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Evaluating Educational Degree Options Within Radiologic Science Programs

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EVALUATING EDUCATIONAL DEGREE OPTIONS WITHIN RADIOLOGIC SCIENCE PROGRAMS

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A Capstone Report
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Currently, with the declining number of students enrolling in four-year radiologic science programs, it is not only worrisome for the survival of these programs, but also a challenge to supply enough graduates to help fill the hospitals' demands for more radiologic technologists. With the increase in radiology staffing shortages, especially since COVID-19, it is important that Radiologic Science programs not only produce high quality technologists, but also maintain a high level of student enrollment.

The purpose of the study is to determine similarities and differences between two-year and four-year Joint Review Committee on Education in Radiologic Technology (JRCERT)-accredited radiologic science programs in Illinois, given the high demand for technologists in healthcare. The research methods that will be used include: document analysis and interviews with radiology administrators. For the document analysis, twenty-two associate degree programs and five bachelor degree programs accredited through JRCERT in Illinois will be reviewed. For the interview process, one radiology administrator from ten Midwest hospitals will be interviewed. From the document analysis and interviews, the researcher will provide recommendations to four-year institutions on how to increase enrollment opportunities.

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DEDICATION

This dissertation is dedicated to my husband, Andy, for being my biggest supporter throughout this program. Without your constant encouragement and understanding, it would have been impossible to complete this paper. Thank you from the bottom of my heart.

Also, to my sons, Cole and Reed, thank you for all your hugs. They always give me the motivation to keep going. Love you boys!

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CHAPTER 1

INTRODUCTION

In the United States there are approximately 135 million imaging (radiology) examinations performed each year (JAMA Network and Radiology Business, 2016). These imaging examinations mostly include Radiography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound, and Nuclear Medicine which are important tests to determine a patient's diagnosis and treatment plan. However, there are only 350,000 registered technologists in the United States to perform these vast numbers of imaging examinations each year, (ARRT Census, 2021). This led the U.S. Bureau of Labor Statistics to conclude that approximately 20,800 new radiologic technologists are needed annually to enter the field (U.S Bureau of Labor Statistics, 2022).

Given this continuing need for new technologists, it is imperative that radiologic science programs increase the "pipeline" of trained students. Presently, with an annual estimate of 15,477 students matriculating in Radiologic Science programs throughout the U.S., this results in an annual deficit of nearly 5,400 technologists. (ASRT Enrollment Snapshots, 2022). Table 1 shows the number of students entering Radiologic Science programs and the annual decline since 2019 (ASRT Enrollment Snapshots, 2022).

Table 1

Total overall students entering Radiologic Science programs in the U.S. per the ASRT

Year	Number of Students Entering Radiologic Science Programs	Percentages
2016	15,537 ↑ - Up 309 students from previous year	↑ 1.4%
2017	15,769 ↑ - Up 232 students from previous year	↑ 1.4%
2018	16,374 ↑ - Up 605 students from the previous year	↑ 2.6%
2019	15,972 ↓ - Down 402 students from the previous year	↓ 1.5%
2020	15,620 ↓ - Down 352 students from the previous year	↓ 1.1%
2021	15,477 ↓ - Down 143 students from the previous year	↓ 2.5%

Permission granted by the ASRT on February 15, 2023 to utilize this data set.

Background of the Healthcare Field of Radiologic Science

The typical radiology department of a local hospital consists of radiologists, radiologic technologists in each modality (such as CT, MRI, Nuclear Medicine, and Ultrasound), and additional radiology team members. Together, these healthcare workers are "an important part of a medical team that diagnoses and treats patients who have a range of disease and injuries" (ARRT, 2022-Primary Pathway-Radiography, para. 2). First, a radiologist is a physician that specializes in diagnosing diseases through various medical imaging modalities. Next, is the radiologic technologist, whose job duties include: interacting with patients for their examination, properly positioning the patient for each radiograph, producing diagnostic images and evaluating them to ensure high quality, and operating the radiology equipment – all while maintaining the safety of the patient (Mayo Clinic, 2022). Even though effective communication and critical thinking skills are important characteristics in a radiologic technologist's care of the patients, one of the most important qualities of a radiologic technologist is having the knowledge base of radiation safety to ensure the patients are not receiving an excessive amount of radiation through

their imaging tests. Finally, the other team members could include radiology nurses, clerical assistants, medical assistants, and patient transporters, whose collective tasks are assisting in the patient care process.

Radiologic science is a healthcare profession that includes all forms of diagnostic imaging. Since a radiologic technologist works in a multitude of healthcare settings, such as hospitals, out-patient centers, urgent care facilities, and specialty physician offices, it is important they be trained in the different modalities. The American Registry of Radiologic Technologists (ARRT) identifies certifications for the following diagnostic imaging modalities:

- Bone Densitometry
- Cardiac Interventional Radiography
- Computed Tomography
- Interventional Radiography
- Magnetic Resonance Imaging
- Mammography
- Nuclear Medicine
- Radiation Therapy
- Radiology Assistant
- Ultrasound (Specialty certifications in Breast and Vascular as well)
- Vascular Interventional Radiography
- Cardiovascular Interventional Radiography (no longer issuing new certifications)
- Quality Management (no longer issuing new certifications)

Furthermore, it is crucial for the radiologic technologists to be highly qualified in the modality in which they work to produce quality images, otherwise the radiologist cannot do their

job properly, resulting in a possible misdiagnosis for the patient (Itri et al, 2018).

Training and Education

All Radiologic Science students are required to complete the ARRT Radiography didactic and clinical competency requirements to be eligible to sit for the ARRT Radiography national registry examination. The purpose of the ARRT didactic requirements are to "verify that individuals had the opportunity to develop fundamental knowledge, integrate theory into practice, and hone effective critical thinking skills required to demonstrate professional competency" (ARRT, 2022 - Primary Certification-Radiography, para. 5). The purpose of the ARRT clinical competency requirements are to "verify that individuals certified and registered by the ARRT have demonstrated competency performing the clinical activities fundamental to a particular discipline (ARRT, 2022 - Primary Certification-Radiography, para. 6). "Demonstration of clinical competence means that the candidate has performed the procedure independently, consistently, and effectively during the course of their education" (ARRT, 2022, - Primary Certification-Radiography, para. 6).

Additionally, to become a radiologic technologist, all students must pass the ARRT Radiography national registry examination. This examination consists of 220 multiple choice questions covering four sections: patient care, safety, image production and procedures (ARRT Primary Eligibility Handbook, 2022). A score of 75% must be attained in order to become "certified" to ensure that the technologist has an adequate knowledge base of radiology. All radiologic technologists who wish to be credentialed by the ARRT, including sitting for the national examination in Radiography, must also earn an associate degree or a bachelor degree from an institution that is recognized by the Association. These two different Radiologic Science degree options are provided as follows:

- The two-year programs prepare the student for the field of radiography, entailing minimally 60 total credit hours, with 15 of those credit hours being general (non-radiology) courses. Thereafter, the student will be able to sit for the ARRT Radiography national registry examination, and upon successful completion, will begin their career in Radiology, without the additional educational training in another modality.
- The other option is a four-year program, entailing minimally 120 total credit hours, with 40 of those credit hours being general (non-radiology) courses. Additionally, the four-year option allows for the training in different modality tracts, which permits the student to sit not only for the ARRT Radiography national registry examination, but also for an additional ARRT national registry examination such as CT, MRI, or Radiation Therapy. Graduates are then able to work in additional modalities aside from Radiography.

Radiology Programs: Two-Year and Four-Year Programs

The American Society of Radiologic Technologists (ASRT) conducts annual studies to ask about the most common terminal degree offered by colleges/universities with a radiology program. As shown in Table 2, the national data show the percentages of the following degree offerings: Associate degree, Bachelor degree, and other degree (e.g., post-associate certificate, post-bachelor certificate, master degree).

Table 2

Terminal Degrees Offered Per Radiologic Science Program Institutions

Year	Associate Degree	Bachelor Degree	Other Degree
2016	62.1%	21.5%	16.4%
2017	61.3%	22.5%	16.2%
2018	60.7%	26.8%	12.5%
2019	63.3%	21.2%	15.5%
2020	65.7%	21.2%	13.0%
2021	63.2%	20.9%	15.9%

Permission granted by the ASRT on February 15, 2023 to utilize this data set.

According to the Joint Review Committee on Education in Radiologic Technology (JRCERT), within the United States there are 48 states with Radiologic Sciences programs. Specifically, in Illinois, there are 27 Radiologic Science programs – 5 four-year Radiologic Science programs and 22 two-year Radiologic Science programs – that produce nearly 400 students trained each year.

Associate Degree Programs/Two-Year Programs

Illinois presently offers 22 Associate Degree Programs in Radiologic Science**.** The degree awarded in all 22 programs is an Associate of Applied Sciences (A.A.S.) and prepares the student only in Radiography. The programs are located throughout Illinois: northern Illinois - 10 programs, central Illinois - 8 programs, and southern Illinois - 4 programs. See Appendix A.

Bachelor Degree Programs/Four-Year Programs

Illinois has four institutions that offer five Bachelor of Science in Radiologic Science degrees and prepares the student for advanced knowledge in Radiography and/or additional training in another modality. Three of the four baccalaureate institutions are private schools and

located in northern Illinois, while the remaining four-year program is a public institution located in southern Illinois.

Problem Statement

Southern Illinois University (SIU) CT/MRI baccalaureate tract program has seen a 45% decline in student enrollment since 2018. See Table 3. Research needs to be conducted for the survival of the program.

Table 3

Number of SIU CT/MRI Graduates since 2018

YEAR	SIU CT/MRI Program Number of Graduates
2018	20 ↓ - Down 1 student from the previous year
2019	22 ↑ - Up 2 students from the previous year
2020	18 ↓ - Down 4 students from the previous year
2021	14 ↓ - Down 4 students from the previous year
2022	12 ↓ - Down 2 students from the previous year

Note: Typically, the CT/MRI program has a cap of 20 students per year due to the number of clinical sites available to the students.

A nationwide ASRT study revealed that the overall total number of Radiologic Science programs' enrollments throughout the United States have declined minimally since 2016. Specifically, on average, only 21% of Radiologic Science students have enrolled in four-year programs since 2016 and enrollment has remained stagnant, while 48% of students have enrolled in two-year programs since 2016 and there has been a growth in enrollment by 7%. Since the data show four-year programs remaining somewhat stable and two-year programs increasing in the number of graduates, there needs to be thorough research to determine what makes the curriculum of two-year programs more attractive. See Table 4.

Table 4

National Percentage of Students Enrolling in Radiologic Science Programs per the ASRT

Student Enrollments	2-Year Programs	4-Year Programs	Other Programs
2016	41%	21%	38%
2017	44% ↑	20% ↓	36% ↓
2018	42% ↓	22% ↑	36% ↔
2019	44% ↑	20% ↓	36% ↔
2020	46% ↑	15% ↓	39% ↑
2021	48% ↑	21% ↑	31% ↓
CONCLUSIONS	Up 7% since 2016	Same since 2016	Down 7% since 2016

Note: Other programs include: For Profit-Schools, Technical Colleges, Medical Center, and Other. "Other Programs" were 2 year or less programs.
Permission granted by the ASRT on February 15, 2023 to utilize this data set.

Purpose Statement

Given the continued demand for Radiologic Science services, it is important that future radiologic technologists are properly trained and ready for the workforce. Since higher education training programs differ in their curricular requirements, it is important to study the similarities and differences between what two-year and four-year programs offer. Further, I am interested in learning the differences in the curriculum between four-year Radiologic Science programs and if four-year program graduates are better prepared to work in advanced modalities throughout the imaging department.

Research Questions

The study seeks to answer the following questions:

RQ1: What are the similarities and differences between two-year and four-year Radiologic Science programs:

1a. Curricular: What are the similarities and differences between the number of credit hours, semesters, faculty, students, tuition rates, and certifications offered, as well as program outcomes (e.g., program completion rates, job placement rates, and ARRT pass rates) between two-year and four-year programs?

1b. Technical Skills: What are the similarities and differences between technologists who are multi-credentialed with a bachelor degree versus technologists who are single-credentialed with an associate degree?

RQ 2: What are the factors that influence a students' decision to enroll in either a two-year or four-year radiologic science program?

2a. How does the cost of a program (i.e., tuition/fees as well as lost income) impact students' decisions to attend a two-year or four-year Radiologic Science program?

Research Design

To answer the research questions, the researcher will conduct a qualitative approach to her research. Qualitative research is defined as a type of research that explores and provides deeper insights into real-world problems and gathers participants' experiences, perceptions, and behavior in order to answer the how and why (Tenny, 2021). For the purpose of this study, open-ended interviews and a document analysis were selected for the data collection in order to gain a deeper understanding of the responses from the interviewees.

Specifically, this qualitative study is designed to outline the differences of two-year versus four-year Radiologic Science programs in the U.S. and determine whether there is value added with additional education. The researcher will utilize two types of review:

- Document Analysis: The researcher will be reviewing the following documents of two-year and four-year radiology programs: program curriculum, student credit hours (general education and radiology specific courses), average number of students per program, number of faculty, number of semesters per program (as well as clinical and laboratory credit hours), tuition cost, ARRT national registry examination pass rates, program completion, job placement rates, and additional certification offered at the various institutions.
- Interview: Researcher will interview radiology administrators who have worked with students from two-year and four-year Radiologic Science programs.

Positionality

I have been in the field of radiology for over 20 years and have been an educator for almost 10 years. Currently, I serve as an Assistant Professor and CT/MRI Program Director at a four-year institution/university. Not only have I taught in both the Radiography and CT/MRI programs, but also have work experience in a variety of settings throughout my career, including hospitals, mobile MRI, and out-patient imaging centers. My passion for radiology is the reason I want to investigate the factors students consider in choosing a two-year or four-year program. As a student who graduated from both two-year and four-year programs, I find it interesting that not all students consider continuing their education and training for additional modalities. After I graduated from a local community college, I wanted to enroll into a four-year program where I could learn additional modality training while attaining a Bachelor degree. Having the additional training and education has allowed me to be a front runner in most job opportunities due to my versatility of modality training.

