for 10 years or more (*n*=5). Most nurses were experienced in oncology, with 30.8% (*n*=4) practiced in oncology for 0-4 years, 23.1% reported having practiced oncology for 5-9 years, and nearly half of respondents (46.2% or *n*=6) reported having practiced in oncology for 10 years or more. However, RO experience was significantly less with over half of respondents (53.8% or *n*=7) reported having worked with RO patients for 0-4 years, 23.1% (*n*=3) for 5-9 years, and 23.1% (*n*=3) for ten years or more.

In terms of RO knowledge (Figure 2), all RNs (*n*=13) reported learning on-the-job, with physicians (76.9%, *n*=10), nursing colleagues (69.2%, *n*=9), radiation therapists (62%, *n*=8), and personal continuing education (53.8%, *n*=7) rounding out the top five sources of RO information. The top 5 answers were all selected by over half of the respondents, and these informal sources of RO knowledge were more commonly reported sources of knowledge than employer-provided education (38.5%, *n*=5), professional association continuing education (38.5%, *n*=5), and nursing school (23.1%, *n*=3).

All nurses (100%, *n*=14) reported their duties included patient education (Figure 1). Most RNs reported their duties included acute symptom management and preparation for radiology procedures in the project department's infusion bay (78.6%, *n*=11), patient phone triage calls and electronic medical record patient communication (78.6% or *n*=11), and patient care in follow-up appointments (78.6% or *n*=11). Most RNs were responsible for psychosocial needs assessments

(71.4%, *n*=10), patient consults (71.4%, *n*=10), and navigation within the department 64.3% (*n*=9). A minority reported that they were responsible for the coordination of care outside the department (35.7%, n=5), and survivorship (35.7%, *n*=5).

A test of knowledge (Appendix C) was developed for the purposes of this project The results are recorded in Appendix G. There was a 57.1% response rate (*n*=8). Scores ranged from 67% to 100% with a mean score of 84% and a standard deviation of 10.9. Questions on systemic therapy and acute radiation therapy management were generally answered well, but only one respondent correctly selected all risk factors or radiation dermatitis (Appendix G). Most respondents (62.5%, *n*=5) incorrectly selected that patients were not radioactive following a PET scan (Appendix G). Most respondents (62.5%, *n*=5) identified incorrect organizations as responsible for enforcing and providing radiation safety oversight (Appendix G). Two questions on general radiation knowledge had half of the respondents (50%, *n*=4) incorrectly answering questions about properties of electrons, photons, protons, and gamma rays (Appendix G). In terms of late effects, 100% (*n*=8) recognized radiation recall, but only one respondent (12.5%, *n*=1) selected all risk factors for lymphedema (Appendix G). RNs were asked about the symptoms of radiation-induced fibrosis, with 87.5% correctly selecting "loss of elasticity of tissue," and 62.5% selecting "decreased or absent secretions from tissue (sweat, saliva)" (Appendix G). There was a single question on Madame Curie (Appendix G); 100% (*n*=8) knew Curie had received a Nobel Prize, 87.5% (*n*=7) knew she had discovered polonium and radium, and 75% (*n*=6) knew that her work involved categorizing radioactive substances and coined the term, "radioactivity."

In terms of RN-expressed confidence, all respondents chose to provide answers (*n*=14). RNs expressed moderate confidence (Table 3) in their understanding of cancer biology (3 [3-4]), radiation in general (3 [3-4]), and their knowledge of the roles and responsibilities of the RO care team (3 [3-4]).

RNs expressed low confidence in their knowledge and understanding of regulatory aspects of radiation safety (2.5, [2-3]), but had a high degree of confidence that they could identify and stay safe from potential radiation hazards in the department (4 [3-5]). In our test of knowledge (Appendix G), most (87.5% or *n*=7) recognized the state radiation protection commission was responsible for oversight, and 75% (*n*=6) of respondents were able to identify the Nuclear Regulatory Commission and the facility's radiation safety officer as groups that provide mandatory oversight. However, 63.5% (*n*=5) incorrectly selected that the CDC and the AEC were responsible for regulatory oversight today. In the needs assessment evaluation of confidence (Appendix B; Figure 3; Tables 1-6), RNs reported lower confidence (2.5 [2-3]) regarding their knowledge and understanding of regulatory aspects of RO, with 42.9% (*n*=6) reported they were "Not Very Confident". No respondents replied to the post-video curriculum test of knowledge (Appendix C).

RNs had moderate confidence (Table 5) regarding educating patients and maintaining safety regarding CT (3 [3-4]), MRI (3 [3-4]), and PET (3 [3-4]) procedures, but RN-reported confidence was more variable teaching patients about simulation which uses these technologies (3 [2-4]). RN-reported confidence in their understanding of radiation treatment planning (3 [2-4]) and set up and positioning to deliver therapy (3 [2-4]) (Table 3) was more variable than their reported confidence in the related activity of teaching patients about EBRT (3 [3-4]) (Table 5).

In terms of the surgical implantation of radioactive materials or HDR (Table 6), HDR scores were bimodal. Respondents graded their confidence they could assist in HDR at 57.1% of respondents rating their confidence at a 1/5 "Not At All Confident" (28.6%, *n*=4) or a 2/5 "Not Very Confident" (28.6%, *n*=4), while 21.4% rated their confidence at a 4/5 "Quite Confident" (21.4%, *n*=3) or a 5/5 "Extremely Confident" (21.4%, *n*=3). Similarly, RN-reported confidence that they could explain HDR to a patient was bimodal, with 38.5% of respondents rating their confidence at a 1/5 "Not At All Confident" (*n*=5) and 28.6% rating their confidence at a 5/5 (*n*=4). RNs overall had low and highly variable confidence that they could assist in HDR (2 [1-4]) or educate patients about HDR (2.5, [1-5]). Moderate sedation modules are mandatory annual education in the project facility as this is used in both HDR and pediatric EBRT, and RNs reported moderate confidence that they could assist with anesthesia recovery (3 [3-4]).

In terms of coordination of care, RNs expressed the most confidence in their understanding of the roles and responsibilities of the larger cancer care team (4 [3-4]) (Table 3) and educating patients about common medications used for side effect management (4 3-4]) (Table 4). There is a palliative care clinic in the project department, and RNs did express a higher degree of confidence in their knowledge and understanding of palliative care (4 [3-4]) (Table 3). RNs expressed a higher degree of confidence in their ability to take triage phone calls from patients (4 [4-5]) (Table 6) and in their ability to recognize an oncologic emergency (4 [3-4]) (Table 6). They expressed moderate confidence in their understanding of wound care (3 [3-4]) (Table 3) and nutrition for cancer treatment (3 [3-4]) (Table 3).

In terms of systemic therapy (Table 4), RNs had moderate confidence that they could explain how chemotherapy and radiation are used together (3 [3-4]) and that they could recognize a potentially serious side effect of chemotherapy (3 [3-4]). RN-expressed confidence was lower that they could recognize potentially serious side effects of immunotherapy (3 [2-3]). When asked about administering hormone therapy, a procedure that is commonly done for patient care groups like prostate cancer patients, there was a bimodal response with 28.6% rating themselves 1/5 “Not At All Confident” that they could perform this procedure and 38.5% rating themselves 4/5 “Quite Confident” (*n*=5) in their ability to administer hormone therapy. Using median and IQR, RNs had variable confidence that they could explain hormone therapy (3 [2-4]) or administer it (3.5 [1-4]).

In terms of providing patient care, RNs reported confidence scores were higher for managing acute toxicities of patients (during treatment and within 90 days of completion, Table 1, Figure 3) with prostate/genitourinary (4 [3-4]), lung (4 [3-4]), and sarcoma cancers (3.5 [2-4]). RNs reported they were the least confident in managing acute toxicities of lymphoma/leukemia (2.5 [2-4]) and pediatric cancers (2 [1-4]). RNs expressed less confidence in their ability to manage the late effects of radiation therapy (over 90 days from the completion of therapy, Table 2, Figure 3) for all disease sites compared to the acute management scores. The highest RN-reported confidence was for prostate/genitourinary (3 [2-4]), sarcoma (3 [2-4]), and breast (3 [2-3]) cancers. The lowest RN-reported confidence was for skin (2 [2-4]), CNS (2 [2-3]), GI (2 [2-3]), lymphoma/leukemia (2 [2-3]), and pediatric cancers (2 [1-2]). When averaging the results of 11 disease sites together, overall RN-reported confidence was higher (3 [3.5]) for acute RO care as compared to their confidence in managing patients with late and chronic RO symptoms (2.5 [2-3], Figure 3).

A post-curriculum evaluation was administered and had a 14.3% response rate (*n*=2). Respondents selected that the modules did increase their RO knowledge, that the modules would be useful in the performance of their duties, that they felt better prepared to provide patient care with the information provided, and that they liked the self-study format. When asked, "Did you feel any modules were "over your head," or too complicated, or needed to be explained in another way?" One respondent answered "yes," with the following free text: "*too much information about particles. I feel like most newer radiation oncology nurses this does not need to be described in such detail. It might overwhelm new employees. Just having a basic overview, but which has more penetration, etc. might need to be explained differently or left out."* (RO RN respondent, free-text written answer, January 2023). The other respondent selected that the modules were appropriate. When asked, "Did you feel any modules were too simple and could be condensed or taught at a higher level?" both respondents selected that they felt this was not the case. When an optional question was asked, "Do you have additional feedback about this QI project that you would like to give?" there were two responses. *"This is a great initiative and would benefit nurses in providing care and keeping a knowledge base that would make them more confident in their role, especially as radiation oncology nurses.* (RO, RN respondent free-text written answer, January 2023). *"This is definitely needed content considering the lack of radiation oncology education out there."* (RO, RN respondent, free-text written answer, January 2023).

Identify barriers to success

During this project, several barriers were identified. Support from leadership was challenging as there was a significant turnover of upper-level nursing management. New stakeholders were identified at every step of the project, while early nursing stakeholders became unavailable. There are two separate research groups for the project facility, one with RO, and one with nursing; it was difficult to determine which stakeholders were essential. Another unanticipated challenge was that the curriculum took longer to develop and record than originally planned, reducing the amount of time available for RNs to participate in this project. After a variety of administrative, academic, and medical personnel reviewed the curriculum and educational videos, several revisions were required prior to final approval, which delayed implementation.