Significance of Study

Radiologic Science students have several options when choosing their education and training: associate degree programs, bachelor degree programs, and other programs such as hospital-based programs and technical colleges. Within many of the bachelor degree programs, students can either complete all four years at the university, or graduates with an associate degree in Radiologic Science can further their education and enroll as a transfer student to attain a bachelor degree. Understanding the value of what a bachelor degree can additionally offer to Radiologic Science students will be important to the survival of the four-year programs.

Currently, with the declining number of students entering SIU's CT/MRI program, it is not only worrisome for the survival of the four-year programs, but also a challenge to supply enough graduates to help fill the hospitals' demands for more radiologic technologists. Being Illinois' only Radiologic Science baccalaureate tract in CT/MRI, the need for more students is becoming an annual trend. So, what can SIU and other four-year radiologic science programs do to grow enrollment and help future students to see the value of earning a bachelor degree in the field? Being the program director of a four-year program, I would like to see the program grow and be able to help our community by providing highly qualified technologists to enter the field.

Definitions

- *American Registry of Radiologic Technologists (ARRT)*-Leading credentialing organization that recognizes qualified individuals in medical imaging, interventional procedures, and radiation therapy (ARRT, 2022)
- *American Roentgen Ray Society (ARRS)*-The first and oldest radiology society in the U.S. that has been a forum for progress in radiology shortly after the discovery of x-ray (ARRS, 2022)

- *American Society of Radiologic Technologists (ASRT)*-Leading professional association that aims to advance and elevate the medical imaging and radiation therapy profession and to enhance the quality and safety of patient care. Formerly called ASXT- American Society of X-Ray Technicians (ASRT, 2022)
- *Association of University Radiologic Technologists (AURT)*-organization that was designed to facilitate teaching concepts, curricula, and educational standards for Radiologic Technology. Later changed their name to AERIS-Association of Educators in Imaging and Radiologic Sciences (AEIRS, 2022)
- *Bone Densitometry* is an imaging test that measures the bone mineral content and bone mineral density of specific skeletal sites of the whole body that can measure bone strength and assist with diagnosis of bone diseases (Merrills, 2019)
- *Cardiac Interventional (CI)* uses minimally invasive, angiographic procedures to help diagnose and treat heart and blood vessel diseases without surgery (Merrills, 2019)
- *Computed Tomography* (CT) is the process of creating a cross-sectional tomographic plane of any part of the body (Merrills, 2019)
- *Diagnostic Medical Sonography* (Ultrasound) is an imaging method used to encompass abdominal, breast, cardiac, gynecologic, obstetric, and vascular sonography which uses high-frequency transducers that receive real-time reflections or frequency shifts from structures or vessels along the sound waves path and are then displayed as a grayscale image (Merrills, 2019)
- *Interventional Radiology (IR)* uses minimally invasive angiographic procedure imaging techniques to both diagnose and treat problems associated with vessels.
- *Joint Review Committee on Education in Radiologic Technology (JRCERT)*-

Organization that promotes excellence in education and evaluates the quality and safety of patient care through the accreditation of educational programs in radiography, radiation therapy, magnetic resonance imaging, and medical dosimetry (JRCERT, 2022)

- *Magnetic Resonance Imaging* (MRI) is a noninvasive imaging tool that produces computer-generated cross-sectional images, similar to those of computed tomography that contain anatomic and physiologic information while utilizing no ionizing radiation, but rather creating images through the interaction of magnetic fields and radio frequency energy on biologic tissue (Merrills, 2019)
- *Mammography* is a specialized medical imaging tool that uses low-dose radiation to assess the breast tissue (Merrill, 2019)
- *Medical Dosimetry* is calculations of proper radiation treatments for an individualized plan of treatment for cancer patients who have been prescribed radiation therapy by their oncologist (Merrills, 2019)
- *Nuclear Medicine* is a specialized area of radiology that focuses on the use of radioactive materials called radiopharmaceuticals, to determine the cause of a medical problem based on the physiologic function or organs and tissues (Merrills, 2019)
- *Positron Emission Tomography (PET)* is a functional modality and diagnostic imaging tool that can measure the in vivo physiology of the metabolic and biochemical function of body tissues (Merrills, 2019)
- *Radiation Therapy* (Radiotherapy or Radiation Oncology) is a cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumors (Merrills, 2019)
- *Radiographer*, also known as a radiologic technologist who administers ionizing

radiation to perform radiographic examinations (Merrills, 2019)

- *Radiography* (X-Ray) is a type of imaging tool that uses radiation to assess patient anatomy (Bushong, 1997)
- *Radiological Society of North America (RSNA)*-A non-profit organization that represents 31 radiologic subspecialties from 145 countries around the world (RSNA, 2022)
- *Vascular Interventional (VI)* uses minimally invasive image-guided vascular procedures including angioplasty, stenting, and thrombolysis (Merrills, 2019)
- *Western Intercollegiate Consortium on Education in Radiologic Technology (WICERT).* Set standards for education in Radiologic Technology. Later changed their name to: ACERT-Association of Collegiate Educators in Radiologic Technology (ACERT, 2022)

Limitations and Delimitations

Limitations:

1. With the study only being conducted on Radiologic Science programs in Illinois, the findings of this study may not be generalized to all U.S. radiologic science programs.

2. With the limited number of Bachelor degree programs and various baccalaureate tracts in Illinois, results could be different in the other states.

Delimitation:

1. Given the large number of radiologic science programs throughout the U.S., this study will focus on radiologic science programs in Illinois.

2. The study will only assess programs in Illinois that are JRCERT certified.

Overview of the Study

In this study, I look at the value added to the four-year radiology program from the qualitative research that I conducted. Data was collected by interviewing working technologists in the radiology field who have worked with students from both two-year radiologic science and four-year radiologic science programs.

In Chapter Two of this study, I provide a review of the literature on how the radiology field began, history of education within radiology, and program layout of two-year and four-year Radiologic Science programs. Chapter Three provides the methodology used to collect the data. Chapter Four, I introduce the radiology administrators who participated in the interview process and the results of the interviews that were conducted. In Chapter Five, I will analyze the data, and the results will be summarized and final conclusions will be determined.

CHAPTER 2

LITERATURE REVIEW

Introduction

In the late 1800s, the field of healthcare was forever changed with the development of a process to image the human body: x-ray. Namely, x-ray (or the field of radiology) played an important role in the diagnosis of fractures. Over time as technological advancements were made, other fields, or advanced modalities, of x-ray were invented. These modalities help to see a patient's anatomy beyond bony structures. Now, other pathologies can be diagnosed from these advanced modalities, such as muscle tears, disease processes, cancer, blood clots, and organ dysfunction. With these advances, a patient's diagnosis can be detected early and treatment can begin, thus increasing the patient's quality of life and life expectancy.

With the expansion of the radiology field, the need for increased education of radiographers has increased as well. The radiology field has different educational route options a student can take to earn their ARRT credential in Radiography. Two-year and four-year programs offer the educational background that enables a student to sit for the ARRT national registry examinations. In addition, the ARRT credentialing body also sets the standards for how a radiologic technologist should conduct themselves and require continuing education to maintain current knowledge within the radiology field (ARRT, 2022). Accrediting bodies such as JRCERT set educational standards for learning institutions to promote excellence in a student's education (JRCERT, 2022). These two leaders in the field are the foundations for maintaining high standards within the radiology field from a technologist standpoint as well as from an educational standpoint.

Radiology History and the Development of X-Rays

On November 8, 1895, Wilhelm Conrad Roentgen, a professor of Physics at the University of Wurzburg, Germany discovered x-rays (Hessenbruch, 2002). While researching with a cathode ray tube, he discovered a new type of ray that caused a fluorescent glow in crystals on an adjacent table. Later, he happened to bring his hand into the path of this new light and was startled to see an image of the bones in his hand. This is when he also discovered that these "new rays" could pass through human tissue and reveal the bones inside (Panchbhai, 2015). He needed to come up with something to actually record the images onto for further review. Roentgen worked tirelessly in his lab barely coming out to eat or sleep.

> "On the evening of December 22, 1895, he photographed his wife Anna Bertha's hand using the new rays. Following a fifteen-minute exposure, an image showing the bones of her hand and the two rings she was wearing appeared, which became the first ever radiograph of a human being" (Panchbhai, 2015, para. 9).

The new rays were originally called Roentgen rays, which later became "x-ray," which came about from mathematics, as "x" is commonly used to indicate an unknown quantity.

By 1896, x-rays were a common practice to diagnose bone fractures. The first x-ray department in the world was established at the Glasgow Royal Infirmary (Panchbhai, 2015). Some of the first x-rays done in that department were the diagnosis of a penny in a child's throat, a kidney stone, and a needle seen embedded into a woman's hand (Panchbhai, 2015). Unfortunately, several pioneers in the field of radiology died of radiation related deaths due to the unknown hazards associated with radiation dosing. But, with these deaths, it was revealed that damaging qualities of x-rays could be used to treat cancer, which is yet another advancement to the field of radiology, called Radiation Therapy.

Roentgen received a Nobel Prize in Physics in 1901. "The award was given in recognition of the extraordinary services he has rendered with the discovery of the remarkable rays" (The Nobel Prize-Line 5-Prize Motivation, 2022). Roentgen donated his award to his university, who later awarded him an honorary Doctor of Medicine degree. On February 10, 1923, Dr. Roentgen died of carcinoma of the intestine, which was not believed to be a result of his work. In his honor in 2004, a new atomic element, Roentgenium (number 111), was named after him. His name and work will live on forever even though the radiology field is witnessing an era in the demise of the x-ray films (The Nobel Prize, 2022). Today x-rays have moved towards the use of Digital Radiography and have foregone x-ray film. Additionally, Roentgen's work has helped spark the creation of other modalities in the field of radiology (See Table 5, ARRT, 2022, ASRT, 2022, & Long et al, 2019).

Table 5

Invention of Modalities

MODALITY	YEAR INVENTED	DESCRIPTION
Radiation Therapy	1953	Cancer treatment that uses high doses of radiation to kill cancer cells
Ultrasound	1956	Imaging method that uses sound waves to produce images of the body
Medical Dosimetry	1961	Part of radiation oncology that sets up the cancer treatment plan
Interventional Radiography	1963	Imaging method that performs minimally invasive procedures uses fluoroscopy
Cardiac Interventional Radiography	1963	Imaging method that performs minimally invasive procedures to diagnose heart and blood vessel issues
Vascular Interventional Radiography	1963	Imaging method that performs minimally invasive vascular procedures such as stenting
Cardiovascular Interventional	1963	Imaging method that combines

Radiography		Cardiac Interventional Radiography and Vascular Interventional Radiography. This certification is no longer issued with the ARRT.
Mammography	1965	Imaging method that uses x-rays to diagnose and locate breast tumors
Computed Tomography (CT)	1971	Imaging method that is considered a type of 3D x-ray used to image internal organs, bones, and blood vessels
Nuclear Medicine	1971	Imaging method that uses very small amounts of radioactive materials to examine organ function and structure
Positron Emission Tomography (PET)	1974	Imaging method where isotopes are introduced into the body to help diagnose the precise location of disease processes
Magnetic Resonance Imaging (MRI)	1977	Imaging method that uses radiofrequencies and a magnetic field to create detailed anatomic images
Bone Densitometry	1987	Imaging method used to measure bone mineral content and density
Quality Management	Not an invention, but rather an implementation for quality control	Used to assist with ensuring quality diagnostic images and proper maintenance of the equipment. This certification is no longer issued with the ARRT.
Radiologist Assistant	Not an invention, an assistant to the radiologist	Performs select clinical procedures

Note: With the addition of these modalities, extended training, education, and licensing arose.

American Registry of Radiologic Technologists (ARRT)

"In 1920, four members of the Radiological Society of North American (RSNA) presented to their organization for the certification of operators of x-ray equipment. Working together with the American Roentgen Ray Society, these two organizations established the operation of the American Society of X-Ray Technicians (ASXT) in 1922." (Radiology Key, para. 2, 2016).

Eighty-nine certifications were given that year and Sister M. Beatrice Merrigan became the country's first registered radiologic technologist. Her test consisted of 20 essay questions and a set of radiographs to analyze (ARRT History, 2022). It was not until 1936 that the national registry examination for Radiography was incorporated through the American Registry of X-Ray Technicians (ARXT) and, by the end of the decade, there were more than 2,400 registered radiologic technologists. By the 1960s, the ARXT introduced National Registry Examinations in Nuclear Medicine and Radiation Therapy. Forty years after the founding of the national registry, the organization changed its name from American Registry of X-Ray Technicians (ARXT) to American Registry of Radiologic Technologists (ARRT) to be more inclusive to the addition of the modalities (ARRT History, 2022). By the 1990s, the ARRT introduced national registry examinations for the following advanced imaging modalities: Computed Tomography, Magnetic Resonance Imaging, Sonography, Mammography, Interventional Radiology, Positron Emission Tomography, Bone Densitometry, Cardiac Interventional, and Vascular Interventional.

According to the ARRT, Illinois has the seventh highest number of radiologic technologists. Currently, the total number of credentialed technologists in the U.S. is 347,749 (ARRT Census, 2022). Radiologic Science programs have extended their education and training to meet the needs of the technologists who would like to be credentialed in the various modalities. The top ten states with the highest number of radiologic technologists are shown in Table 6 (ARRT Census, 2022). Additionally, the ARRT also provides a census report on the number of technologists credentialed in each modality (See Table 7, ARRT Census, 2022).