Additionally, due to unusually high patient volumes during the project timeline, RNs at the facility had to work longer shifts. This potentially reduced the amount of time that they could spend on their continuing education modules. The project required the completion of a significant number of modules and surveys for the participants. While demographics were made optional to reduce survey fatigue, annual competency requirements and accreditation visits from multiple organizations were simultaneously happening in the project department. That might have also contributed to survey fatigue. Ultimately, no staff participated in the post-test of knowledge, making it impossible to determine if the curriculum improved knowledge objectively. This project was conducted over several months, and there was staff-turnover during this time with four nurses leaving during the course of the project. The time constraints and time needed to review the modules and all surveys prevented using newly hired nurses after the project opened.

Although it is unclear to what extent these barriers contributed to the absence of responses to the post-test, all of these are likely to have played a role. Moreover, there is no fully validated tool available to measure RN confidence regarding acute versus late radiation effects in oncology patients. There were also no validated tests of RO knowledge on the subject.

There was a limited time frame for the intervention and data analysis due to the constraints of the academic timeline requirements for the completion of the DNP project. The necessity of learning the software and subject matter particularly for the lead author added to the challenges. As a final point, there was a lack of funding for the project so no financial incentives to encourage nursing staff participation were possible. A lack of funding also restricted the development of education modules and surveys to available free software platforms; more engaging presentations could have been created with greater investment.

Finally, while the author considered this to be an important topic that required improved education, the author as a nurse lacked credentials and formal training in this modality as all American nurses do at this time. Multiple sources were reviewed, and many experts were consulted to create the best possible curriculum.

Identify strengths to overcome barriers

The biggest single strength identified for this project is the growing momentum created by a broad range of recent research in this field, of which the lion's share is affiliated with ROECSG. Additionally, several sources of videos and written education on RO were identified and this knowledge was disseminated to the project facility. While the various software programs were an initial challenge to learn to use, once learned they were effective tools for communication and education for this project, and any future projects.

As part of this project, an online and on-demand video curriculum was developed. This curriculum can be made available to all health system nurses at the individual nurse's convenience. The self-study format provides an effective option to overcome RO department barriers to traditional education, namely, that this department has small numbers of busy staff spread out over multiple facilities. This video curriculum resource can additionally be used for staff education outside of this specialty as an aid to multidisciplinary care. This format can be used as a model for any other department in the health system that faces similar challenges. Finally, this single-site pilot project had a 100% response rate to the needs assessment section which perhaps shows a strong interest in the department RNs in participating in educational initiatives and a strong desire to better know this modality. As a partial curriculum is now developed and recorded, this is a significant resource for anyone else who chose to expand on this project.

Discussion

As far as they were able to determine, Moskalenko et al. (2021) published the first study examining the educational needs and training for RO nurses in the USA. Therefore, to the best of our knowledge, this is only the second education needs assessment conducted for RO nurses in the USA and the first needs assessment to examine the confidence of RNs in RO regarding concurrent systemic therapies, and the management of patients with acute or late radiation therapy effects. There were few articles to draw upon for the purposes of this project, indicating that this is an area ripe for research. While several radiation education resources were identified, the ONS/ONCC Radiation Certificate currently is the only resource explicitly targeting a nursing target audience.

Many of our demographics results were similar to Moskalenko et al. (2021). They found 87% of their sample had ≥5 years of experience in nursing, and our sample had 85% with ≥5 years' experience. Moskalenko et al. (2021) found their sample had 52% of ≥5 years of RO patient care experience; our sample had 46.2% ≥5 years RO patient care experience. This is perhaps in part to the project facility actively recruiting new graduate nurses into the department and new positions being created as the department expands. We did not collect the same demographics for our single-site pilot project as age and highest degree could be used to directly identify individual staff members; if this project was expanded upon, this would be less of a concern.

When comparing our findings to those of Moskalenko et al., (2021) it must be pointed out that our confidence scores did vary from those researchers, but this department practices a primary nurse model by disease group. The primary nurse is the most likely to see and educate a patient with a specific diagnosis in consult, in weekly toxicity checks, and in follow up, as well as receiving triage phone calls for that disease group. That means that some nurses are very comfortable with certain disease group sites while having limited contact with other groups. The regular use of HDR techniques is only for gynecological cancers in this project department, and therefore something is usually done by a cadre of select staff. Concurrent systemic therapy agents are specific to certain disease groups as well. While the full effect of the COVID-19 pandemic is not yet known, relying on the knowledge and skills of small handful of staff for a specialized complex multifaceted oncology position is challenging during staffing shortages and turnover (Challinor et al., 2020). The online and on-demand curriculum developed for this project can serve as a resource to newly hired staff or those suddenly floated to an unfamiliar disease group or area.

One finding in common with Moskalenko et al., (2021), all nurses reported being responsible for educating patients. In their responses to our survey, nurses reported only moderate confidence in their knowledge and understanding of common everyday procedures in their work environment, and their ability to teach patients about these procedures. RO RNs expressed only moderate confidence that they understood the roles and responsibilities of their colleagues with whom they regularly interact which is a significant hurdle to overcome for interprofessional collaboration (Schultz et al., 2021).

With increasing trends to multi-disciplinary care, RNs have a broad-based education that creates many opportunities for collaboration with those from outside RO. RNs did indeed express higher confidence in their knowledge of the larger cancer care team (4 [3-4]). However, they expressed only moderate confidence in their overall knowledge and understanding of concurrent systemic therapies (Table 4) which limits their ability to understand the work of medical oncology and infusion therapy staff. Additionally, the RO RNs in this sample expressed only moderate confidence in their understanding of radiology (Table 5) and RO procedures (Table 3; Table 5) which might limit their ability to be a collaborative resource to groups outside of the RO department. Collaboration with outside groups would also be potentially affected by confidence of RO nurses, and their confidence in their ability to manage the acute (Table 1) and chronic (Table 2) needs were highly variable depending on the diagnosis and individual nurse.

RNs had expressed low confidence in their knowledge and understanding of radiation safety and oversight (2.5 [2-3]). The test of knowledge showed over half of the nurses in this sample misidentified the CDC and AEC as responsible for oversight (Appendix G). Half of nurses answered basic radiation knowledge questions incorrectly. However, when RNs were asked how confident they were that they could identify radiation hazards in the department and stay safe they expressed high confidence (4 [3-5]). This question was perhaps badly worded as RNs may feel safe and have high confidence in the strong work done by the radiation protection division for this facility regardless of their ability to identify radiation hazards.

Previous literature had reported that frontline RNs in RO spent only 2% on personal CE (Moore-Higgs, 2003). To address a lack of RO nursing educational resources, we previously developed an online journal club (Hillson et al., 2022a) to create relevant and convenient CEs for the nurses in this department. In this QI DNP project, over a year since the journal club went live, over half of the respondents reported that personal CE was a source of RO knowledge. Personal CE was reported as a source of RO knowledge by more respondents than nursing schools, employer-provided education, and professional association-offered education. While we cannot attribute this result directly to our previous project, the implications are that the nurses of this department are either far more motivated to learn more about their specialty than was found in earlier literature, or that our staff responded well to opportunities for professional CE. A similar conclusion was reached by the research of Mlambo et al., (2021) in the support of enhancing onsite nursing education. Their results determined that continuing professional development (CPD) is vital for nurses who want to fortify their skills and knowledge, keeping current in all aspects of patient care. Researchers identified that nurses' attitudes and motivations, as well as their perceptions of barriers such as organizational culture and administrative support, have a significant impact on their participation in training and education offered by their health care facility. In addition, the researchers determined that the availability of learning opportunities within the workplace environment as well as management's appreciation of nurse's commitment to CPD were integral to ensuring that nurses participated in educational opportunities. (Mlambo et al., 2021).

This pilot project worked to develop a convenient and accessible educational resource for a single department. The resources created for this project can be made available on an online learning management platform health system-wide or on an internet-based platform. While this single-site pilot project is limited by a small sample size, we have tried to highlight the need for a formalized curriculum, scope of practice, and credentialing for American RO nurses. The data gathered here can inform future education projects and curriculum development.

As all RO RNs, present and future, will already be nurses, it was felt that KTOAL offers a practical approach to creating new education in this field. These RNs will already have existing training and experiences to draw on, and they will be called upon to immediately utilize their new knowledge with patient care. RO is a complex scientific field, but nurses will require down-to-earth problem-solving skills that KTOAL advocates for (Merriam, 2002).

The PDSA framework was felt to be the most effective approach for the initial steps, and the long-term approach. The cyclical nature of the PDSA format allows for constant improvement and revision, and the field of RO is rapidly developing. While medical radiation itself has been around for over a century, the major steps toward becoming a precision modality have all been far more recent. RO advancements that directly affect patients' experiences are heavily tied to advancements in technology (Cuccia et al., 2022), but the field has recently expanded to embrace the human side of this highly technological field (LaVigne et al., 2023; McClelland et al., 2020) by addressing disparities of access due to race, geography, and poverty. Groups like ROECSG and ROVER are rapidly transforming how this field is taught to the next generation of physicians. ONS and ONCC are currently re-examining their materials on this specialty. The art and science of RO, and how it is taught, are currently in flux. The PDSA format is well-designed to accommodate growth in a rapidly developing field.

Conclusion

We present the findings of an RO nursing education needs assessment QI pilot project from a single-site RO department attached to a large academic medical center in the American Southeast. Despite a high-functioning department with experienced nurses, respondents reported several areas of practice where they had moderate or lower confidence in their ability to deliver care to RO patients. This was the second RO nursing education needs assessment in the USA to the best of our knowledge, and the first with a nurse as the lead author. To the best of our knowledge, this is the first education needs assessment to explore RN-reported confidence with both acute and survivorship care.

The paucity of education and resources for specialist RO nurses also means limited educational resources for other professionals both inside and outside the specialty in a wide range of roles. A single patient may need the long-term informed and collaborative effort of managers, educators, dieticians, social workers, speech therapists, surgical teams, medical oncology teams, infusion therapy specialists, inpatient teams, urgent care, emergency departments, palliative care, pain management, and primary care – and many others. As the number of survivors increases, it is reasonable to anticipate that increasing numbers of medical professionals outside of the RO specialty will be involved in managing radiation therapy's acute or chronic side effects. While this project focused on the needs and education of frontline specialist nurses, we believe such projects help fulfill the needs of many health professionals and patients.

The knowledge base of RO and RO nursing is broad, and so this project looked at many disparate subjects that have been found to affect the nursing role in this specialty. With this data as a foundation, hopefully, future projects can be more focused on individual topics with the goal of creating a truly comprehensive curriculum and a deeper appreciation and understanding of the RO nursing role.

While educational opportunities for nurses and other health professionals on RO are a critical gap that needs to be addressed, there is some good news. RO nursing education has advanced internationally within the past twenty years (CNSA, 2022; IAEA, 2008; CANO/ACIO, 2006). This project identified several recent education projects, many ROECSG affiliated, that have substantively contributed to improved RO education for medical students, RO residents, APPs, and CMAs. ONS/ONCC continues to show leadership for American oncology nurses with a recently announced role delineation study for RO RNs.

The greatest strength identified for this project and for future RO nursing education endeavors is the recent momentum and high-caliber work being generated country-wide and internationally by professionals dedicated to well-developed, rational, logical RO curricula. This growing body of knowledge represents an enormous opportunity for collaboration and growth for all professionals in this exciting field.

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Appendix A

Limited demographics section

The authors for this QI project would like to ask you some questions about yourself. These are simple demographic questions about your certifications, education, and experience.

There will be no questions about gender, race, or age. Your responses will be kept completely confidential, and no effort will be made to identify you. This will not affect your access to the training modules, nor will this affect your employment in any way.

1. Are you willing to fill out this section of the survey?
   - Yes, I will fill out the demographics section
   - No, I wish to finish now (selecting this answer ends the demographics section)
2. Are you a Certified Oncology Nurse (OCN)?
   - Yes
   - No
3. Have you completed the ONS/ONCC Radiation Therapy Certificate Course?
   - Yes
   - No
4. Did your nursing school have an affiliated radiation oncology department?
   - Yes
   - No
   - Not Sure
5. Did your nursing school have a radiation oncology clinical experience for nursing students?
   - Yes
   - No
   - Do not remember
6. Did your nursing school curriculum contain any content related to radiation oncology?
   - Yes
   - No
   - Do not remember
7. Where would you say your radiation oncology knowledge came from? (CHECK ALL THAT APPLY)
   - Employer provided oncology education
   - Nursing school
   - On-the-job clinical experience
   - Nursing colleagues
   - Professional association
   - Dosimetrists
   - Medical physicists
   - Radiation therapists

- Physicians
- Previous job experience
- Personal continuing education
- Other

8. Not including nursing school, how many years total of nursing experience do you have **(Total years' experience as an RN, not just oncology or radiation oncology)?**
- 0-4 years
- 5-9 years
- 10 years or more

9. Not including nursing school, how many years total of nursing experience were in oncology nursing **(Total years as an oncology nurse, not just radiation oncology)?**
- 0-4 years
- 5-9 years
- 10 years or more

10. How many years total have you been caring for **radiation oncology patients?**
- 0-4 years
- 5-9 years
- 10 years or more

Appendix B

Moskalenko et al. (2021) adapted and modified survey for use with this project

1. Which of the following best describes your job?
   - o Primary nursing
   - o Assigned to a location/station (alcove, brachytherapy)
   - o Both
2. What types of patient care are you responsible for in this radiation oncology department?
   - o Patient education
   - o Coordination of care/navigation inside the department
   - o Coordination of care/navigation involving groups outside of the project center's radiation oncology department
   - o Psychosocial needs and assessment
   - o Triage (phone, email, EHR)
   - o Alcove/Acute care needs
   - o Consult
   - o Follow-up
   - o Survivorship
3. Simulation: "How confident are you that you can: (Grade the following, from Extremely Confident to Not At All Confident).

	Extremely Confident	Quite Confident	Somewhat Confident	Not Very Confident	Not At All Confident
Explain Simulation to Patients?					
Explain a CT scan to a patient / maintain CT safety?					
Explain an MRI to a patient / maintain MRI safety?					
Explain a PET scan to a patient / maintain PET safety?					
Explain External Beam					

Radiation Treatment to a patient?					
Identify and stay safe from potential radiation hazards in the department?					

4. Systemic treatment and radiation: “How confident are you that you can:” (Grade the following, from Extremely Confident to Not At All Confident)

	Extremely Confident	Quite Confident	Somewhat Confident	Not Very Confident	Not At All Confident
Explain hormone therapy to a patient?					
Administer hormone therapy?					
Explain how chemotherapy and radiation are used together?					
Recognize potentially serious side effects of chemotherapy?					
Recognize potentially serious side effects of immunotherapy?					
Explain the use and side effects of common medications used for side effect management?					

5. "How Confident are you that you can:" (Grade the following, from Extremely Confident to Not At All Confident)

	Extremely Confident	Quite Confident	Somewhat Confident	Not Very Confident	Not At All Confident
Assist in the HDR area?					
Recognize an oncologic emergency?					
Assist with anesthesia recovery?					
Explain brachytherapy to a patient?					
Take a triage call from a patient or their loved ones, or an outside provider? (Includes Email, Phone, or EHR)					
Your knowledge and understanding of the regulatory aspects of radiation oncology					
Your knowledge and understanding of palliative care					
Your knowledge of wound care					
Your knowledge of nutrition and cancer treatment					

6. Please rate your confidence in your ability to educate and care for patients with **Acute side effects and issues** from the following disease-specific cancer sites or treatments. **(Acute means during treatment or within 90 days afterward)**.

	Extremely Confident	Quite Confident	Somewhat Confident	Not Very Confident	Not At All Confident
CNS					
Head and Neck					
Lung					
Breast					
Gastrointestinal					
Gynecology					
Prostate/genitourinary					
Lymphoma/Leukemia					

Sarcoma					
Pediatric Cancers					
Skin Cancers					

7. Please rate your confidence to identify, educate, and care for patients with **<u>Chronic/Survivorship side effects and issues</u>** from the following disease-specific sites? **<u>(Chronic issues means more than 90 days after acute therapy)</u>**

	Extremely Confident	Quite Confident	Somewhat Confident	Not Very Confident	Not At All Confident
CNS					
Head and Neck					
Lung					
Breast					
Gastrointestinal					
Gynecology					
Prostate/genitourinary					
Lymphoma/Leukemia					
Sarcoma					
Pediatric Cancers					
Skin Cancers					

Appendix C

1. Which of the following is a common oral chemotherapy ("chemo pill") used with gastrointestinal cancers?
   - Xeloda (capecitabine)
   - Temodar (temozolomide)
   - Lupron (leuprolide)
   - Cisplatin
2. Which of the following are possible dexamethasone side effects?
   - Increased difficulty with diabetes control
   - Insomnia
   - Mood changes and psychosis
   - Sedation
   - Seizures
3. TRUE or FALSE: Patient who have a PET scan are radioactive following this procedure?
   a. True
   b. False
4. A patient arrives for her first oral cavity head and neck radiation treatment and tells you she had a tooth extracted this morning. What does the nurse do?
   - Hold treatment and inform the radiation oncologist. The patient's mouth may need to heal before the patient can start treatment
   - Make sure the patient has enough pain medicine from their dentist
   - Recommend protein supplement milkshakes for the rest of the team
   - Make sure the patient has antibiotics to help their mouth heal
5. Which best describes neo-adjuvant radiation?
   a. Using radiation to shrink the tumor for a less morbid surgery later on
   b. "Cleaning up" microscopic disease after surgery
   c. Giving chemotherapy and radiation together for a stronger effect on the cancer
   d. Any time we give a new round of radiation therapy, that is neo-adjuvant radiation
6. A patient says that she was told that the surgery removed her cancer completely, but now she is being advised to get radiation therapy. Which option best describes the rationale for post-operative radiation therapy?
   a. Radiation therapy is used to treat microscopic disease in at-risk areas like the surgical site and nearby regions
   b. Radiation therapy is only done to give the patient more peace of mind
   c. Radiation therapy helps make sure the healthy tissue left behind will not develop into new cancer
   d. Radiation therapy would only be used if large visible chunks of tumor were left behind.
7. What is the purpose of Image-Guided Radiation Therapy (IGRT)?
   a. This method is used when less precise targeting is required
   b. IGRT helps better target tumors that are moving during or in between treatments
   c. IGRT is done for more documentation during radiation therapy for legal purposes

   d. IGRT allows for delivering lower doses of radiation to a larger area
8. Which of the following statements are true?
   a. The radiation safety officer is the person in an organization responsible for regulatory compliance and the safe use of radiation machines and radioactive materials
   b. All staff who work with radiation machines and radioactive materials are responsible for safety
   c. All nuclear regulatory commission licensed facilities must appoint a radiation safety officer by law
   d. The radiation safety officer is an elected state government official who oversees radiation exposure risks
9. The regulatory laws that we must comply with come from which of the following?
   a. North Carolina Radiation Protection Commission
   b. Nuclear Regulatory Commission
   c. Atomic Energy Commission
   d. Centers for Disease Control and Prevention
   e. Duke Radiation Safety Office
10. "Women Who Curie" is a day of celebration of women radiation professionals. What are Madame Curie's contributions?
    a. Discovered polonium and radium
    b. Categorized radioactive substances and coined the term, "Radioactivity"
    c. First woman to win a Nobel Prize, and the only woman to win the Nobel Prize twice
    d. Developed the first linear accelerator
11. Which of the following forms of radiation are charged particles with mass?
    a. Electrons
    b. Protons
    c. Photons
    d. Gamma
12. Which type of radiation has the lowest penetration?
    a. Protons
    b. Photons
    c. Gamma
    d. Electrons
13. A patient is asking why she is losing hair to the right posterior neck when she is being treated to the left anterior neck
    a. This is photon exit dose
    b. This is radiation scatter
    c. The patient may have a larger tumor than they thought they did
    d. The radiation was delivered to the posterior neck by accident
14. Which of the following are risk factors for radiation dermatitis? (CHECK ALL THAT APPLY)

   a. Treatments closer to the body's surface
   b. Obesity
   c. Poor nutritional status
   d. Smoking
   e. Concurrent chemotherapy
   f. Using deodorant
   g. Cancers that are deeper in the body
15. The patient's daughter phones the department. The patient is receiving external beam radiation therapy for breast cancer. "I am pregnant, can I be around my mother? I don't want to hurt my baby." The nurse knows:
   a. External beam treatment does not make a patient radioactive; there is no risk to the baby
   b. The patient should avoid pregnant women for the next 48 hours
   c. The patient will be radioactive, but the amount of radiation will be safe for the baby
   d. The patient should be kept away from others because she is at risk of catching infections because of her radiation therapy
16. Cisplatin is a common radiosensitizer. Which of the following are possible side effects of concurrent cisplatin therapy?
   a. Hearing loss
   b. Acute renal toxicity
   c. Nausea and vomiting days after getting the drug infused
   d. Magnesium and potassium wasting
   e. Rash
   f. Diarrhea
17. A patient asks why they are immobilized on the treatment table. Immobilization helps with: (CHECK ALL THAT APPLY)
   a. More accurate therapy
   b. Better sparing of healthy tissues
   c. Let's that patient tolerate higher doses of radiation
   d. Helps make the patient feel more secure and at ease
18. A patient develops a rash only in her prior radiation treatment field immediately after getting chemotherapy. Her last radiation treatment was three years ago. This is potentially:
   a. An allergic reaction
   b. Radiation recall
   c. This is a chemotherapy reaction and won't have anything to do with radiation
   d. This is possible a sign of recurrence
19. Which of the following are risk factors for developing lymphedema? (CHECK ALL THAT APPLY)
   a. More extensive surgeries that remove more lymph nodes
   b. Cancers that compress lymphatic tissue

c. Arthritis
d. Weight loss

20. Radiation-induced fibrosis is associated with the following findings: (CHECK ALL THAT APPLY)
    a. Early onset
    b. Decreased or absent secretions from the tissue (sweat, saliva, hormones)
    c. Loss of elasticity in tissue
    d. Temporary stiffness