Table 6

States with the Highest Number of Credentialed Technologists in the Field of Radiology

Texas	27,333
Florida	25,466
California	25,078
New York	17,646
Pennsylvania	16,533
Ohio	15,162
Illinois	14,231
North Carolina	12,526
Georgia	11,426
Michigan	10,869

Table 7

Credentialed Radiologic Technologists in the U.S. per Modality

Modality	**Number of Credentials Held per Modality**
Radiography	323,377
Computed Tomography	81,487
Mammography	47,877
Magnetic Resonance Imaging	42,996
Radiation Therapy	22,664
Nuclear Medicine	11,719
Vascular Interventional	4,997
Bone Densitometry	4,072
Cardiovascular Interventional Radiography	2,718
Ultrasound (Breast and Vascular as well)	2,223

Cardiac Interventional	1,279
Quality Management (no longer credentialing)	1,083
Radiologist Assistant	435
TOTAL CERTIFICATIONS	548,196
TOTAL CERTIFIED TECHNOLOGISTS	347,749

Evolution of the Education of Radiologic Technology (Science)

Wilhelm Conrad Roentgen's 1895 discovery of x-rays sparked an interest in the general public of the new technology. Since x-rays were considered a type of photograph, many professional photographers were the first to purchase and operate the new equipment. But quickly by the early 1900s, x-rays were used more for diagnosing illness and disease and turned to more of a chemist or engineer operated equipment (Young & McElveny, 1995). Physicians began to send their patients to acquire an x-ray for diagnostic purposes.

By the 1910s, physicians began to purchase their own x-ray machines for use in their offices. At first, these physicians were the operators of the x-ray equipment, but due to time constraints, this was no longer feasible for the physician (Young & McElveny, 1995). The task of taking x-rays began to fall to their office assistants. The issue then became that these office assistants had no medical background. It is then that the physicians turned to nurses in hopes that they could be employed as their x-ray technicians because they had a basic knowledge of the medical field (Young & McElveny, 1995). Not only were these nurses required to take the x-rays and develop the film from the x-rays, but also perform maintenance on the x-ray equipment. Little did these nurses know, but the radiation they were acquiring during their time in x-ray would later cause a reduction in their life expectancy. No one seemed to realize that x-rays could cause damage to skin and tissue (Young & McElveny, 1995). "It wasn't until nearly 20 years

after Roentgen's discovery that precautions such as lead aprons and film badges came into widespread use" (ASRT, History of the ASRT, para. 9, 2022).

With no real standards for taking x-rays, Eddy C Jerman, who was an x-ray technician, developed educational standards for training technicians through the Victor X-Ray Corporation (later became General Electric Company) in 1917 (Young & McElveny, 1995). He and 13 of his fellow x-ray technicians established the American Association of Radiological Technicians in an effort to enhance collaboration and critical thinking of how to improve the radiologic technology field (Young & McElveny, 1995). Later in 1929, they formalized their organization by the establishment of the society's first journal, *The X-Ray Technician.* By 1932, the organization changed its name from American Association of Radiological Technicians to American Society of X-Ray Technicians (ASXT). The organization started with around 400 members and by 1952 they had over 4000 members (Young & McElveny, 1995).

In 1952, the ASXT established formal education standards for the profession. The program design was a one-year program, with time spent working patients, learning anatomy, darkroom procedures (where the development of x-ray images occurred) and physics. The American Medical Association (AMA) recognized the new educational standards. Twelve years later in 1964, the ASXT changed its name from the American Society of X-Ray Technicians to the American Society of Radiologic Technologists (ASRT) due to the formalizing of education and the emphasis on professional development (ASRT History, 2022). Their name is still the same today.

"In 1967, twenty-six educators from colleges and universities throughout the country met in St. Louis, Missouri to discuss how they would best establish radiologic technology as an academic career. Their efforts resulted in the Association of University Radiologic

Technologists (AURT), designed to encourage the exchange of teaching concepts and curricula and establish minimum standards for teaching radiologic technology at the certificate, diploma, associate, and baccalaureate levels; to stimulate an interest in academic radiologic technology as a career; and to advance radiologic technology as an allied health science by encouraging members to conduct research and write technical papers" (Young & McElveny, pg. 558, 1995). AURT later changed its name in 1984 to Association of Educators in Imaging and Radiologic Sciences (AEIRS).

"In 1975 representatives from twelve western United States colleges and universities formed the Western Intercollegiate Consortium on Education in Radiologic Technology (WICERT). The founders sought to improve the quality of college-level radiologic technology education by providing a network for radiologic science educators who found themselves newcomers to the college and university setting" (Young & McElveny, pg. 559, 1995). In 1991, they changed their name to ACERT-Association of Collegiate Educators in Radiologic Technology.

By 1995, the American Registry of Radiologic Technologists mandated continuing education for all radiologic technologists. "Continuing education is a mechanism to assure the medical community and public that the radiologic technologist is qualified by knowledge and skills to practice in the profession of Radiologic Technology" (AHEC Continuing Education, para. 1, 2021). Radiologic technologists are required to have 24 continuing education credits every two years. These continuing education credits are for every modality in Radiologic Science and required no matter the degree of the radiologic technologist.

Today, as reported by JRCERT, there are 472 Associate Degree programs in Radiologic Science throughout the United States and 80 Bachelor Degree programs in Radiologic Science in

the United States (JRCERT, 2022). All graduates of these programs are licensed through the ARRT. In order to become an accredited program, educational institutions must undergo evaluation from JRCERT, who is the leader in accrediting both two-year and four-year Radiologic Science programs.

Responsibilities of a Radiologic Technologist

A registered radiologic technologist is an important team member of healthcare. The technologist will aid the radiologist in the diagnosis of various pathologies. "The knowledge and skills of a radiologic technologist serve an integral part of the medical community in the treatment and well-being of the patient" (Rend Lake College Radiology Program, para. 8, 2022). Some responsibilities the student will learn through their education towards becoming a radiologic technologist include:

- Positioning the patient for their exam
- Using the proper patient radiation dose
- Taking quality, diagnostic images
- Processing images
- Maintaining the imaging equipment
- Supporting and communicating with the patients
- Giving compassionate patient care
- Taking a proper patient history for the radiologist to make an effective diagnosis, and
- Being able to identify and respond to emergent situation

Analyzing Two-Year and Four-Year Radiologic Science Programs

Sample Two-Year Program Mission Statement and Goals

The Rend Lake College Radiologic Science program defines their mission statement as: Our Mission is to provide students with both academic and technical skills to competently and safely perform Radiologic procedures, to prepare qualified imaging technologists who will ethically respond to the needs of the patients with competence and compassion, and to assume a vital professional role as a medical team member. The four goals are: students will be clinically competent, students will communicate effectively, students will use critical thinking and problem-solving skills, and students will evaluate the importance of professional growth and development (Rend Lake College Radiology Program, 2022) (See Tables 8 and 9).

Table 8

Sample Two Year Radiologic Science Program Curriculum

Year One-44 Credit Hours

FALL	**SPRING**	**SUMMER**
Cross Sectional Anatomy I-4	Cross Sectional Anatomy II-4	Clinical Education-6
Interpersonal Responses-2	Clinical Education-7	English Composition-3
Clinical Education-4	Radiologic Technology II-5	
Radiologic Technology I-5	Medical Terminology-1	
Basic Math-3		
Total Credit Hours=18	Total Credit Hours=17	Total Credit Hours=9

Year Two-32 Credit Hours

FALL	**SPRING**	
Speech-3	Psychology-3	
Radiologic Pathology-2	Social Science-3	
Clinical Education-7	Clinical Education-4	
Radiologic Technology III-5	Radiologic Technology IV-5	
Total Credit Hours=17	Total Credit Hours=15	**Total Program Credit Hours-76**

Sample Four-Year Program Mission Statement and Goals

The Southern Illinois University Radiologic Science program defines their mission statement as: The mission of the Radiography Program is to provide a quality program integrating education, research and service in order to meet the needs of the profession and improve health care of the people and communities we serve. The six goals are: prepare the student to practice as a competent entry-level professional radiographer by offering a balanced curriculum and quality didactic and clinical instruction, provide didactic and clinical experiences that lead to research in educational, professional, or health care issues related to radiography, provide avenues to students for professional development and growth with the profession, provide avenues for students to develop and apply skills in effective communication necessary for successful radiography practice, provide avenues for students to develop and apply skills in critical thinking and in problem solving necessary for successful radiography practice, and provide clinical and didactic environment which leads to the development of clinical skills and competence appropriate for an entry-level radiographer (SIU-C Radiologic

Science Program, 2022).

Table 9

Sample Four Year Radiologic Science Program Curriculum

Year One-30 Credit Hours

FALL	**SPRING**
Foundation Course-1	Seminar in Radiology-2
English I-3	English II-3
Zoology-3	Oral Communications-3
Anatomy & Physiology-4	Chemistry/Physics-3
Medical Terminology-2	Humanity of Choice-3
	Math-3
Total Credit Hours=13	Total Credit Hours=17

Year Two-37 Credit Hours

FALL	**SPRING**	**SUMMER**
Intro to Radiology-3	Clinical Education-9	Special Procedures-2
Anatomy & Positioning-3	Interdisciplinary Course-3	Selected Anatomy Systems-3
Anatomy & Positioning Lab-1		Selected Anatomy Systems Lab-1
Radiographic Physics-3		Social Science of Choice-3
Social Science of Choice-3		
Humanities of Choice-3		
Total Credit Hours=16	Total Credit Hours=12	Total Credit Hours=9

Year Three-27 Credit Hours

FALL	**SPRING**
Clinical Education-9	Radiographic Pathology-3
Fine Arts of Choice-3	Cross Sectional Anatomy & Pharmacology-3
	Radiation Biology and Protection-3
	Special Imaging Modalities-3
	Multicultural Course of Choice-3
Total Credit Hours=12	Total Credit Hours=15

Year Four-Four Different Baccalaureate Tracts-31 Credit Hours

MODALITY	**FALL**	**SPRING**	**SUMMER**
CT/MRI	13 Credit Hours	12 Credit Hours	6 Credit Hours
Radiation Therapy	13 Credit Hours	12 Credit Hours	6 Credit Hours
Cardiac Interventional	13 Credit Hours	12 Credit Hours	6 Credit Hours
Radiology Management	13 Credit Hours	12 Credit Hours	6 Credit Hours
			Total Credit Hours=125

All Radiologic Science programs that wish to be an accredited program will undergo evaluation by the JRCERT. Through this accreditation, the program is recognized that they have met the level of educational standards in Radiologic Science.

Joint Review Committee on Education in Radiologic Technology (JRCERT)

"Accreditation is the primary means of assuring and improving the quality of higher education institutions and programs in the United States" (JRCERT, 2022). "The JRCERT is the only organization recognized by the United States Department of Education (USDE) and the Council for Higher Education Accreditation (CHEA) for the accreditation of educational

programs in radiography, radiation therapy, magnetic resonance imaging, and medical dosimetry" (JRCERT, Mission Statement, 2022). Originally established in 1969, the JRCERT is considered the "gold standard" of accreditation for over 700 radiologic science programs (JRCERT, 2022).

The JRCERT will only accredit those programs that set and maintain high academic standards. When Radiologic Sciences programs undertake the accreditation process with the JRCERT, the program can be recognized in the following ways: not awarded accreditation, three-year accreditation, five-year accreditation, or eight-year accreditation. "The maximum length of an initial accreditation award granted by the JRCERT is three years. The maximum length of a continuing accreditation award granted by the JRCERT is eight years, with an Interim Report required after the first four years" (JRCERT, Accreditation, 2022). When the accreditation cycle is up for renewal, a re-accreditation process consists of a site visit with JRCERT members and a review of program documentation such as assessment plans and program effectiveness documentation. From their reviews, a final decision will be made and a new accreditation window will begin.

One component of the renewal process is the reporting of program compliance data. An accredited program is required to submit annual assessment plans to the JRCERT for review to ensure that when combined over a five-year period, ARRT national registry credentialing examination pass rates, program completion rates, and job placement rates are all higher than 75%. The credentialing examination pass rate is the number of students who pass the national registry examination in the first attempt. Program completion rates are the number of students who complete the program from the start of the program through graduation. Job placement rates are the number of graduates who are employed in the field within six months of graduation.

Programs are required to submit Interim Reports (halfway mark of accreditation window) to ensure program and student success. If annual benchmarks are not met, remedial action will be required for improvement, and the current accreditation status could be in jeopardy.

In addition to adhering to high educational standards, the JRCERT strives to instill high integrity and strong ethical considerations to the Radiologic Science programs in order to provide the best possible education to the students. Instilling these standards to the students will, in turn, produce quality radiologic technologists to better serve the patients. The JRCERT has seven core values (JRCERT, 2022):

1. Believes educational quality and integrity should not be compromised
2. Respects and protects the rights of students
3. Promotes the welfare of patients
4. Encourages educational innovation
5. Collaborates with other organizations to advance the profession
6. Exemplifies the highest ethical principles in its actions and decisions, and
7. Responds in a proactive and dynamic manner to the environment in which it operates

Continuing Education after Graduation

"Continuing education gives radiologic technologists a way to maintain competency and prevent professional obsolescence. It benefits technologists, the patients they serve, and the profession as a whole" (ASRT, Continuing Education, 2022). Once students graduate from a Radiologic Science program and pass the ARRT national registry examination, they will be required to complete and report their continuing education activities every two years. The two-year time frame is called a technologist's biennium. "A biennium begins on the first day of the technologist's birth month every other year, and extends for two years, ending on the last day of

the month before the technologist's birth month" (ARRT, Biennium CE Requirements, para. 7, 2022). "Most radiologic technologists are required to earn 24 approved continuing education credits during their biennium, regardless of how many ARRT credentials they hold" (ARRT, Biennium CE Requirements, para. 1, 2022). Failure to uphold these continuing education credits can result in probation or revocation of the technologist's credentials. There are several resources for technologists to earn these continuing education credits. Some examples are: "online classes, self-study readings, seminar lectures, and classroom learning" (ARRT Education, para. 3, 2022). One of the primary providers of these continuing education credits is through the ASRT.