Appendix D

Radiation Oncology Nursing Core Curriculum

Introduction

Goals of the radiation oncology nursing core

What is Radiation Oncology

What is Radiation Therapy

Services in the department

Locations

Why is radiation therapy given?

- Monotherapy, neoadjuvant, adjuvant, concurrent, palliative

Members of the radiation oncology team

- Radiation oncologists
- Residents
- Medical physics
- Radiation safety Officer
- Dosimetrist
- Radiation therapist
- Radiology technicians

Workflow to get to treatment

- Consult, simulation, contouring/dosimetry/plan evaluation, QA, treatment, follow up

Radiology fundamentals

History

Early development

Radiation doses

X-ray

CT scan

CT sim

4D CT sim

Respiratory gating

Marking soft tissue: bb’s, wires, barium, fiducials, SpaceOAR

MRI

PET/CT

What is Simulation? ROECSG IROC video

Image-guided radiation therapy

Interfraction movement

Intrafraction movement – respiratory gating

Survivorship

Radiation Safety

Highlights in the history of radiation protection (or lack thereof), Manhattan Project, AEC, risks to public

Current Regulation

Radiation Safety Officer

Website links to emergency resources for Duke

NC Radiation Protection Commission

US NRC

ICRP, IAEA, NCRP, ONS certificate

ALARA

Protection: time, distance, shielding

Available website resources

Intro to Radiation

What is radiation

Background radiation doses, annual safe limits

Structure of the atom

What is an ion

Non-ionizing radiation

Ionizing radiation

Action: direct versus indirect

DNA damage- single and double strand breaks

Radiation sensitivity and factors affecting it

When we give radiation, we cannot take it back

How treatment is targeted,

Treatment volumes – examples of how this is used.

Treatment volumes

Organs At Risk (OARs)

Fractionation

Radiation effects on the body:

Acute versus Late definition

Inflammation

Radiation dermatitis (acute, late)

- Risk factors
- Presentation
- Grading
- Management

Mucositis – what does this mean – 7 types in CTCAE (Acute, late)

- Risk factors
- Presentation
- Grading
- Management

Fibrosis (Late, chronic effect)

- Risk factors
- Presentation
- Grading
- Management

Lymphedema (Late/chronic)

- Risk factors
- Presentation
- Grading
- Management

Necrosis

<u>LINAC (Linear Accelerator)</u>

Ionizing radiation from manmade source for external beam treatment

History

Photons

Electrons

Protons

Compare and contrast the energies

Modifying the beam shape

- Cerrobend blocks, MLC

Modifying the beam depth

- Bolus

Techniques

- 2D
- 3D
- IMRT

VMAT

SRS

SBRT

IGRT

Videos on linear accelerator design and ROECSG video on patient set-up and verification

Chemical Modifiers of Radiation Response

Radiation can be combined with hormone therapy, chemotherapy, immunotherapy

Therapeutic ratio

Effects of oxygen

Antioxidants

Chemotherapy

Mechanisms of action

Effects on DNA

Effects on bone marrow

Nadir

Scheduling and workflow

Symptoms to be reported

Supportive medications

Antiemetic regimen, pain, constipation

1. 5FU
2. Cisplatin
3. Temozolomide
4. Docetaxel

Growth Colony Stimulating factors

Hormone therapy

Androgen deprivation

Side effects, effects when combined

Aromatase, selective estrogen receptor modifiers, LHRH

Side effects, Effects when combined

Radioprotectants

Amifostine

MSNOD

- BMX, GC4419

Monoclonal antibodies

- Cetuximab
- Bexxar – off the market, but proof of concept
- Bevacizumab

Immunotherapy

Systemic effects

Timing of effects

Radiation Recall

Site Specific: Head and Neck

What does head and neck mean?

About H&N

Review chemo – cisplatin, docetaxel

- Addition of Mucinex and fluconazole to supportive medication
- Use of topical analgesics
- Constipation – avoid magnesium citrate
- Liquid narcotics – burn

Set up for H&N

Reviewing anatomy and implications:

- Skin
- Paranasal sinuses and nasal cavity
- Oral cavity
- Salivary gland tumors
    - Dental scatter
- Nasopharynx
- Oropharynx
- Larynx
- Hypopharynx
- Thyroid cancer

Treatment of the neck implications

Smoking Cessation

Dermatitis

Dry Mouth (xerostomia)

- Dryness in other H&N structures

Mucositis

Dysgeusia and Dysosmia

Psychosocial

- Suicide
- Poverty

Support groups and patient advocacy organizations

Appendix E:

Post-Curriculum Feedback Survey

"This survey asks for feedback on the modules developed for this project."

1.

	Yes	Maybe	No
Do you feel that the modules increased your knowledge of radiation oncology?			
Do you feel that this knowledge will be useful in the performance of your duties as a radiation oncology nurse?			
Do you feel better prepared to provide patient care with the information provided?			
Did you like the self-study format?			

2. Did you feel any modules were "over your head," too complicated, or needed to be explained in another way?

- Yes
- No

2a. (Question asked only if the answer above was, "*yes*."); If Yes, which ones? What would you do differently? (Free text)

3. Did you feel any modules were too simple and could be condensed or taught at a higher level?

- Yes
- No

3a. (Question asked only if the answer above was, "*yes*."); If Yes, which ones? What would you do differently? (Free text)

5. Do you have any additional feedback about this QI project that you would like to give? (If No, you can press the right-facing arrow on the bottom of the page to finish).

Appendix F

Recruitment poster

Pro00111095: Email and staff meeting introduction to staff

Topic: Assessing knowledge needs and implementing an asynchronous online radiation oncology nursing education program

We are initiating a quality improvement project that aims to provide radiation oncology nursing staff opportunities to augment your knowledge and confidence in providing radiation oncology nursing care.

<u>Why are we doing this project?</u>
It is known that we do not have a standardized national nursing or Duke Health nursing core curriculum for radiation oncology as an oncology specialty. Many schools of nursing offer limited opportunities to learn about radiation oncology nursing, if at all. As radiation oncology is a primary component of most cancer treatment plans and we offer infusion therapy during radiation treatments, radiation oncology nursing is becoming recognized as a specialty unit requiring unique knowledge and skills. It is our hope that we can build and implement a radiation oncology curriculum that benefits all oncology nurses across the health system, but we want to pilot this program here at Duke University Cancer Center.

<u>What is involved in this project?</u>
The project will involve participating in a total of five sessions involving approximately 20 minutes of your time for each session. The modules will focus on basic radiation oncology, radiobiology, radiation therapy, chemical modifiers of radiation, and disease-specific information. Prior to initiating and following completion of the sessions, you will be asked to complete a needs assessment and knowledge survey. You will also be provided the opportunity to evaluate the program upon completion. The surveys are housed in Qualtrics, a secure platform at Duke, and will take no longer than 20 minutes to complete. If you decide to participate:

1. Your participation is voluntary and confidential.
2. Your responses are anonymous, you will not be identified.
3. You do not have to answer any question that makes you feel uncomfortable.
4. You choose if you want to participate or not.
5. As a Duke employee if you decide not to participate, it will not affect your employment in any way.
6. There is no compensation for participating in this program.

It is our hope that you learn more about radiation oncology that will help direct your nursing care in triage, patient education, and symptom management. Your survey responses will guide the department in providing future educational session based on your needs.

<u>What if I have questions?</u>
If you have questions, please contact:

- John Hillson at john.hillson@duke.edu or call at 919-636-1919
- Deborah “hutch” Allen, Nurse Scientist at hutch.allen@duke.edu or 919-883-7002.

Thank you for your time and consideration.