American Society of Radiologic Technologists (ASRT)

"The mission of the American Society of Radiologic Technologists is to advance and elevate the medical imaging and radiation therapy profession and to enhance the quality and safety of patient care" (ASRT, About Us, 2022). The ASRT is the world's largest and oldest membership for imaging technologists. "Founded in 1920, the ASRT now has more than 156,000 members and is located in Albuquerque, NM." (ASRT, History of the ASRT, para. 1, 2022). "The ASRT provides its members with educational opportunities, promotes radiologic technology as a career, and monitors state and federal legislation that affects the profession. It is also responsible for establishing standards of practice for the radiologic science profession and developing educational curricula" (ASRT, History of the ASRT, para. 2, 2022).

The ASRT provides educational and research information to its members, such as research reports, research grants, and peer-reviewed publications. Through the research reports, the ASRT studies and surveys workplace trends such as wage and salary surveys, professional development such as staffing surveys, and educational program statistics such as enrollment

snapshot surveys (ASRT, Research Reports, 2022). Additionally, the ASRT offers competitive research grants for new, emerging, as well as experienced researchers (ASRT, Research, 2022). As a new researcher, the grant allows professionals in the field as well as students to conduct scientific research with additional support from the ASRT. This grant funds projects up to $3,000. As an emerging researcher, the grant allows professionals in the field to conduct scientific research with access to professional development courses to help the researchers with their research and writing skills. This grant funds projects up to $4,000. As an experienced researcher, the grant allows professionals in the field to "cultivate the next generation of researchers" (ASRT, Research, 2022). This grant funds projects from $10,000 to $25,000. Lastly, the ASRT publishes bi-monthly peer-reviewed journals with continuing education modules to enhance the field knowledge of its members.

Declining Registered Technologists

COVID-19 Impact

COVID-19 had a significant and negative impact on the radiology field. Healthcare staffing shortages now plague the field of radiology. Many technologists who were working in the field during the height of COVID-19 suffered from burnout and exhaustion. "As the chest x-ray emerged as a key tool for diagnosing COVID-19, the radiology staff experienced a surge in exam volume" (Madden, para. 4, 2021). Due to the influx of patients, this prompted the radiology departments to abruptly change their workflow processes to keep up with the demand for imaging tests. Unfortunately, the pandemic caused an unwanted but necessary change in the technologists' job duties. With these changes, many radiologic technologists did not receive the necessary training needed for the new job responsibilities, thus creating a stressful situation (Madden, 2021). Additionally, many departments saw the infection spread within their staff.

"Nosocomial outbreaks among clinical teams threatened the sustainability of services as a result of staff absence due to illness or self-isolation" (Taylor et. al., para. 6, 2021). Furthermore, with radiologic technologists being front line workers, many technologists not only suffered from exhaustion and burnout, but also fear of acquiring the disease while working in the healthcare field.

Educational institutions have also been dramatically impacted from COVID-19. "According to the National Student Clearinghouse Research Center, undergraduate enrollment year over year fell by 3.6% in fall 2020 and by 3.1% in fall 2021. Total undergraduate enrollment declined 6.6% from fall 2019 to fall 2021, representing a loss of just over a million students" (Inside Higher Ed, para. 2, 2022). Additionally, in fall 2020, there were 20.7% fewer students enrolling in college right after high school as compared to 2019 (Inside Higher Ed, 2022). Higher education institutions will need to evaluate how to overcome the negative impact that COVID-19 has put on campuses.

Staffing Shortages and Decline of Radiologic Science Students

The Advanced Health Education Center (AHEC) conducted a radiology staffing shortage study in 2021 with over 350 participants. The study revealed 81.3% of the participants stated their facility is experiencing a staffing shortage (AHEC, 2021). The study further described which modalities are experiencing the largest shortages (these participants were asked to mark all that apply). Radiography, CT, and Ultrasound were the modalities that showed the highest number of shortages (See Table 10). Additionally, the AHEC study also asked their participants if their facility is receiving applications for the Radiologic Science positions that are open (See Table 11).

Table 10

Shortage Percentages per Modality

Radiography	69.9%
Computed Tomography	62.3%
Ultrasound	38.2%
Magnetic Resonance Imaging	36.7%
Mammography	34.7%
Nuclear Medicine	14.1%
Radiation Therapy	7.5%

Table 11

Are Facilities Receiving Applications For Radiologic Technologists?

Yes	30.5%
No	37.6%
Did Not Know	31.9%

The ASRT also conducted a study on radiologic technologists' shortages. "In 2019, radiology departments in the U.S. were already experiencing an 8.5% understaffing of radiologic technologists", prior to COVID-19, with CT technologists, Sonographers, and MRI technologists experiencing approximately the same percentage of unfilled positions (ASRT, Radiologic Sciences Staffing and Workplace Survey, pg. 2, 2019). With the decline of students entering radiologic science programs, the staffing shortage continues to rise, thus facilities are seeing a drop in job applications for open radiology positions. The staffing deficit is exacerbated by locum tenens, per diem, contract, or travel tech jobs in order to fill these open positions (ASRT,

2022). Unfortunately, hiring technologists in this manner is not cost effective for facilities because typically they offer triple the pay as compared to typical technologist pay (ASRT, 2022).

Summary

The field of radiology is an important department in the healthcare field. It is "a key diagnostic tool for many diseases and has an important role in monitoring treatment and predicting outcome" (NIH, para. 3, 2010). Radiology has seen tremendous growth since the discovery of x-ray in 1895. Through the discovery of x-ray and the modalities came the need for structured education. Whether the education is a certificate program or a two-year and/or four-year program, it is important to be an accredited program to ensure high educational standards and integrity of the program. Although some Radiologic Science programs are seeing a decline in enrollment, it is important for these programs to provide quality graduates to help fill the staffing shortages that are facing the radiology field.

CHAPTER 3

METHODOLOGY

Introduction of the Study and Purpose

The purpose of this study is to look at the similarities and differences between what two-year and four-year Radiologic Science programs offer. With the continued demand for radiologic technologists, it is important to ensure student readiness for the workforce. Chapter Three entails a review of the study's research methodology, namely, how will data/information be collected and analyzed. The first part of the chapter reviews the research questions, followed by an explanation of the research design. Next, the researcher will discuss how data will be collected, using both a document analysis and an interview process with technologists who work with graduates of two-year and four-year Radiologic Science programs. The final sections of the Chapter will focus on the analysis procedures to be utilized in interpreting the data, followed by the chapter summary.

Research Questions

This study has two main research questions that will be utilized to determine the factors students consider when choosing a Radiologic Science program, followed by learning why a higher percentage of students choose a two-year program over a four-year program.

Research Question 1: What are the similarities and differences between two-year and four-year Radiologic Science programs?

1a. Curricular: What are the similarities and differences between the number of credit hours, semesters, faculty, students, tuition rates, and certifications offered, as well as program outcomes (e.g., program completion rates, job placement rates, and ARRT pass rates) between two-year and four-year programs?

1b. Technical Skills: What are the similarities and differences between technologists who are multi-credentialed with a bachelor degree versus technologists who are single-credentialed with an associate degree?

Research Question 2: What are the factors that influence a student's decision to enroll in either a two-year or four-year Radiologic Science program?

2a. How does the cost of a program (i.e., tuition/fees as well as lost income) impact students' decisions to attend a two-year or four-year Radiologic Science program?

Research Design Options

There are three different designs to conduct research: Quantitative, Qualitative, and Mixed Methods. In selecting the appropriate mode of research for the study, it is important to understand the differences between them.

Quantitative research methods involve collecting and analyzing data in order to show a numerical representation. "One of the main goals of quantitative research is to build valid and reliable measurements that allow for statistical analysis" (Goertzen, 2017, para. 3). Quantitative research is designed to discover trends, samples, and populations across various data sets. These data sets are then statistically analyzed and can be highlighted on a graph or table to showcase the findings.

Unlike quantitative research, "qualitative research involves purposeful use for describing, explaining, and interpreting collected data" (Williams, 2007, p. 67). Rather than analyzing numerical data, qualitative research is defined as "a type of research that explores and provides deeper insights into real-world problems and gathers participants' experiences, perceptions, and behavior in order to answer the how's and why's" (Tenny, 2021, para. 1). There are three primary types of qualitative research: "(1) Exploratory research which seeks to investigate an

under researched aspect of social life, (2) Descriptive research which seeks to richly describe an aspect of social life, and (3) Explanatory research which seeks to explain an aspect of social life" (Hesse-Biber, 2017).

Lastly, combining quantitative and qualitative methods are considered a mixed method approach, which can allow for more comprehensive research. "It requires a purposeful mixing of methods in data collection, data analysis and interpretation of the evidence (triangulation used-more than three methods used to enhance the validity). Purposeful data integration enables researchers to seek a more panoramic view of their research landscape, viewing phenomena from different viewpoints and through diverse research lenses" (Shorten & Smith, 2017, para. 3).

Research Design and Methodology of the Study

A qualitative design will be utilized in this study to explore the similarities and differences of two-year and four-year JRCERT accredited Radiologic Science programs in Illinois. The decision for a qualitative study was predicated on the ASRT having previously examined this topic area using a quantitative design. For the purpose of this qualitative study, document review and open-ended, key informant interviews were selected as the research methodologies.

"Interviews consist of oral questions asked by the interviewer and oral responses by the research participants" (Gall et al. 2003, p. 222). There are three major types of research interviews: key informant interviews, survey interviews, and focus group interviews. The researcher decided to conduct key informant interviews. By definition, a key informant interview is where "the interviewer collects data from individuals who have specific knowledge or perceptions that would not otherwise be available to the researcher. Key informants often have more knowledge, better communication skills, or different perspectives than other members

of the defined population" (Gall et al. 2003, p. 237). The interview protocol will enable the researcher to gain insight into radiology professionals' experiences, knowledge of the field, skill sets required for the job, their thoughts about education, and ideas for improving the readiness of the student to become a technologist. Gall et al. (2003) defined eight steps when conducting interviews: (1) defining the purpose of the study, (2) selecting a sample, (3) designing the interview format, (4) developing questions, (5) selecting and training interviewers, (6) doing a pilot test of the interview procedures, (7) conducting the interviews, and (8) analyzing the interview data. These steps will be useful in preparing for the interviews.

"A primary source is a document that was written by individuals who actually conducted the research study or who formulated the theory or opinions that are described in the document" (Gall et al. 2003, p. 92). "A secondary source is a document written by someone who did not actually do the research, develop the theories, or express the opinions that they have synthesized into a literature review" (Gall et al. 2003, p. 92). The researcher will be looking at documents provided by the leaders in the radiology field (ASRT, ARRT, & JRCERT) to gain information about the various radiologic science programs. The ASRT provides primary documents such as enrollment snapshots and workplace and staffing surveys. The ARRT provides primary documents such as didactic and clinical competency requirement documentation as well as a census report. The JRCERT provides secondary documentation through the various JRCERT accredited radiology programs' website links regarding each programs' information.

Population and Sample Selection

The population for this study is the 27 two-year and four-year Radiologic Science programs accredited by the JRCERT in the state of Illinois.

Interviews: To measure the graduates' skill set, interviews will be conducted on one

technologist from 10 different hospitals that house the clinical internships for both SIU Radiologic Science students as well as students from two-year Radiologic Science programs. The 10 hospitals that were selected: acute care facility (1), trauma level II (3), and trauma level I hospitals (6). The technologists of the interview process have different positions throughout the Radiology department (Imaging Manager, Supervisor of Imaging, Lead Technologist, Staff Technologist).

Documents: The researcher will review documents from two primary sources: the three national associations and the 27 higher education institutions in Illinois. The national associations that oversee radiological science are the ASRT, JRCERT, and ARRT. The ASRT is the leading professional association for the medical imaging community. Its website contains annual trends on student demographic and enrollment analyses that will be useful to this study. The JRCERT is an accrediting body for radiologic science programs throughout the United States. Through its website, the JRCERT provides a list of Radiologic Sciences programs that are accredited per state. This will enable the researcher to analyze each accredited program's curriculum through the JRCERT's direct link to each Radiologic Science program's website. It also provides a five-year trend for each program on job placement rates, the ARRT national registry examination pass rates, and program completion rates. Third, the ARRT is the credentialing body for the Radiologic Science field. Through its website, the ARRT provides a certificate census of registered technologists by location and modality.

Instrumentation: Interview Protocol

After the interview questions are created, a pilot study will be conducted to examine the feasibility of the interview protocol and accompanying processes. Then, a panel of experts will review the interview protocol and necessary modifications will be made to the questions. This

process resulted in seven open-ended, key informant questions, which will be asked of each participant during the interview process (See Table 12).

Table 12

Research Questions/Interview Questions

Research Questions	Interview Questions
RQ 1: What are the similarities and differences between two-year and four-year Radiologic Science programs? **1a.** Curricular: What are the similarities and differences between the number of credit hours, semesters, faculty, tuition rates, and certifications offered, as well as program outcomes (e.g., program completion rates, job placement rates, and ARRT pass rates) between two-year and four-year programs? **1b.** Technical Skills: What are the similarities and differences between technologists who are multi-credentialed with a bachelor degree versus technologists who are single-credentialed with an associate degree?	1. What are some similarities and differences on the readiness of work for two-year vs four-year radiologic science graduates? 2. What are the benefits of two-year and four-year programs? What are some reasons additional education is or is not supported at your organization? 3. Does your facility prefer to employ technologists who are multi-credentialed, why or why not? 4. What are some pros and cons of having technologists capable of working in more than one modality? 5. Is it preferred to hire technologists who are already trained in multiple modalities or is it preferred to hire technologists that will need to be cross trained in other modalities, and why?
RQ 2: What are the factors that influence students' decision to enroll in either a two-year or a four-year radiologic science program? **2a:** How does the cost of a program (i.e. tuition/fees as well as lost income) impact students' decision to attend a two-year or a four-year radiologic science program?	1. What could four-year programs do to attract future students to their programs? 2. Why do you think more students enroll into two-year programs? Is it worth the cost to continue your education?

Data Collection

The Institutional Review Board of Southern Illinois University Carbondale approved this study (See Appendix D). For this qualitative study, documents will be collected and individual interviews will be conducted to generate the research data.

Documents

During the document collection, the researcher will review the 22 two-year Radiologic Science programs and 5 four-year Radiologic Science programs in Illinois. Information on the two different degree programs can be found on the ASRT, JRCERT, and ARRT websites. Summarizing the similarities and differences of these two distinct types of programs will be crucial to show the value of each degree.

Gall et al. (2003) described the four elements that comprise the document collection process. First is the identification of documents that are part of the study. Second is the determination of what documents might be relevant to the research. Third is to determine how the researcher can collect these documents for analysis within the guidelines for ethical conduct of research. Lastly, the researcher will need to consider the validity of the materials.

Specifically, the researcher will review documents that provide a detailed description of the following regarding two-year and four-year radiology programs: program curriculum, student credit hours, FTE faculty, laboratory simulation hours, clinical internship hours, ARRT (American Registry of Radiologic Technologists) national registry examination pass rates, program completion, and job placement rates.

Interviews

The researcher contacted technologists at 10 different hospitals throughout Illinois via email at the beginning of November 2022. These hospitals selected, house both the clinical

internships for SIU's CT/MRI students as well as the associate degree programs of Radiologic Science students.

The email contained an introductory letter presenting the study, researcher background, and the option to agree or decline participation in the study. After one week, a follow-up email was sent to the participants that did not respond. For the participants that declined, a follow-up email was sent to ask if there were any other technologists in their department willing to participate in the study. For the participants that agreed, a consent form was sent to them via email. The participants then selected a day and time for the interview. Once the date and time were agreed, the researcher scheduled a Zoom or Microsoft Teams meeting (based on their preference) and asked each participant to accept the invitation to ensure a calendar reminder could be attained. With the online platform of these meetings, the researcher provided the meeting ID number, password, and short description of the meeting. A consent agreement was emailed prior to the interview (See Appendix B).

At the start of the interview, participants will be reminded that they have the right to discontinue it at any time. All participants will be asked for permission to record the meeting. The interviewees will be kept anonymous without any personal identifiers. Since most of the technologists who will be interviewed are still current employees of the hospitals, the confidentiality of their identity was necessary to not show bias towards any Radiologic Science programs. These interviews will be conducted via Zoom or Microsoft Teams so that the meetings can be recorded and later transcribed. Further, the researcher will take copious field notes to help highlight insights and/or questions that occur during the actual interview.

Data Analysis Procedures

"Data analysis in qualitative research is defined as the process of systematically searching

and arranging the interview transcripts, observation notes, or other non-textual materials that the researcher accumulates to increase the understanding of the phenomenon" (Wong, p. 15). For the purpose of the study, the researcher will utilize the six steps Creswell (2014) provided to analyze the data collected.

1. The first step includes transcribing the interviews/notes and reviewing the researcher's field notes taken during each interview. Microsoft Word will be used to transcribe the responses from the recorded Zoom and Microsoft Teams meetings.

2. The next step is to read through all the participants' responses and the researcher's field notes that were taken during each interview. This will allow the researcher to gather general ideas from review of the documents and the interviews. This step helps the researcher better understand the participants' statements.

3. The third step is a detailed analysis of the data collected to categorize, or code, the interview comments. In this step, information will be organized into segments to make analyzing the data easier. "Coding or categorizing the data is the most important stage in the qualitative data analysis process. Coding merely involves subdividing the huge amount of raw information or data, and subsequently assigning them into categories" (Wong, 2008, para. 6).

4. The fourth step is developing themes for similarities and differences of responses from the participants. The step is useful to help tell the story and set the stage about the technologists involved in the study.

5. During the fifth step, the researcher may select to use a narrative passage to discuss the outcomes of the analysis (Creswell, 2013). The researcher will hopefully gain insight on why radiologic technologists prefer graduates from either a two-year or four-year program.

6. The final step involves interpreting variables and drawing out conclusions from the

results of the interview questions to aid in answering the research questions.

Validity and Reliability

Validity refers to the accuracy, appropriateness, meaningfulness, and usefulness of the data (Gall et al., 2003). Reliability refers to the extent to which other researchers would arrive at similar results if they studied the same case using the same procedures as the original research (Gall et al., 2003). In the present study, the 27 higher institutions and leading associations in the field of Radiology (ASRT, JRCERT, and ARRT) provided the information. Through the documents of the ASRT, JRCERT, and ARRT, the researcher will be able to demonstrate the study's validity and reliability through their annual surveys that consistently ask the same questions of the registered radiologic technologists and accredited radiologic science programs.

Summary

In Chapter 3, the researcher provided the purpose of the study, the research design that consists of a qualitative approach, document analysis, and interview details. In Chapters 4 and 5, the researcher will provide the responses for each participant in the study.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

The purpose of the study was to determine similarities and differences between two-year and four-year Joint Review Committee on Education in Radiologic Technology (JRCERT)-accredited radiologic science programs in Illinois, given the high demand for technologists in healthcare. The research methods used in this chapter include: document analysis and interviews with radiology administrators. For the document analysis, twenty-two associate degree programs and five bachelor degree programs accredited through JRCERT in Illinois were reviewed. For the interview process, one radiology administrator from ten Midwest hospitals was interviewed.

Document Analysis

The information for this document analysis was reviewed from the JRCERT website as well as from the websites from each of the twenty-two Illinois JRCERT-accredited associate degree programs and five Illinois JRCERT-accredited bachelor degree programs. In this section, information from the documents are reported out by the following four themes for each of the twenty-seven institutions in this study:

1. Program Outcomes: American Registry for Radiologic Technologists (ARRT) examination pass rates, program completion rates, and job placement rates.
2. Program Details:
    A. Total number of credit hours, radiology specific credit hours, general education credit hours
    B. Average number of students from the last five years and number of faculty for each radiologic science program

C. Total number of semesters to graduate, total number of clinical semesters, and total number of on-campus laboratory procedure semesters

3. Yearly Tuition Rate: Resident versus Non-Resident tuition.

4. Additional Certifications Offered (other than Radiography): Mammography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Radiation Therapy, Nuclear Medicine, Sonography, Cardiac Interventional (CI), Echocardiography, and Radiology Assistant.

Program Outcomes

ARRT Examination Pass Rates

The ARRT national average pass rate for all radiography students is 83.8%, lower than the pass rate percentages for both associate and bachelor degree programs in Illinois. Over a five-year span, the first attempt pass rate percentage for the ARRT examination for Illinois associate degree programs was 90.4%. During this same five-year timeframe, six programs received a 95% or higher first attempt pass rate percentage. Further, six programs received a 90-94% first attempt pass rate percentage over five years, while ten programs received a 90% or lower pass rate percentage over five years. The lowest program average pass rate was 75%, and the highest program average was a 100% pass rate.

The average first attempt pass rate percentage for the ARRT examination for Illinois bachelor degree programs was 1.3% higher (or 91.7% total) than their associate degree counterparts. Of the five programs, three programs received a 90% or higher first attempt pass rate average, leaving one program with an average pass rate percentage under 90% (and one program not reporting pass rate data since it was a new degree program). The lowest program average pass rate was 83%, and the highest program average was a 96% pass rate.

Currently, four of the five programs offer advanced modality certifications at the bachelor's degree level, although one program does not have statistical program outcomes yet for the advanced modality certification because they are a new bachelor degree program. Similar to radiography, it is interesting that the advanced modality ARRT pass rates for Illinois' bachelor programs clearly exceeds the national norm. Of the three programs with data, one program had a tract into CT/MRI with a 95% pass rate, and two programs had tracts into radiation therapy with a 92.9% pass rate and the other program with an 83% pass rate. The ARRT national average pass rates for MRI are 66.3% and for radiation therapy are 79.8%, thus creating Illinois bachelor degree program pass rates higher than the national average.

Program Completion Rates

The average program completion rates over a five-year span for Illinois associate degree programs was 86.4%. Of the twenty-two programs, eight programs had a 90-100% program completion rate, ten programs had an 80-89% program completion rate, and four programs had less than an 80% program completion rate. The overall highest program completion rate was 100% and the lowest was at 65%.

The average program completion rates over a five-year span for Illinois bachelor degree programs was 97.8%. Of the five programs, three programs had a 100% program completion rate and one program was at a 91% program completion rate (with one new program not reporting program completion rate data).

In comparison of the associate degree and bachelor degree programs, the bachelor degree programs had an 11.4% higher program completion rate.

Job Placement Rates

From the five-year data of this study, the average job placement rates for Illinois

associate degree programs was 98.7%. Of the twenty-two programs, almost 70 percent (15 programs) had a 100% job placement rate, another 22 percent (five programs) had a 99-95% job placement rate, and the remaining 8 percent (two programs) had less than a 95% job placement rate. The overall highest was a 100% job placement rate, and the lowest was an above-average 89% job placement rate.

In reviewing the four-year programs within the five-year data, the average job placement rates for Illinois bachelor degree programs was 99.8%. Of the five programs, three programs had a 100% job placement rate, and one program had a 99% job placement rate (one new program did not have reported job placement rate data yet). The bachelor degree programs had a slightly higher job placement rate over the associate degree programs, resulting in a 1.1% higher average.

Table 13-RADIOLOGIC SCIENCE PROGRAM OUTCOMES

ASSOCIATE DEGREE PROGRAM OUTCOMES	ARRT EXAMINATION PASS RATES	PROGRAM COMPLETION RATES	JOB PLACEMENT RATES
Associate Degree Radiology Program 1	96%	89%	100%
Associate Degree Radiology Program 2	93%	84%	100%
Associate Degree Radiology Program 3	89%	100%	100%
Associate Degree Radiology Program 4	100%	84.6%	100%
Associate Degree Radiology Program 5	93%	85%	100%
Associate Degree Radiology Program 6	94.87%	90%	100%
Associate Degree Radiology Program 7	97%	100%	100%
Associate Degree Radiology Program 8	94.5%	100%	98.8%
Associate Degree Radiology Program 9	82%	85%	97%
Associate Degree Radiology Program 10	98%	86%	100%
Associate Degree Radiology Program 11	87%	81%	100%

Associate Degree Radiology Program 12	83%	86%	92%
Associate Degree Radiology Program 13	82%	78%	100%
Associate Degree Radiology Program 14	88.9%	100%	97.6%
Associate Degree Radiology Program 15	81%	100%	100%
Associate Degree Radiology Program 16	89%	65%	98%
Associate Degree Radiology Program 17	93.5%	90%	100%
Associate Degree Radiology Program 18	95.6%	83%	99%
Associate Degree Radiology Program 19	99%	71%	100%
Associate Degree Radiology Program 20	94%	89%	100%
Associate Degree Radiology Program 21	75%	65%	89%
Associate Degree Radiology Program 22	84%	90%	100%

BACHELOR DEGREE PROGRAM OUTCOMES	ARRT EXAMINATION PASS RATES	PROGRAM COMPLETION RATES	JOB PLACEMENT RATES
Bachelor Degree Radiology Program 1	None Available-Recent switch from Associate Degree to Bachelor Degree	None Available-Recent switch from Associate Degree to Bachelor Degree	None Available-Recent switch from Associate Degree to Bachelor
Bachelor Degree Radiology Program 2	96%	100%	100%
Bachelor Degree Radiology Program 3	95%	100%	99%
Bachelor Degree Radiology Program 4	92.9%	100%	100%
Bachelor Degree Radiology Program 5	83%	91%	100%

Program Details

A. Total Credit Hours

Typically, the average number of credit hours to earn an associate's degree is 60-80 total credit hours (IPDS, 2022). Of the study's twenty-two participating associate degree programs, the average number of credit hours was 73.3. Of these programs, twenty fell between the 60-80 credit hour average. Nine of the twenty programs had credit hours within the range of 60-70 credit hours; eleven programs had credit hours between 71-80 credit hours; and two programs exceeded 80 credit hours. The program with the highest number of credits (108) to complete an associate degree was set up differently than the other programs, as they are set up on the quarter system instead of semesters, but still completed within two years. The other program required 96 credit hours, but those students earned an associate's degree in their third year, while working to complete a bachelor degree in year four. None of the twenty-two programs were below 60 credit hours.

Typically, the average number of credit hours to earn a bachelor's degree is 120 total credit hours (IPDS, 2022). Of the five Illinois JRCERT-accredited, bachelor degree radiologic science programs there was only a slight difference in the number of required credit hours for degree completion. The higher end of required credit hours was 127, while the lower end of required credit hours was 120, thus averaging 124.3 credit hours.

In comparing the associate degree versus the bachelor degree credit hours, a student can expect to have an average of 51 additional credit hours to complete their bachelor degree. Generally, this can be accomplished in an additional one or two years depending on the university's general education requirements.

Radiologic Science Credit Hours

With the national average of 60-80 credit hours to graduate with an associate's degree, the average number of radiologic science specific credit hours within this study's associate degree programs averaged 55.8. The lowest number of radiologic science specific credit hours was 49, while the highest was 75 credit hours. The program with the highest recorded radiologic science specific courses was a program that sets their courses up per quarter or in eight week sessions rather than the traditional semester-based courses.

With the national average of 120 credit hours to graduate with a bachelor degree, the average number of radiologic science specific credit hours within the study's bachelor degree programs was 73.7. The lowest number of radiologic science specific credit hours was 65, while the highest was 81 credit hours.

A student can expect to add 18 additional radiologic science specific credit hours when working towards a bachelor degree. Two of the five bachelor degree programs had these additional credit hours in only radiography, while the remaining three programs taught an advanced modality within these additional radiologic specific credit hours.

General Education Credit Hours

Commonly, most associate degree programs require 60-80 credit hours to graduate. This study's average number of general education credit hours averaged 17.5 credit hours. Within the twenty-two programs, three programs required 10 or less general education credit hours. Twelve programs required 11-20 general education credit hours, while seven programs required more than 20 general education credit hours to graduate with an associate's degree. The highest number of required general education credit hours was 46, which just happens to fulfill the requirements of that program's bachelor degree.