Appendix G

Appendix C with answers and number of respondents by test item

21. Which of the following is a common oral chemotherapy ("chemo pill") used with gastrointestinal cancers?
    - **Xeloda (capecitabine)** (*n*=7)
    - Temodar (temozolomide) (*n*=1)
    - Lupron (leuprolide)
    - Cisplatin
22. Which of the following are possible dexamethasone side effects?
    - **Increased difficulty with diabetes control** (*n*=8)
    - **Insomnia** (*n*=8)
    - **Mood changes and psychosis** (*n*=8)
    - Sedation
    - Seizures (*n*=1)
23. TRUE or FALSE: Patient who have a PET scan are radioactive following this procedure?
    a. **True** (*n*=3)
    b. False (*n*=5)
24. A patient arrives for her first oral cavity head and neck radiation treatment and tells you she had a tooth extracted this morning. What does the nurse do?
    - **Hold treatment and inform the radiation oncologist. The patient's mouth may need to heal before the patient can start treatment** (*n*=8)
    - Make sure the patient has enough pain medicine from their dentist
    - Recommend protein supplement milkshakes for the rest of the team
    - Make sure the patient has antibiotics to help their mouth heal
25. Which best describes neo-adjuvant radiation?
    a. **Using radiation to shrink the tumor for a less morbid surgery later on** (*n*=7)
    b. "Cleaning up" microscopic disease after surgery
    c. Giving chemotherapy and radiation together for a stronger effect on the cancer (*n*=1)
    d. Any time we give a new round of radiation therapy, that is neo-adjuvant radiation
26. A patient says that she was told that the surgery removed her cancer completely, but now she is being advised to get radiation therapy. Which option best describes the rationale for post-operative radiation therapy?
    a. **Radiation therapy is used to treat microscopic disease in at-risk areas like the surgical site and nearby regions** (*n*=8)
    b. Radiation therapy is only done to give the patient more peace of mind
    c. Radiation therapy helps make sure the healthy tissue left behind will not develop into new cancer
    d. Radiation therapy would only be used if large visible chunks of tumor were left behind.
27. What is the purpose of Image-Guided Radiation Therapy (IGRT)?

a. This method is used when less precise targeting is required
b. IGRT helps better target tumors that are moving during or in between treatments (*n*=8)
c. IGRT is done for more documentation during radiation therapy for legal purposes
d. IGRT allows for delivering lower doses of radiation to a larger area

28. Which of the following statements are true?
    a. The radiation safety officer is the person in an organization responsible for regulatory compliance and the safe use of radiation machines and radioactive materials (*n*=8)
    b. All staff who work with radiation machines and radioactive materials are responsible for safety (*n*=8)
    c. All nuclear regulatory commission licensed facilities must appoint a radiation safety officer by law (*n*=8)
    d. The radiation safety officer is an elected state government official who oversees radiation exposure risks (*n*=1)
29. The regulatory laws that we must comply with come from which of the following?
    a. North Carolina Radiation Protection Commission (*n*=7)
    b. Nuclear Regulatory Commission (*n*=6)
    c. Atomic Energy Commission (*n*=5)
    d. Centers for Disease Control and Prevention (*n*=5)
    e. Duke Radiation Safety Office (*n*=6)
30. "Women Who Curie" is a day of celebration of women radiation professionals. What are Madame Curie's contributions?
    a. Discovered polonium and radium (*n*=7)
    b. Categorized radioactive substances and coined the term, "Radioactivity" (*n*=6)
    c. First woman to win a Nobel Prize, and the only woman to win the Nobel Prize twice (*n*=8)
    d. Developed the first linear accelerator (*n*=1)
31. Which of the following forms of radiation are charged particles with mass?
    a. Electrons (*n*=7)
    b. Protons (*n*=7)
    c. Photons (*n*=4)
    d. Gamma (*n*=3)
32. Which type of radiation has the lowest penetration?
    a. Protons (*n*=4)
    b. Photons
    c. Gamma
    d. Electrons (*n*=4)
33. A patient is asking why she is losing hair to the right posterior neck when she is being treated to the left anterior neck
    a. This is photon exit dose (*n*=8)

   b. This is radiation scatter
   c. The patient may have a larger tumor than they thought they did
   d. The radiation was delivered to the posterior neck by accident

34. Which of the following are risk factors for radiation dermatitis? (CHECK ALL THAT APPLY)
    a. <u>Treatments closer to the body's surface</u> (*n*=8)
    b. <u>Obesity</u> (*n*=7)
    c. <u>Poor nutritional status</u> (*n*=7)
    d. <u>Smoking</u> (*n*=7)
    e. <u>Concurrent chemotherapy</u> (*n*=6)
    f. Using deodorant (*n*=2)
    g. Cancers that are deeper in the body
35. The patient's daughter phones the department. The patient is receiving external beam radiation therapy for breast cancer. "I am pregnant, can I be around my mother? I don't want to hurt my baby." The nurse knows:
    a. <u>External beam treatment does not make a patient radioactive; there is no risk to the baby</u> (*n*=8)
    b. The patient should avoid pregnant women for the next 48 hours
    c. The patient will be radioactive, but the amount of radiation will be safe for the baby
    d. The patient should be kept away from others because she is at risk of catching infections because of her radiation therapy
36. Cisplatin is a common radiosensitizer. Which of the following are possible side effects of concurrent cisplatin therapy?
    a. <u>Hearing loss</u> (*n*=8)
    b. <u>Acute renal toxicity</u> (*n*=5)
    c. <u>Nausea and vomiting days after getting the drug infused</u> (*n*=8)
    d. <u>Magnesium and potassium wasting</u> (*n*=7)
    e. Rash (*n*=2)
37. A patient asks why they are immobilized on the treatment table. Immobilization helps with: (CHECK ALL THAT APPLY)
    a. <u>More accurate therapy</u> (*n*=8)
    b. <u>Better sparing of healthy tissues</u> (*n*=8)
    c. Let's that patient tolerate higher doses of radiation
    d. Helps make the patient feel more secure and at ease
38. A patient develops a rash only in her prior radiation treatment field immediately after getting chemotherapy. Her last radiation treatment was three years ago. This is potentially:
    a. An allergic reaction
    b. <u>Radiation recall</u> (*n*=8)
    c. This is a chemotherapy reaction and won't have anything to do with radiation
    d. This is possible a sign of recurrence

39. Which of the following are risk factors for developing lymphedema? (CHECK ALL THAT APPLY)
    a. **More extensive surgeries that remove more lymph nodes** (*n*=8)
    b. **Cancers that compress lymphatic tissue** (*n*=8)
    c. **Arthritis** (*n*=1)
    d. Weight loss
40. Radiation-induced fibrosis is associated with the following findings: (CHECK ALL THAT APPLY)
    a. Early onset (*n*=1)
    b. **Decreased or absent secretions from the tissue (sweat, saliva, hormones)** (*n*=5)
    c. **Loss of elasticity in tissue** (*n*=7)
    d. Temporary stiffness (*n*=1)

Correct answers bolded and underlined. Number of respondents indicated.

Response rate	57.1% (*n*=8)
Range of test scores in percent	67% to 100%
Mean test score	84%
Standard deviation	10.9

Figure 1.

Duties for RO nurses at the project site cancer center (Question from Appendix B)

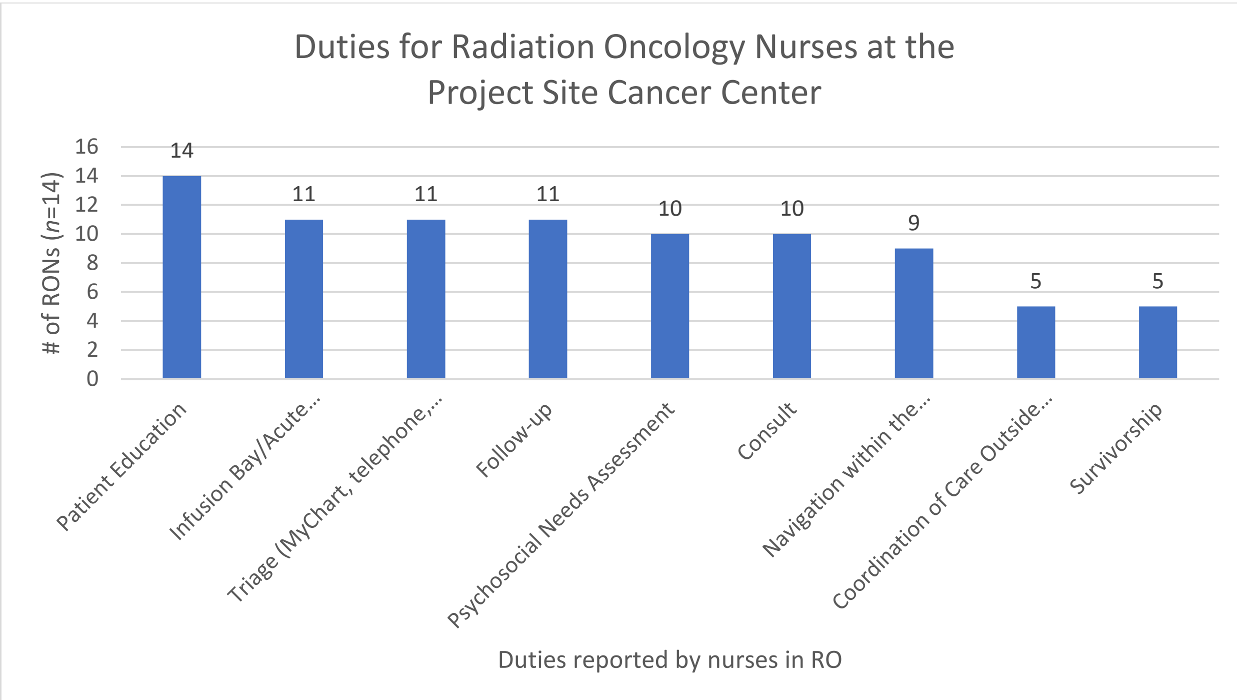


Figure 2

Question #1 "Where would you say your radiation oncology knowledge came from?"