Generally, most bachelor degree programs require 120 credit hours to graduate. This study's average number of general education credit hours averaged 50.6 credit hours. Of the five programs, the credits ranged from 46 to 55 hours, with three programs requiring more than 50 credit hours, while two programs required less than 50 general education credit hours to graduate with a bachelor's degree. In sum, bachelor degree programs on average require 33.1 additional general education credit hours to graduate.

Table 14A-RADIOLOGIC SCIENCE PROGRAM DETAILS

ASSOCIATE PROGRAMS	TOTAL CREDIT HOURS	RADIOLOGY CREDIT HOURS	GENERAL EDUCATION CREDIT HOURS
Associate Degree Radiology Program 1	70	49	21
Associate Degree Radiology Program 2	67	58	9
Associate Degree Radiology Program 3	71	55	16
Associate Degree Radiology Program 4	72	52	20
Associate Degree Radiology Program 5	72	52	20
Associate Degree Radiology Program 6	72	62	10
Associate Degree Radiology Program 7	68.5	55.5	13
Associate Degree Radiology Program 8	76	59	17
Associate Degree Radiology Program 9	69	57	12
Associate Degree Radiology Program 10	64	52	12
Associate Degree Radiology Program 11	75	57	18
Associate Degree Radiology Program 12	72	50	22
Associate Degree Radiology Program 13	108	75	33

Associate Degree Radiology Program 14	71.5	59.5	12
Associate Degree Radiology Program 15	68	53	15
Associate Degree Radiology Program 16	69.5	60.5	9
Associate Degree Radiology Program 17	72	54	18
Associate Degree Radiology Program 18	69.5	52.5	17
Associate Degree Radiology Program 19	96	50	46
Associate Degree Radiology Program 20	73	59	14
Associate Degree Radiology Program 21	77	54	23
Associate Degree Radiology Program 22	60	51	9
BACHELOR PROGRAMS	**TOTAL CREDIT HOURS**	**RADIOLOGY CREDIT HOURS**	**GENERAL EDUCATION CREDIT HOURS**
Bachelor Degree Radiology Program 1	124	71	53
Bachelor Degree Radiology Program 2	123.5	70.5	53
Bachelor Degree Radiology Program 3	127	81	46
Bachelor Degree Radiology Program 4	127	81	46
Bachelor Degree Radiology Program 5	120	65	55

B. Average Number of Students Reported from the Last Five Years

For the Illinois JRCERT accredited associate degree programs, there was an average number of 18.5 students in each radiologic science program. Of the twenty-two associate degree programs, nine programs had up to 14 students, seven programs had 15-20 students, and six programs had 20+ students. The highest number of enrolled students (37) came from two different programs.

As for the bachelor degree programs, there was an average number of 13.5 students in each radiologic science program. Of the five programs, one program did not have any student enrollment data to report since they are a new bachelor degree program, two programs had 17 students, one program had 12 students, and the remaining program had eight students.

Overall, the comparison between these two-degree programs resulted in the bachelor degree programs having approximately five less students in each program compared to the associate degree programs.

Number of Faculty

The average number of faculty teaching in the radiologic science programs for associate degree programs was a headcount of 3.3. Of the twenty-two programs, sixteen programs had three or less faculty teaching in the program, while six programs had more than three faculty teaching in their programs, with the highest number being seven faculty.

The average number of faculty teaching in the radiologic science programs for bachelor degree programs was 4.4. Of the five programs, three programs had more than three faculty teaching in their programs, while two programs had only three faculty. The highest number of faculty was six for bachelor degree programs.

When comparing the Illinois JRCERT associate degree and bachelor degree programs on

the amount of faculty they have for each program, there was only a slight difference of 1.1 more faculty for bachelor degree programs. Interestingly, there were also fewer students in the bachelor degree program, thus revealing a higher student-faculty ratio for bachelor degree programs.

Table 14B-RADIOLOGIC SCIENCE PROGRAM DETAILS

22 ASSOCIATE PROGRAMS	AVERAGE NUMBER OF STUDENTS OVER THE LAST FIVE YEARS	NUMBER OF FACULTY	STUDENT-FACULTY RATIO
Associate Degree Radiology Program 1	33	6	5.5:1
Associate Degree Radiology Program 2	16	2	8:1
Associate Degree Radiology Program 3	10	2	5:1
Associate Degree Radiology Program 4	13	7	1.9:1
Associate Degree Radiology Program 5	18	2	9:1
Associate Degree Radiology Program 6	8	3	2.7:1
Associate Degree Radiology Program 7	15	2	7.5:1
Associate Degree Radiology Program 8	20	3	6.7:1
Associate Degree Radiology Program 9	11	3	3.7:1
Associate Degree Radiology Program 10	12	3	4:1
Associate Degree Radiology Program 11	37	7	5.3:1
Associate Degree Radiology Program 12	21	2	10.5:1
Associate Degree Radiology Program 13	19	3	6.3:1
Associate Degree Radiology Program 14	11	2	5.5:1

Associate Degree Radiology Program 15	14	3	4.7:1
Associate Degree Radiology Program 16	19	2	9.5:1
Associate Degree Radiology Program 17	12	6	2:1
Associate Degree Radiology Program 18	18	4	4.5:1
Associate Degree Radiology Program 19	26	4	6.5:1
Associate Degree Radiology Program 20	37	2	18.5:1
Associate Degree Radiology Program 21	12	3	4:1
Associate Degree Radiology Program 22	26	2	13:1
BACHELOR PROGRAMS	**AVERAGE NUMBER OF STUDENTS OVER THE LAST FIVE YEARS**	**NUMBER OF FACULTY**	**STUDENT-FACULTY RATIO**
Bachelor Degree Radiology Program 1	N/A-New bachelor degree program	3	N/A
Bachelor Degree Radiology Program 2	17	6	2.8:1
Bachelor Degree Radiology Program 3	26 for sophomore and junior year 12 for the student's senior year	4 Faculty for Sophomore/Junior 2 Faculty for Senior Tract	6.5:1 6:1
Bachelor Degree Radiology Program 4	26 for sophomore and junior year 17 for the student's senior year	4 Faculty for Sophomore/Junior 2 Faculty for Senior Tract	6.5:1 8.5:1
Bachelor Degree Radiology Program 5	8	3	2.7:1

C. Number of Semesters to Graduate

The average number of total semesters to complete an associate's degree for the twenty-two Illinois JRCERT accredited programs was 6.27 total semesters. Of the twenty-two programs, three programs consist of five semesters, thirteen programs consist of six semesters, and six programs consist of seven semesters.

The average number of total semesters to complete a bachelor's degree for the five Illinois programs was 8.8 total semesters. Of the five programs, two programs consist of seven or eight semesters, one program consists of nine semesters, and two programs consist of ten semesters. As a comparison between associate degree programs and bachelor degree programs, there is an average of an additional two and a half semesters to earn a bachelor degree.

Total Number of Off-Campus Clinical Semesters

The twenty-two community colleges offered, on average, 4.9 clinical semesters as part of its associate's degree curriculum. These programs ranged between two and six clinical semesters – sixteen programs consisted of five clinical semesters, three programs consisted of six clinical semesters, two programs consisted of four clinical semesters, and one program consisted of two clinical semesters (the lone program to require two full semesters without any didactic work that focused on only one modality).

Interestingly, the five four-year programs offered, on average, 4.2 clinical semesters as part of its bachelor's degree curriculum. Of these programs, four programs required four clinical semesters, and one program required five clinical semesters. Further, of the five programs, three programs have didactic and clinical intermingling throughout the semester, while two of the programs separated the didactic and clinical semesters.

Astonishingly, when comparing the associate degree and bachelor degree programs, there

were actually more clinical hours for the two-year programs over the four-year programs. There are approximately 0.7 more clinical semesters for the associate's degree programs.

Total Number of On-Campus Laboratory (Procedure) Semesters

Illinois' twenty-two JRCERT accredited programs average 3.2 on-campus, laboratory semesters to earn an associate's degree. Of the twenty-two programs, eight programs required four or five semesters, nine programs required three semesters, and five programs required less than three semesters. The highest number of on-campus laboratory semesters was five, while the lowest was two on-campus laboratory semesters.

Unanticipated, the average number of total on-campus laboratory semesters to earn a degree for the five Illinois bachelor's programs was also 3.2 semesters. To the researcher's surprise, there was no difference in the number of on-campus laboratory semesters for associate degree and bachelor degree programs, with both degree programs ranging from two to five on-campus laboratory semesters.

Table 14C-RADIOLOGIC SCIENCE PROGRAM DETAILS

ASSOCIATE PROGRAMS	NUMBER OF SEMESTERS TO GRADUATE	NUMBER OF OFF-CAMPUS, CLINICAL SEMESTERS	NUMBER OF ON-CAMPUS LABORATORY (PROCEDURE) SEMESTERS
Associate Degree Radiology Program 1	7 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 2	7 Semesters and 3 Intersession Semesters	5 Semesters and 3 Intersession Semesters	2 Semesters
Associate Degree Radiology Program 3	7 Semesters	6 Semesters	4 Semesters
Associate Degree Radiology Program 4	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 5	7 Semesters	5 Semesters	4 Semesters
Associate Degree Radiology Program 6	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 7	6 Semesters	5 Semesters	5 Semesters
Associate Degree Radiology Program 8	5 Semesters	5 Semesters	4 Semesters
Associate Degree Radiology Program 9	6 Semesters	6 Semesters	3 Semesters
Associate Degree Radiology Program 10	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 11	6 Semesters	4 Semesters	3 Semesters

Associate Degree Radiology Program 12	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 13	7 Quarters	6 Quarters	5 Quarters
Associate Degree Radiology Program 14	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 15	6 Semesters	5 Semesters	4 Semesters
Associate Degree Radiology Program 16	6 Semesters	4 Semesters	2 Semesters
Associate Degree Radiology Program 17	6 Semesters	5 Semesters	4 Semesters
Associate Degree Radiology Program 18	5 Semesters	5 Semesters	2 Semesters
Associate Degree Radiology Program 19	7 Semesters	2 Semesters	2 Semesters
Associate Degree Radiology Program 20	6 Semesters	5 Semesters	3 Semesters
Associate Degree Radiology Program 21	6 Semesters	5 Semesters	4 Semesters
Associate Degree Radiology Program 22	5 Semesters	5 Semesters	4 Semesters

BACHELOR PROGRAMS	NUMBER OF SEMESTERS TO GRADUATE	NUMBER OF CLINICAL SEMESTERS	NUMBER OF ON-CAMPUS LABORATORY PROCEDURE SEMESTERS
Bachelor Degree Radiology Program 1	8 Semesters	4 Semesters	3 Semesters
Bachelor Degree Radiology Program 2	9 Semesters	5 Semesters	5 Semesters
Bachelor Degree Radiology Program 3	10 Semesters	4 Semesters	3 Semesters
Bachelor Degree Radiology Program 4	10 Semesters	4 Semesters	3 Semesters
Bachelor Degree Radiology Program 5	7 Semesters	4 Semesters	2 Semesters

Yearly Tuition Rates: Resident vs Non-Resident

Resident Tuition

The average annual residential tuition rate for Illinois associate degree programs was $7,364. Of the twenty-two programs, nine programs were less than $5,000 per year (41%), another nine programs were between: $5,000 - $8,000 (41%), and three programs were more than $8,000 per year (14%), and one program did not have current tuition rates (4%). The overall highest residential yearly tuition rate was a whopping $19,475 per year (with an average standard cost of $325 per credit hour), whereas the lowest residential tuition rate was $1,600 per year (with an average standard cost of $134 per credit hour) – an annual differential of $17,875!

When examining residential tuition for the Illinois bachelor degree programs, their average yearly rates were $21,532. Of the five programs, three programs were higher than $25,000 per year, and two programs were under $10,000 per year. The three programs that were higher than $25,000 per year were private institutions and of those three programs, their average cost per year was $29,720. The two programs that were under $10,000 per year were public institutions and those two programs averaged $9,250 per year. The overall highest residential yearly tuition rate was $32,000 per year (with an average standard undergraduate cost of $573.51), whereas the lowest residential tuition rate was $8,547.90 per year (with an average standard undergraduate cost of $321.50 per credit hour).

On average, the yearly cost of an in-state bachelor degree program is $14,167.69 more than an associate degree program. The national average in-state tuition per credit hour for an associate degree program is $141 per credit hour, whereas the average in-state tuition per credit hour for a bachelor degree program is $390 per credit hour (Hanson, 2022).

Non-Resident Tuition

The average non-resident yearly tuition rate for Illinois associate degree programs was $11,957.01. Of the twenty-two programs, one program was less than $5,000 per year, ten programs were between $5,000-$10,000, eight programs were between $10,000-$15,000, and one program was more than $15,000 per year (with two programs not reporting data for non-resident tuition rates) . The highest (annual) non-residential tuition rate was $27,395 per year, with an average standard cost of $420 per credit hour; whereas the lowest non-resident tuition rate was $2,400 per year, with an average standard cost of $324 per credit hour.

Contrastingly, the average non-resident yearly tuition rate for Illinois' bachelor degree programs was $21,532. Of these five, three programs were higher than $25,000 per year, and two programs were under $10,000 per year. The overall highest non-resident yearly tuition rate was $32,000 per year, with a standard undergraduate cost of $574 per credit hour; whereas the lowest non-resident tuition rate was $8,548 per year, with a standard undergraduate cost of $322 per credit hour.

On average, the yearly cost of a non-resident bachelor degree program is $9,575 more than an out-of-state associate degree program. The national average out-of-state tuition per credit hour for an associate degree program is $174 per credit hour, whereas the average out-of-state tuition per credit hour for a bachelor degree program is $1,126 per credit hour (Hanson, 2022).