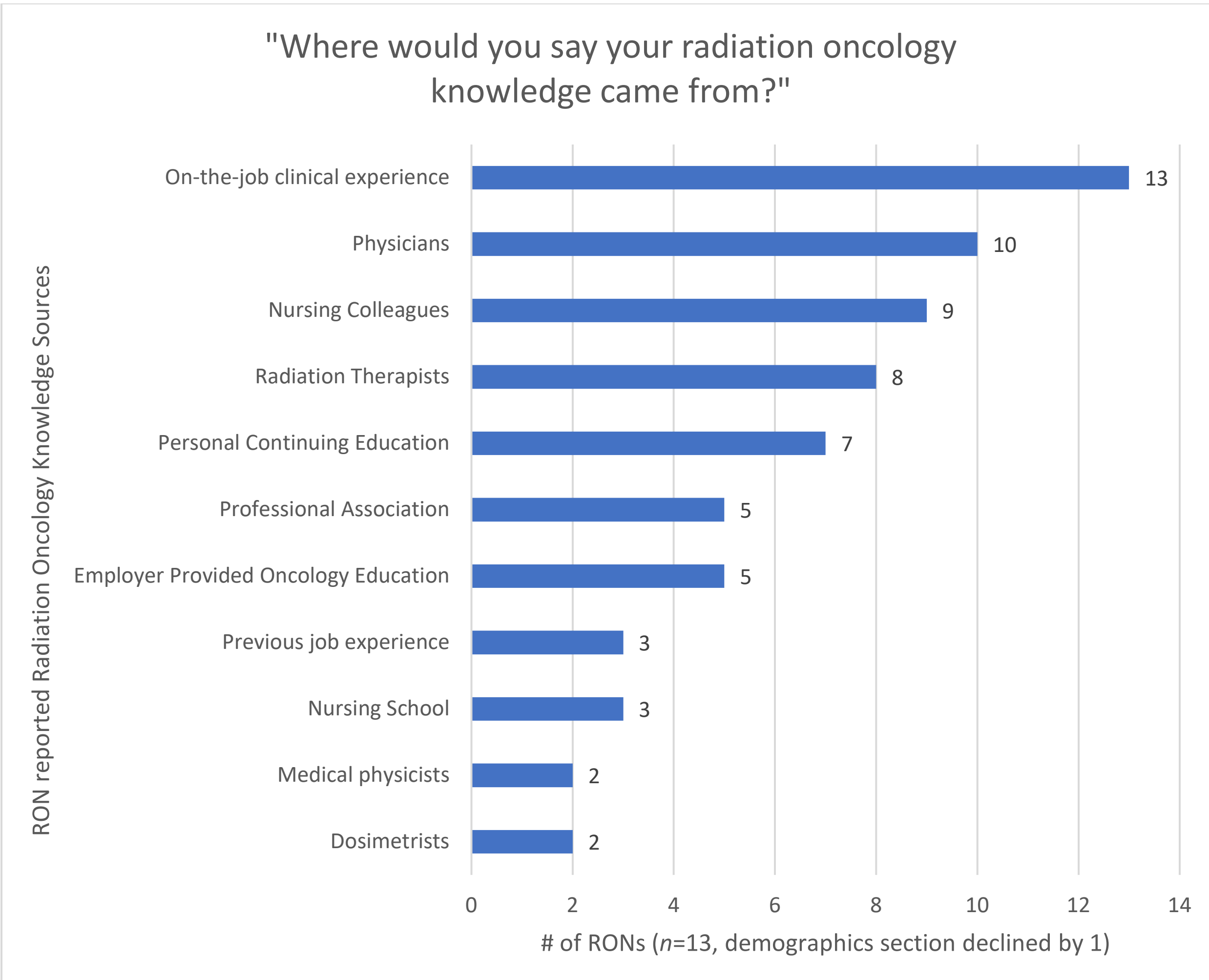
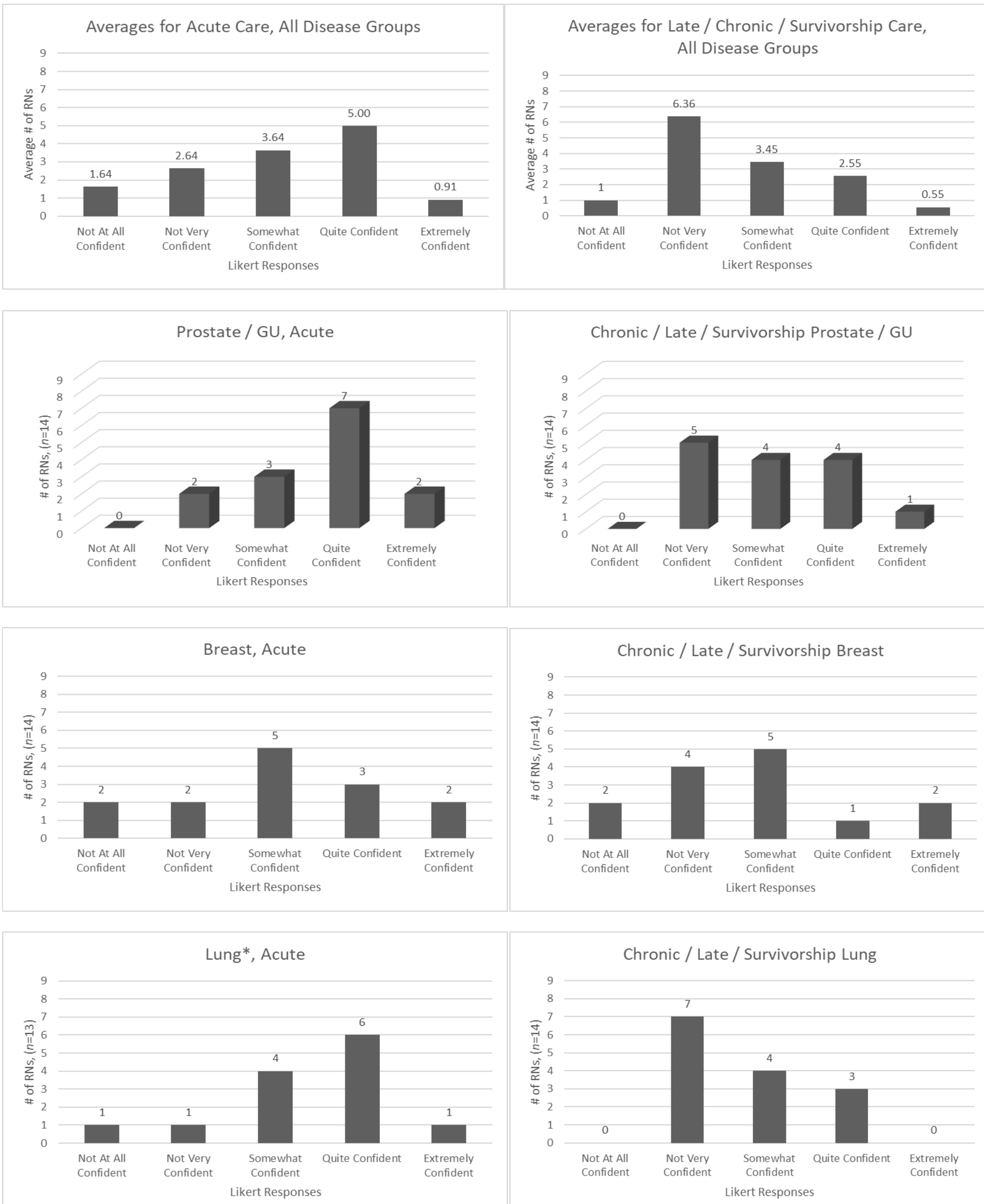
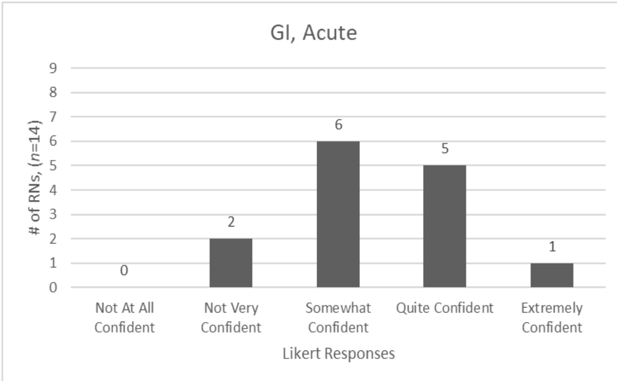
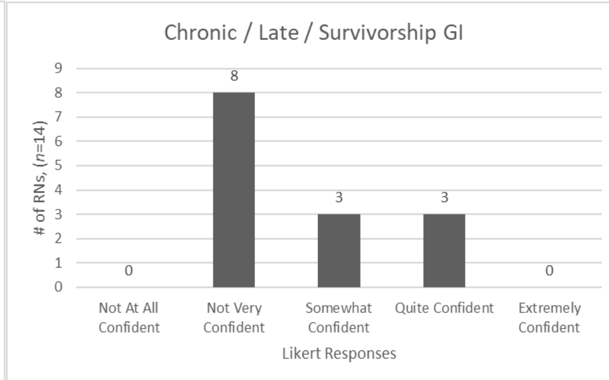


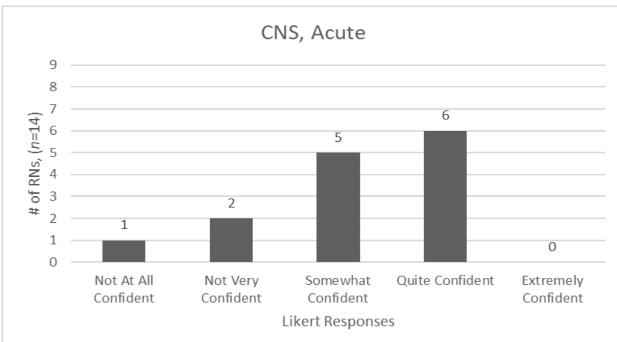
Figure 3

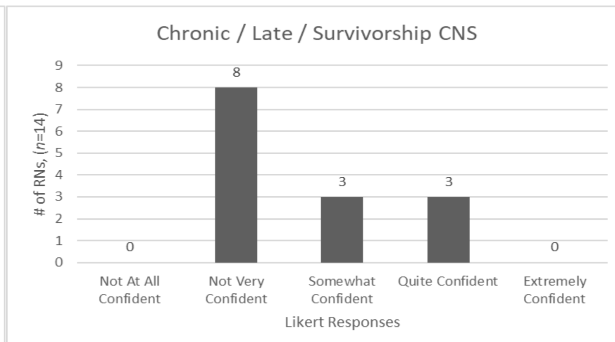
Bar Graph comparison of Acute and Chronic by Disease Site

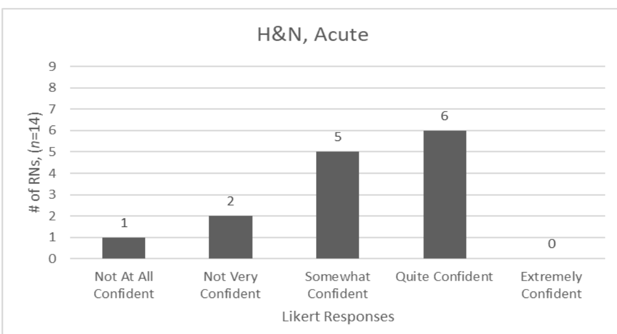


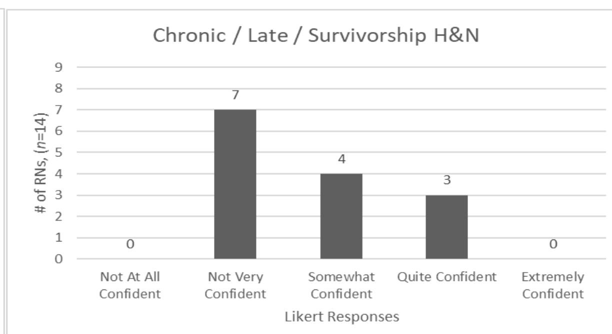

GI, Acute
# of RNs, (n=14)
0
2
6
5
1
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

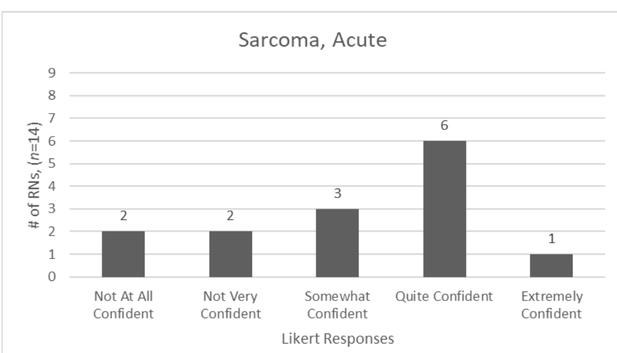

Chronic / Late / Survivorship GI
# of RNs, (n=14)
0
8
3
3
0
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

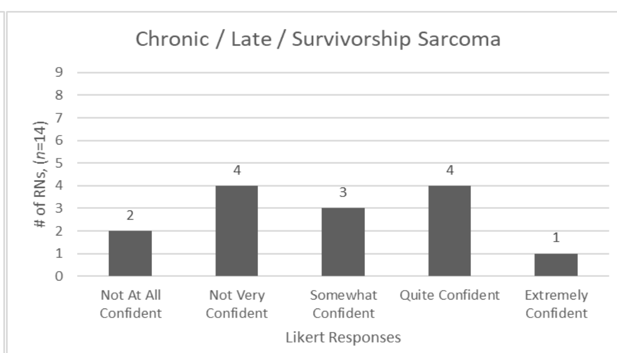

CNS, Acute
# of RNs, (n=14)
1
2
5
6
0
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

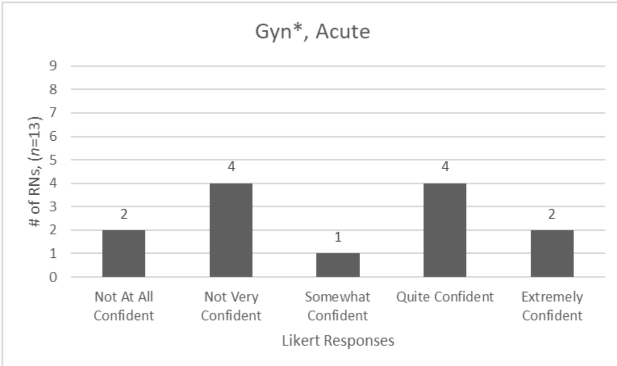

Chronic / Late / Survivorship CNS
# of RNs, (n=14)
0
8
3
3
0
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

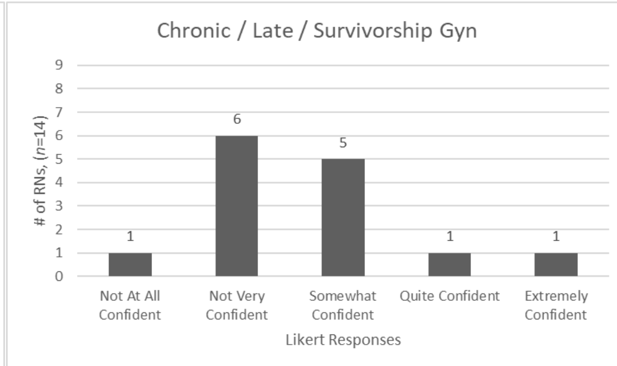

H&N, Acute
# of RNs, (n=14)
1
2
5
6
0
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

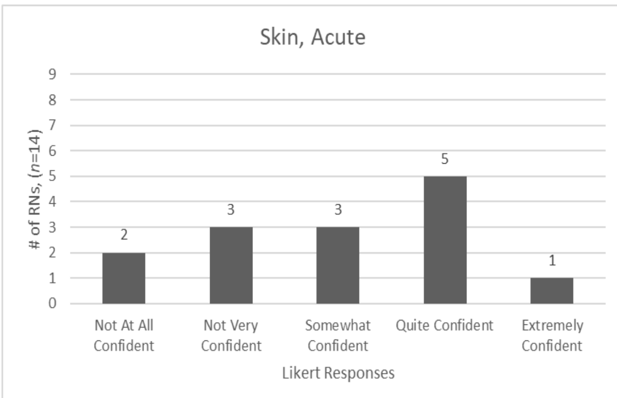

Chronic / Late / Survivorship H&N
# of RNs, (n=14)
0
7
4
3
0
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

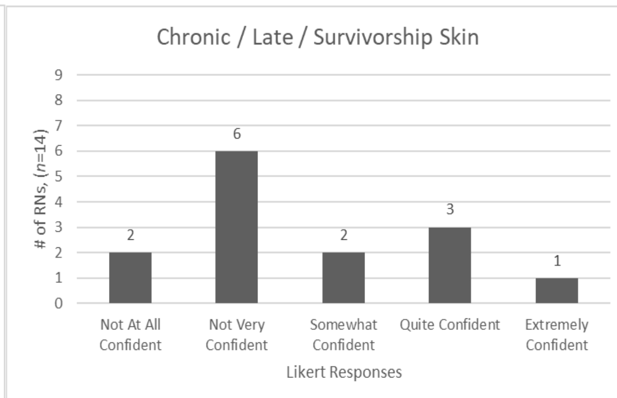

Sarcoma, Acute
# of RNs, (n=14)
2
2
3
6
1
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

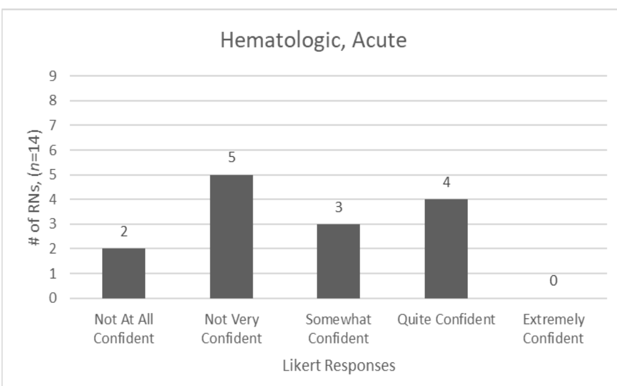

Chronic / Late / Survivorship Sarcoma
# of RNs, (n=14)
2
4
3
4
1
Not At All Confident
Not Very Confident
Somewhat Confident
Quite Confident
Extremely Confident
Likert Responses

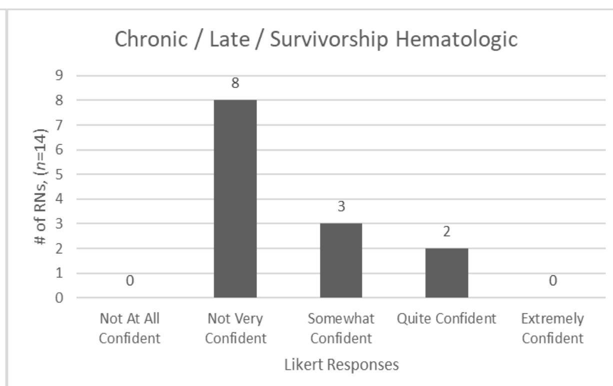


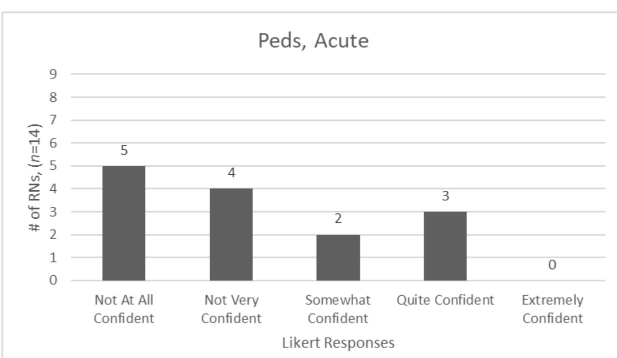


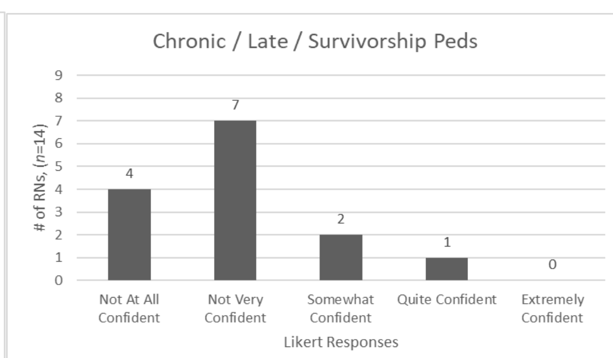












Note: *("*" means that the data table had n=13 respondents)*

Table 1

Acute Care Responses to Likert-scale questions.

Question #6. "Please rate your confidence in your ability to educate and care for patients with **ACUTE** side effects from the following disease-specific sites." (Acute care means during or within 90 days of acute therapy).

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Prostate / GU	0	2 (14.3%)	3 (21.4%)	7 (50.0%)	2 (14.4%)	4 [3-4]
Lung*	1 (7.7%)	1 (7.7%)	4 (30.8%)	6 (46.2%)	1 (7.7%)	4 [3-4]
Sarcoma	2 (14.3%)	2 (14.3%)	3 (21.4%)	6 (42.9%)	1 (7.1%)	3.5 [2-4]
Gyn*	2 (15.4%)	4 (30.8%)	1 (7.7%)	4 (30.8%)	2 (15.4%)	3 [2-4]
CNS	1 (7.1%)	2 (14.3%)	5 (35.7%)	6 (42.9%)	0	3 [3-4]
H&N	1 (7.1%)	2 (14.3%)	5 (35.7%)	6 (42.9%)	0	3 [3-4]
GI	0	2 (14.3%)	6 (42.9%)	5 (35.7%)	1 (7.1%)	3 [3-4]
Skin Ca	2 (14.3%)	3 (21.4%)	3 (21.4%)	5 (35.7%)	1 (7.1%)	3 [2-4]
Breast	2 (14.3%)	2 (14.3%)	5 (35.7%)	3 (21.4%)	2 (14.3%)	3 [2-4]
Lymphoma / Leukemia	2 (14.3%)	5 (35.7%)	3 (21.4%)	4 (28.6%)	0	2.5 [2-4]
Peds	5 (35.7%)	4 (28.6%)	2 (14.3%)	3 (21.4%)	0	2 [1-3]

*=these questions had fewer respondents, (*n*=13)

All groups, acute, median [IQR] = 3 [3-3.5]

Table 2.