Table 15-YEARLY TUITION RATES: RESIDENT VS NON-RESIDENT

ASSOCIATE PROGRAMS	YEARLY RESIDENT TUITION	YEARLY NON-RESIDENT TUITION
Associate Degree Radiology Program 1	5,040	11,772
Associate Degree Radiology Program 2	3,816	8,640
Associate Degree Radiology Program 3	19,475	27,395
Associate Degree Radiology Program 4	2,507	7,521
Associate Degree Radiology Program 5	5,550	15,000
Associate Degree Radiology Program 6	4,831	9,661
Associate Degree Radiology Program 7	6,244	11,138
Associate Degree Radiology Program 8	6,420	9,860
Associate Degree Radiology Program 9	8,500	N/A
Associate Degree Radiology Program 10	5,600	9,000
Associate Degree Radiology Program 11	4,858	10,558

Associate Degree Radiology Program 12	1,600	2,400
Associate Degree Radiology Program 13	N/A	N/A
Associate Degree Radiology Program 14	4,808	14,455.21
Associate Degree Radiology Program 15	7,305	13,124
Associate Degree Radiology Program 16	5,115	N/A
Associate Degree Radiology Program 17	5,355	10,605
Associate Degree Radiology Program 18	3,497	7,500
Associate Degree Radiology Program 19	8,415	8,415
Associate Degree Radiology Program 20	4,125	7,446
Associate Degree Radiology Program 21	19,000	19,000
Associate Degree Radiology Program 22	4,050	9,750

BACHELOR PROGRAMS	YEARLY RESIDENT TUITION	YEARLY NON-RESIDENT TUITION
Bachelor Degree Radiology Program 1	28,280	28,280
Bachelor Degree Radiology Program 2	28,872.50	28,872.50
Bachelor Degree Radiology Program 3	8,547.90	8,547.90
Bachelor Degree Radiology Program 4	9,958.75	9,958.75
Bachelor Degree Radiology Program 5	32,000	32,000

Additional Certifications Offered

Number of Schools that Offer Additional Certifications

All twenty-two Illinois associate degree programs offer the radiography certification. However, almost 70% (15 programs) offer additional certifications in "advanced modalities." Specifically, thirteen programs offer the computed tomography (CT) certification, seven programs offer the magnetic resonance imaging (MRI) certification, five programs offer the mammography certification, two programs offer the radiation therapy certification, two programs offer the sonography certification, two programs offer the cardiac interventional (CI) certification, two programs offer the nuclear medicine certification, one program offers echocardiography certification, and one program offers the radiology assistant certification.

Number of Additional Credit Hours for the Advanced Modality Certifications

Fifteen institutions offer nine certifications in advanced modalities. Each modality has varying credit hours, depending upon the degree of difficulty, ranging from 46 to 8.1 credit hours (see list below):

- Additional number of credit hours averaged for Mammography=8.1
- Additional number of credit hours averaged for Radiology Assistant=16.5
- Additional number of credit hours averaged for CT=18
- Additional number of credit hours averaged for MRI=21.4
- Additional number of credit hours averaged for Cardiac Interventional=28.5
- Additional number of credit hours averaged for Radiation Therapy=35
- Additional number of credit hours averaged for Nuclear Medicine=40
- Additional number of credit hours averaged for Echocardiography=41
- Additional number of credit hours averaged for Sonography=46

Of the five Illinois bachelor degree programs, four offer an advanced modality certifications option within their program. Specifically, two programs offer radiography plus radiation therapy certifications; one program offers radiography, CT, and MRI certifications; and the last program offers radiography and either CT, MRI, or women's imaging certifications.

Table 16-ADDITIONAL CERTIFICATIONS OFFERED

ASSOCIATE PROGRAMS	ADDITIONAL CERTIFICATIONS OFFERED AND NUMBER OF ADDITIONAL CREDIT HOURS
Associate Degree Radiology Program 1	Mammography (7), CT (18), MRI (27), Radiation Therapy (39), Nuclear Medicine (40)
Associate Degree Radiology Program 2	CT (16) & MRI (18)
Associate Degree Radiology Program 3	Echocardiography (41) and Sonography (42)
Associate Degree Radiology Program 4	CT (25), MRI (27), and Mammography (13)
Associate Degree Radiology Program 5	CT (16), MRI (16), and Mammography (4)
Associate Degree Radiology Program 6	CT (9)
Associate Degree Radiology Program 7	Radiology Assistant (16.5)
Associate Degree Radiology Program 8	CT (16), Mammography (7.5), Sonography (50)
Associate Degree Radiology Program 9	None Available
Associate Degree Radiology Program 10	None Available
Associate Degree Radiology Program 11	None Available

Associate Degree Radiology Program 12	CT (19) and Mammography (9)
Associate Degree Radiology Program 13	Offer B.S. Degree in Health Information Management-Online (Additional 2 Years for Degree Completion)
Associate Degree Radiology Program 14	None Available
Associate Degree Radiology Program 15	CT (12) and MRI (15)
Associate Degree Radiology Program 16	CT (16) and MRI (16)
Associate Degree Radiology Program 17	None Available
Associate Degree Radiology Program 18	CT (16)
Associate Degree Radiology Program 19	Bachelor Degree Completion Routes: CT/MRI, Rad Therapy, CI, and Radiology Management/Leadership (Additional Year for Degree Completion)
Associate Degree Radiology Program 20	CT (N/A)
Associate Degree Radiology Program 21	CT (22) and CI (26) Offers a Bachelor in Health Sciences
Associate Degree Radiology Program 22	Nuclear Medicine

BACHELOR PROGRAMS	**ADDITIONAL CERTIFICATIONS OFFERED-ARE ALL BUILT INTO THE BACHELOR DEGREE COMPLETION**
Bachelor Degree Radiology Program 1	Radiography AND either CT, MRI, or Women's Imaging- Choose one advanced modality
Bachelor Degree Radiology Program 2	Radiography
Bachelor Degree Radiology Program 3	Radiography AND Combined CT and MRI
Bachelor Degree Radiology Program 4	Radiography AND Radiation Therapy
Bachelor Degree Radiology Program 5	Optional Radiography (or pre-professional science) AND Radiation Therapy

2-Interviews

Interviewee Selection

The researcher selected one participant from ten Midwest hospitals for the interview process. All participants held a leadership/management role within the radiology department of the various hospitals and held a job classification of lead technologist, manager, or supervisor within radiology.

Technologist Profiles

"Dan". Dan is an Executive Director of Radiology at a central Illinois hospital. Dan has been in this role for over 40 years. He attended a hospital-based radiography program and later earned a bachelor degree in allied health and biology through Millikin University. Dan is credentialed in radiography.

"Brock". Brock is a Director of Radiology at a central Illinois hospital. Brock began his career as a staff X-Ray/CT technologist and through continuing his education is now in a leadership role. He earned his associate's degree in radiologic sciences from a local community college and later pursued a bachelor degree in healthcare administration from Purdue University. While Brock only received formal education in x-ray, he later cross-trained through on the job training into CT, and ultimately obtained credentials in radiography and computed tomography.

"Cole". Cole is a CT Imaging Supervisor at a hospital in the St. Louis, Missouri area. Cole began his career as a staff technologist in CT and now holds a leadership role. He earned his Bachelor of Science degree in radiologic sciences with a focus on CT/MRI from Southern Illinois University. Cole is credentialed in radiography and computed tomography, with ten years of experience. Currently, he is pursuing a master degree in healthcare management.

"Debra". Debra is a lead CT technologist at a southern Illinois hospital. She has over

ten years of experience in the field and is the most senior CT technologist at her facility. She attended a local community college for radiologic science and then transferred to Southern Illinois University to complete a Bachelor of Science degree in radiologic science with a focus on CT/MRI. Debra is credentialed in radiography and computed tomography.

"Derek". Derek is a lead CT technologist at a southern Illinois hospital. Derek has over fifteen years of experience in radiology. He has a Bachelor of Science degree in mortuary science. Later, he went back to school at Southern Illinois University to attend the radiologic science program. After the third year, he discontinued his education after the radiography portion of the program. Like Brock, he, too, was cross trained into CT. Derek is credentialed in radiography and computed tomography.

"Jessica". Jessica is a lead Diagnostic technologist at a southern Illinois hospital. She attended a community college to earn her associate degree with radiologic science and has over twenty-five years of experience. Later, she furthered her education with a Bachelor of Science through an online program. Although Jessica crossed trained into CT and vascular interventional (VI), she is only credentialed in radiography and VI.

"Kevin". Kevin is a Manager of Inpatient Imaging and Radiation Oncology at a central Illinois hospital. Kevin has been in this role for over twenty years. He attended a community college for radiologic science and later pursued a bachelor degree. He cross trained into MRI and is credentialed in radiography and magnetic resonance imaging (MRI).

"Lisa". Lisa is a lead CT technologist at a southern Illinois hospital. Lisa attended a local community college for radiologic science and then transferred to Southern Illinois University to complete her Bachelor of Science degree in radiologic science with a focus on CT/MRI. She has over five years of experience in the radiology field. Lisa is credentialed in

radiography, computed tomography, and magnetic resonance imaging.

"Michelle". Michelle is a CT Manager at a northern Illinois hospital. Michelle has over ten years of experience in the radiology field. She attended a hospital-based program for radiologic science and radiation therapy. Additionally, she cross trained into CT. Michelle is credentialed in radiography, radiation therapy, and computed tomography.

"Tom". Tom is an Imaging Manager at a central Illinois hospital. Tom received his associate degree in radiologic science from a local community college and then later went back to earn a bachelor degree and master degree in public administration. Additionally, Tom has experience as a staff technologist and an instructor in radiologic science at a community college. He cross trained into CT and is now credentialed in radiography and computed tomography.

Table 17 - TECHNOLOGISTS DEMOGRAPHICS

Technologist	Credentials	Position	Education	Cross Trained into Advanced Modality
“Dan”	RT(R)	Executive Director of Radiology	Hospital-Based, later earned B.S.	No, does not work in an advanced modality
“Brock”	RT(R)(CT)	Director of Radiology	Community College, later earned B.S.	Yes, CT
“Cole”	RT(R)(CT)	CT Imaging Supervisor	B.S.in CT/MRI	No, Education-based training
“Debra”	RT(R)(CT)	Lead CT Technologist	Transferred to 4-year from 2-year	No, Education-based training
“Derek”	RT(R)(CT)	Lead CT Technologist	Bachelor Degree, discontinued RAD program after 3rd year	Yes, CT
“Jessica”	RT(R)(VI)	Lead Diagnostic Technologist	Community college, later earned B.S.	Yes, CT and VI
“Kevin”	RT(R)(MR)	Manager of Inpatient Imaging	Community college, later earned B.S.	Yes, MRI
“Lisa”	RT(R)(CT)(MR)	Lead CT Technologist	Transferred to 4-year from 2-year	No, Education-based training
“Michelle”	RT(R)(T)(CT)	CT Manager	Hospital-Based Program Plus	Yes, CT
“Tom”	RT(R)(CT)	Imaging Manager	Community college, later B.S. and MPA	Yes, CT

Responses from Interview Questions

Interview Question One: What are some similarities and differences on the readiness of work for two-year vs four-year radiologic science graduates?

Of the ten interviews, six participants felt that four-year program graduates were readier to "hit the ground running" as a new technologist. They felt that those graduates had a better understanding of patient care, legal matters, and were more advanced from a technical standpoint. Additionally, they felt that four-year program graduates were less timid with patients than the two-year program graduates. "Cole" (CT imaging supervisor) stated "I can tell the level of the student we are getting from a four-year program; they understand the equipment a little bit more and they are more engaged with the why behind the scenes of scanning over a student from a two-year program."

However, the three other participants believed that the two-year graduates were more "hands-on" with the patients. They believed this was because students in two-year programs intermingle didactic and clinical work throughout the semester; whereas in four-year programs, the clinical and didactic are completely separate. Specifically, two-year program students are in a hospital setting every semester that they are in the radiologic science program, whereas students in four-year programs are in a hospital setting every other semester. One participant stated that she really did not observe a noticeable difference in the readiness of work between the two-year and four-year graduates.

Interview Question Two: What are the benefits of two-year and four-year programs? What are some reasons additional education is or is not supported at your organization?

Due to the current overall staffing shortages in healthcare, all ten participants stated that the main benefit of attending a two-year program was that graduates are able to start their career

quicker and can possibly be cross-trained into advanced modalities, if that was their preference. Furthermore, all ten participants stated that having a bachelor degree in radiology was not really necessary unless a student was pursuing a career in leadership or management. "Jessica" (lead diagnostic technologist) stated "After I received my bachelor's degree, I did not receive a bump in pay because a bachelor's degree is not required for my job. Although, the hospital did give me a tuition reimbursement once I graduated."

Lastly, again, all ten participants also stated that their hospital would support additional education for full-time employees. Although the hospitals do not require a degree beyond an associate degree for technologist positions, they are willing to assist the employees with continuing their education once they are hired. Many hospitals offer grants or tuition reimbursement options for pursuing higher education or advanced certifications. "Kevin" (manager of inpatient imaging) stated "If there are students interested in working now, we offer a tuition reimbursement after they have been employed for three months and we will pay for the school tuition."

Interview Question Three: Does your facility prefer to employ technologists who are multi-credentialed, why or why not?

Although all participants articulated there was value in having an employee that is multi-credentialed, only three participants utilized their technologists in more than one modality. Surprisingly, the other seven participants stated that technologists typically stay in only one modality, so being multi-credentialed is not a necessity.

However, all ten participants felt that multi-credentialed technologists are more of a benefit at smaller facilities where there are a limited number of technologists in the radiology department. "Debra" (lead CT technologist) stated at her facility with sister hospitals, "We have

PRN positions that cover imaging in general, so having someone credentialed in more than one modality is quite beneficial." Additionally, five of the ten participants were worried that having technologists working in dual modalities could cause scheduling issues. "Tom" (imaging manager) stated "Having a bucket of technologists that float from various modalities can cause a scheduling conundrum, which is why most of our technologists stay in one modality."