Late Effects and Chronic Care Responses to Likert-scale questions.

Question #7 “Please rate your confidence in your ability to identify, educate, and care for patients with **Late/Chronic/Survivorship** side effects and issues from the following disease-specific sites.”(Late issues means more than 90 days after acute therapy).

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Prostate / GU	0	5 (35.7%)	4 (28.6%)	4 (28.6%)	1 (7.1%)	3 [2-4]
Lung	0	7 (50.0%)	4 (28.6%)	3 (21.4%)	0	2.5 [2-3]
Sarcoma	2 (14.3%)	4 (28.6%)	3 (21.4%)	4 (28.6%)	1 (7.1%)	3 [2-4]
Gyn	1 (7.1%)	6 (42.9%)	5 (35.7%)	1 (7.1%)	1 (7.1%)	2.5 [2-3]
CNS	0	8 (57.1%)	3 (21.4%)	3 (21.4%)	0	2 [2-3]
H&N	0	7 (50.0%)	4 (28.6%)	3 (21.4%)	0	2.5 [2-3]
GI	0	8 (57.1%)	3 (21.4%)	3 (21.4%)	0	2 [2-3]
Skin Ca	2 (14.3%)	6 (42.9%)	2 (14.3%)	3 (21.4%)	1 (7.1%)	2 [2-4]
Breast	2 (14.3%)	4 (28.6%)	5 (35.7%)	1 (7.1%)	2 (14.3%)	3 [2-3]
Lymphoma / Leukemia*	0	8 (57.1%)	3 (21.4%)	2 (14.3%)	0	2 [2-3]
Peds	4 (28.6%)	7 (50.0%)	2 (14.3%)	1 (7.1%)	0	2 [1-2]

*=this question had fewer respondents, (*n*=13)

All groups, late/chronic/survivorship, median [IQR] = 2.5 [2-3]

Table 3.

General Knowledge Responses to Likert-scale questions.

Question #5. *"Please rate your confidence in your knowledge and understanding of the following:"*

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Cancer biology	0	1 (7.1%)	8 (57.1%)	4 (28.6%)	1 (7.1%)	3 [3-4]
Radiation in general	0	2 (14.3%)	8 (57.1%)	4 (28.6%)	0	3 [3-4]
Radiation treatment set up and positioning	0	5 (35.7%)	5 (35.7%)	3 (21.4%)	1 (7.1%)	3 [2-4]
Radiation treatment planning	0	5 (35.7%)	4 (28.6%)	3 (21.4%)	1 (7.1%)	3 [2-4]
Roles and responsibilities of the RO team	2 (14.3%)	1 (7.1%)	7 (50.0%)	4 (28.6%)	0	3 [3-4]
Roles and responsibilities of the larger cancer treatment team	0	1 (7.1%)	5 (35.7%)	6 (42.9%)	3 (14.4%)	4 [3-4]
Regulatory aspects of radiation oncology	1 (7.1%)	6 (42.9%)	4 (28.6%)	2 (14.3%)	1 (7.1%)	2.5 [2-3]
Palliative care	0	0	4 (28.6%)	9 (64.3%)	1 (7.1%)	4 [3-4]
Wound care	0	2 (14.3%)	7 (50.0%)	1 (7.1%)	4 (28.6%)	3 [3-4]
Nutrition and cancer treatment	0	1 (7.1%)	8 (57.1%)	4 (28.6%)	1 (7.1%)	3 [3-4]

Table 4.

Systemic Therapies Responses to Likert-scale questions.

Question #20. *"How confident are you that you can:"*

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Explain hormone therapy to a patient?	2 (14.3%)	2 (14.3%)	4 (28.6%)	4 (28.6%)	2 (14.3%)	3 [2-4]
Administer hormone therapy	4 (28.6%)	1 (7.1%)	2 (14.3%)	5 (35.7%)	2 (14.3%)	3.5 [1-4]
Explain how chemotherapy and radiation are used together?	0	2 (14.3%)	7 (50.0%)	2 (14.3%)	3 (21.4%)	3 [3-4]
Recognize potentially serious side effects of chemotherapy?	0	1 (7.1%)	8 (57.1%)	2 (14.3%)	3 (21.4%)	3 [3-4]
Recognize potentially serious side effects of immunotherapy?	0	4 (28.6%)	7 (50.0%)	0	3 (21.4%)	3 [2-3]
Explain the use and side effects of common medications used for side effect management?	0	2 (14.3%)	4 (28.6%)	7 (50.0%)	1 (7.1%)	4 [3-4]

Table 5.

Simulation and Radiology Response to Likert-scale questions.

Question #4. "How confident are you that you can:"

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Explain simulation to patients	2 (14.3%)	2 (14.3%)	4 (28.6%)	4 (28.6%)	2 (14.3%)	3 [2-4]
Explain a CT scan to a patient / maintain CT safety?	0	3 (21.4%)	6 (42.9%)	3 (21.4%)	0	3 [3-4]
Explain an MRI to a patient / maintain MRI safety?	0	0	9 (64.3%)	3 (21.4%)	2 (14.3%)	3 [3-4]
Explain a PET scan to a patient / maintain PET safety?	0	2 (14.3%)	7 (50.0%)	4 (28.6%)	1 (7.1%)	3 [3-4]
Explain External Beam Radiation Treatment to a patient?	2 (14.3%)	1 (7.1%)	6 (42.9%)	3 (21.4%)	2 (14.3%)	3 [3-4]
Identify and stay safe from potential radiation hazards in the department?	0	0	4 (28.6%)	7 (50.0%)	3 (21.4%)	4 [3-5]

Table 6.

High Dose Rate (HDR) Radiation Therapy Confidence Response to Likert-scale questions.

Question #21. *"How confident are you that you can:"*

	Not At All Confident	Not Very Confident	Somewhat Confident	Quite Confident	Extremely Confident	Median [Interquartile range]
Assist in HDR?	4 (28.6%)	4 (28.6%)	0	3 (21.4%)	3 (21.4%)	2 [1-4]
Recognize an oncologic emergency?	0	0	6 (42.9%)	6 (42.9%)	2 (14.3%)	4 [3-4]
Assist with anesthesia recovery?	3 (21.4%)	0	5 (35.7%)	3 (21.4%)	3 (21.4%)	3 [3-4]
Explain brachytherapy to a patient?	5 (35.7%)	2 (14.3%)	2 (14.3%)	1 (7.1%)	4 (28.6%)	2.5 [1-5]
Take a triage call from a patient, their loved ones, or an outside provider (includes email, phone call, EHR)?	0	0	2 (14.4%)	7 (50.0%)	5 (35.7%)	4 [4-5]

Table 7.

Demographics responses to Appendix A

Certifications obtained

	Yes	No
Are you an oncology certified nurse (OCN)?	8/13 or 61.5%	5/13 or 38.5%
Have you completed the ONS/ONCC Radiation Therapy Certificate course?	2/13 or 15.3%	11/13 or 84.6%

Nursing School

	Yes	No	Do Not Remember
Did your nursing school have an affiliated radiation oncology department?	1/13 or 7.7%	11/13 or 84.6%	1/13 or 7.7%
Did your nursing school have a radiation oncology clinical experience for nursing students?	1/13 or 7.7%	11/13 or 84.6%	1/13 or 7.7%
Did your nursing school curriculum contain any content related to radiation oncology?	3/13 or 23.1%	7/13 or 53.8%	3/13 or 23.1%

Years of experience

	0-4 years	5-9 years	10 years or more
Not including nursing school, how many years total of nursing experience do you have (Total years as an RN, not just oncology or radiation oncology)?	2/13 or 15.4%	6/13 or 46.2%	5/13 or 38.5%
Not including nursing school, how many years total of nursing			

experience were in oncology nursing (Total years as an oncology nurse, not just radiation oncology)?	4/13 or 30.8%	3/13 or 23.1%	6/13 or 46.2%
How many years total have you been caring for radiation oncology patients?	7/13 or 53.8%	3/13 or 23.1%	3/13 or 23.1%

Table 8.

Post-curriculum evaluation answers to Appendix E

Post-Curriculum Feedback Survey

"This survey asks for feedback on the modules developed for this project."

1.

	Yes	Maybe	No
Do you feel that the modules increased your knowledge of radiation oncology?	100% (*n*=2)		
Do you feel that this knowledge will be useful in the performance of your duties as a radiation oncology nurse?	100% (*n*=2)		
Do you feel better prepared to provide patient care with the information provided?	100% (*n*=2)		
Did you like the self-study format?	100% (*n*=2)		

2. Did you feel any modules were "over your head," too complicated, or needed to be explained in another way?

Yes	50% (*n*=1)
No	50% (*n*=1)

2a. (Question asked only if the answer above was, "*yes*."); If Yes, which ones? What would you do differently?

	"Too much information about particles, I feel like most newer radiation oncology nurses this does

Respondent 1	*not need to be described in such detail. It might overwhelm new employees. Just having a basic overview, but which has more penetration, etc. might need to be explained differently or left out."*

3. Did you feel any modules were too simple and could be condensed or taught at a higher level?

Yes	0%
No	100% (*n*=2)

3a. (Question asked only if the answer above was, "*yes*."); If Yes, which ones? What would you do differently? (no answers given)

6. Do you have any additional feedback about this QI project that you would like to give? (If No, you can press the right-facing arrow on the bottom of the page to finish).

Respondent 1	*"This is a great initiative and would benefit nurses in providing care and keeping a knowledge base that would make them more confident in their role, especially as radiation oncology nurses."*
Respondent 2	*"This is definitely needed content considering the lack of radiation oncology education out there."*

Permission to use and adapt survey tool:

Hello Sameer,

I am getting closer to my IRB. I am very interested in using your survey, but I am asking for your permission to adapt it.

As an example, we do not perform prostate brachytherapy, but we do have a very busy sarcoma group. The bulk of the device would stay the same, but I would change some of the questions based on the work happening in our specific facility.

I am hoping this is okay with you.

John Hillson, RN BSN OCN
AGPCNP DNP student
UNCG

Hi John,

Yes no problem. Have a great weekend!

Sameer

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