All ten participants have employed technologists who were later cross-trained from X-Ray into CT. Having a prospective employee that is multi-credentialed versus a candidate with only one credential was not a factor in determining who to hire. Nine of the ten participants stated that technologists must be credentialed in the modality upon which they work within 12-18 months of their hire date.

Interview Question Four: What are some pros and cons for having technologists capable of working in more than one modality?

All ten participants felt that a technologist is more valuable when they can work in more than one modality, however, many of the larger facilities do not float their technologists around in the various modalities. Five participants stated that having the flexibility to move technologists to cover staffing shortages has been a huge benefit. Four of these five participants stated that this is a new concept that they have had to adapt to with staffing shortages. "Michelle" (CT manager) stated "I would love to have a world where we had more technologists who knew more than one modality and could be more fluid with their job assignments."

From a management perspective, three participants stated that it could present a scheduling issue when someone is working part-time in CT and in MRI. Larger hospitals have the modalities in separate departments, so there can be scheduling conflicts between managers of each modality. Additionally from a management perspective, having technologists who work in

more than one modality can cause hard feelings between technologists in regards to who has more seniority in each modality. Lastly, these same three participants also felt that the technologist's skills can be hindered by alternating the modalities in which they work. "Kevin" (manager of inpatient imaging) stated "In our environment where our scanning protocols change so rapidly in our advanced modalities, it is harder to keep someone competent in more than one modality."

Interview Question Five: Is it preferred to hire technologists who are already trained in multiple modalities or is it preferred to hire technologists that will need to be cross trained in other modalities, and why?

Of the ten participants interviewed, eight participants preferred for the technologist to already be trained in the modality. Functionally, they saw a benefit of the previously-training technologist being able to scan solo quicker. But, the most beneficial aspect of already being trained was the technologist's understanding of cross-sectional anatomy, which was lacking in technologists who were cross-trained.

Two of the ten participants felt indifferent because they saw positive/negative to whether or not a technologist was previously trained. The primary benefit was that the technologist already has a basic knowledge of how to scan in that modality. The key negative aspect was that the technologist may be "set in their ways" and not as willing to be flexible to a different hospital's protocols. "Derek" (lead CT technologist) stated "It is hard to teach somebody about CT and experience goes a long way in my personal book, however, some technologists that have experience do not come to a new facility with an open mind about protocols, so it can be a double-edged sword."

Interview Question Six: What could four-year programs do to attract future students to their programs?

Of the ten participants that were interviewed, six of them recommended an online portion to the bachelor completion. Allowing students to complete their didactic portion online and then complete their clinical internship at the hospital in which they are already employed would be beneficial. Interestingly, no participant felt that the four-year program was lacking in its curriculum.

Six of the participants offered suggestions as to how to improve a four-year program. One participant mentioned having a bachelor degree tract that does not lead into learning an advanced modality. Specifically, they recommended a tract into leadership for those technologists who wish to advance their career in a leadership role.

A second participant suggested having more healthcare-based general education courses rather than the traditional type of general education courses. “Debra” (lead CT technologist) stated “I had to complete a lot of random classes just to get a bachelor’s degree, so it felt like wasted time and wasted money. Having courses that are more healthcare related would have been more beneficial."

A third participant mentioned having more collaborations with hospitals. For example, allowing the students to complete their clinical internships at the hospitals they know they want to work at when they are completely done with the program. “Lisa” (lead CT technologist) stated “For me, the collaboration of SIH and SIU attracted me to the SIU radiologic science program. I wanted to stay local and being a clinical student at SIH got my foot in the door for employment.”

Lastly, three participants mentioned that four-year programs need to promote what a

technologist can do with a bachelor degree in radiologic science. Additionally, having testimonials from graduates with a bachelor degree or higher promote what jobs they are able to attain with a higher degree. Along with the testimonials, showcase the new advancements in the modalities by showing images that entice the student to want to learn more about the modalities. As "Tom" (imaging manager) stated "draw students in with cool imaging and then share testimonials of how this modality made such an impact in the life of the patient and tie that in with someone such as a family member."

Interview Question Seven: Why do you think more students enroll into two-year programs and is it worth the cost to continue your education?

The three primary responses for this question focused on time, cost, and location. First, six participants stated the main reason associate degree programs have more students is because the students can complete their education quicker and start their career earlier than the four-year graduates. Although, one participant mentioned that associate degree programs are actually more than two years, with many community college programs taking two to three years in length when program prerequisites are added. "Dan" (executive director of radiology) stated "the two year associate degree programs are really more like three year programs because they just do not take you right out of high school anymore. You have prerequisites that are required before entering the two-year program." The primary downside to the two-year program is the additional time it takes for hospitals to cross-train a technologist into another modality. "Kevin" (manager of inpatient imaging) stated "I cannot take the time to cross train somebody into MRI, it would be too difficult to learn in a short period of time."

The second key factor for two-year programs was cost. Four participants stated that the cost difference between two-year and four-year programs was the main reason more students

enrolled in the associate degree programs. "Brock" (director of radiology) stated, "When I was looking in radiologic science programs, cost was definitely a consideration. I also thought about transferring to SIU after my associate's degree to complete my bachelor's degree with CT/MRI, but it is difficult to justify going off to college when you are getting the job already." "Cole" (CT imaging supervisor) stated "If a student is paying for school on their own, they are going to take the quicker and easier route to get out and start paying their loans off." "Lisa" (lead CT technologist) stated, "I think the cost was worth the benefit because I felt better prepared in the advanced modalities with the structured classroom experience and clinical experience."

Lastly, three participants felt that location plays a large role in students' decision between a two-year and four-year program. With a two-year program, the clinical internships have to be in close proximity to the college because they intermingle didactic and clinical work throughout the semesters. On the other hand, four-year programs potentially could have their clinical internships in a different state because their semesters do not intermingle didactic and clinical work. Unfortunately, this may mean the student will have to relocate for a semester to be closer to their clinical internship; therefore, this can also be an additional financial burden upon the student. "Jessica" (lead diagnostic technologist) stated, "I think cost and location are the main reasons for choosing a two-year program. The students are young and if they can still live at home with their parents, then they do not need to worry about the cost of living expenses."

Of interest was that nine participants stated additional education is really only beneficial if one plans to enter a leadership role within the radiology field, such as a supervisor or manager. Likewise, additional education is not needed to become a staff technologist. "Debra" (lead CT technologist) stated, "As a staff technologist, a bachelor degree doesn't really help you and the hospital does not pay you more per hour with additional degrees." However, the remaining

participant felt that a baccalaureate degree provided her with more knowledge of healthcare in general, which enabled her to be a better technologist.

Summary

In this chapter, the researcher showcased the Illinois JRCERT accredited associate and bachelor degree Radiologic Science programs to investigate the curricular and technical similarities and differences. Additionally, the researcher introduced the participants who were interviewed. The profiles help to illustrate participant preferences upon hiring Radiologic Science graduates. Also, gaining perspective on what four-year programs can do to attract more students was beneficial. In the following chapter, the researcher will present the recommendations for four-year radiologic science programs by organizing the findings into four themes to help answer the research questions of the study.

CHAPTER 5

SUMMARY

The purpose of this study was to ensure that future radiologic technologists are properly trained and ready for the workforce, given the continued demand for Radiologic Science services. Since higher education training programs differ in their curricular requirements, it was important to study the similarities and differences between what two-year and four-year programs offer. In addition, this study also reviewed the differences in the technical skills between two-year and four-year Radiologic Science programs.

This study reviewed two-year and four-year Radiologic Science programs through document analysis and interviews with radiology hospital administration. Document analysis was conducted through reviewing program outcomes, comparing Illinois' twenty-seven-degree programs, and the following national association websites: JRCERT, ASRT, and the ARRT. Interviews were conducted with one radiology administrator from 10 different hospitals that house both two-year and four-year Illinois Radiologic Science program students. Utilizing these two methodologies, the researcher was able to address the following research questions:

1. What are the similarities and differences between two-year and four-year Radiologic Science programs?

   1a. Curricular: What are the similarities and differences between the number of credit hours, semesters, faculty, students, tuition rates, and certifications offered, as well as program outcomes (e.g., program completion rates, job placement rates, and ARRT pass rates) between two-year and four-year programs?

   1b. Technical Skills: What are the similarities and differences between technologists who are multi-credentialed with a bachelor degree versus

technologists who are single-credentialed with an associate degree?

2. What are the factors that influence a student's decision to enroll in either a two-year or four-year Radiologic Science program?

   2a. How does the cost of a program (i.e., tuition/fees as well as lost income) impact students' decisions to attend a two-year or four-year Radiologic Science program?

Research Question One

RQ 1: "What are the similarities and differences between two-year and four-year Radiologic Science programs?" This question was divided into two primary components – curriculum and technical skills – to examine what, if any, differentiation exists between two-year and four-year programs.

Curricular Comparisons

In answering this question, there were three main factors for consideration: (1) program outcomes (program completion rates, job placement rates, and ARRT national examination pass rates); (2) program details (number of credit hours, semesters, students, and faculty); and (3) additional certifications offered per institution.

(1) Program Outcomes

Foremost, data revealed there were little differences (>1%) in the ARRT examination pass rates as well as job placement rates between associate degree programs and bachelor degree programs. With both of these degree programs having very high national examination pass rates and job placement rates, prospective students could have difficulty justifying why a student would undertake a four-year program over a two-year program. However, one redeeming program outcome component for the four-year programs was, on average, bachelor degree

programs have a 12% higher program completion rate over the associate degree programs.

(2) Program Details

To no surprise, a clear difference between degree programs was the number of credit hours and semesters. After reviewing the curriculum for the various programs, there were an additional 51 (on average) credit hours and an additional 2.6 semesters to attain a bachelor degree beyond the associate degree. With most students undertaking two-three years to complete an associate degree program in Radiologic Science, obtaining a bachelor degree would take the student an additional one-two more years to complete. Furthermore, even though there was a slight difference in the number of students and number of faculty, the bottom line was that bachelor degree programs have smaller class sizes along with a greater number of faculty. Specifically, the associate degree programs averaged 18.5 students per class and 3.3 faculty per program, while the bachelor degree programs averaged 13.5 students per class and 4.4 faculty per program.

(3) Additional Certifications

The two-year programs offer many of the same certifications as the four-year programs. Of the five Illinois bachelor degree programs in this study, the only certifications offered within these four-year programs were CT, MRI, and radiation therapy. Of the twenty-two associate degree programs, x-ray is the only modality offered within the two-year program, but the student does have the option for a post-associate degree certificate in the following areas: CT, MRI, mammography, radiation therapy, sonography certification, cardiac interventional, nuclear medicine, echocardiography, and radiology assistant.

Technical Skills

Through the interviews conducted for this study, most hospital administrators concluded

that the four-year graduates have a higher level of technical understanding over the two-year graduates. Administrators expressed that there was value in furthering a student's education, but only for those seeking advancement in leadership roles. However, in practice, hospitals are being forced to cross-train their employees rather than waiting for them to complete a four-year program due to staffing shortages that have plagued the hospitals, especially since COVID-19. Further, administrators also mentioned that if technologists wanted to pursue a bachelor degree, that an online program might prove most beneficial – allowing technologists to work a full-time job and not have the scheduling conflicts of attending class in-person. Nonetheless, nearly every administrator declared that it is more important for a staff technologist to be credentialed in more than one modality than it is to earn a higher degree.

One major difference between the two-degree programs was the impact of the clinical internships. The two-year programs intermingled their clinical and didactic work throughout the semesters (on average five or six semesters); whereas, the four-year programs conducted didactic and clinical work separately (on average three or four semesters). When comparing the two programs, since the associate degree programs are in a hospital setting every semester, some administrators believe that the two-year graduates have more hands-on experience over the four-year graduates. Although, one benefit to the four-year programs is the option to extend the radius of the clinical internships, which can allow them to gain a broader clinical experience since fewer students would be competing for exam competencies.

Research Question Two

RQ 2: "What are the students' determining factors in their decision to enroll in either a two-year or four-year Radiologic Science program?" "How does the cost of a program (i.e., tuition/fees as well as lost income) impact students' decisions to attend a two-year or four-year

Radiologic Science program?"

Administrators concluded that cost played the primary role in students' decision to attend an associate degree or a bachelor degree program. Annual tuition rates averaged approximately $10,000 more per year for the four-year programs ($40,000 total). One possible explanation for this tuition differential is that three of the five bachelor degree programs were private institutions – and traditionally more expensive – which had the effect of skewing the tuition upward. Specifically, the three private baccalaureate institutions averaged $29,720 per year, while the two public institutions averaged $9,250 per year. None of the community colleges were private institutions. With on-the-job training available and lack of necessity for additional education (unless one is pursuing a leadership role), most students tend to choose a program where they can finish faster, have fewer student loans, and thus get an earlier start to their career.

Another cost consideration with the four-year programs is the relocation expenses associated with moving closer to their clinical internship site for a semester and then returning back to campus the following didactic semester. This is an additional cost that two-year program students do not incur because the clinical and didactic semesters are intermingled, thus allowing clinical sites to be close in proximity to the college.

In sum, since it takes additional time (approximately one or two more additional years) to complete a bachelor degree, along with the additional costs of increased tuition and clinical internship relocation, students may find it difficult to justify additional education since they can be gainfully employed after earning an associate degree.

Reflections

Trouble for the four-year Radiologic Science programs….

Much to my dismay, it appears that formal education beyond an associate degree is not warranted for a staff technologist. The data show three primary factors that have influenced why students are increasingly leaning toward attending a two-year program: Industry, Outcomes, and Cost.

First and foremost, the healthcare industry is driving Radiologic Science education. Specifically, hospitals now cross-train their associate-degree technologists in lieu of sending them back to school for additional training in modalities. Moreover, radiology administrators are not requiring their employees to have additional degree coursework, unless pursuing a leadership role.

Even though being a multi-credentialed technologist has its benefits – such as being more marketable, having more job options, having a broader understanding of the radiology field, and having the ability to be utilized in more than one modality– many of the larger hospitals only utilize their employees in one modality. The idea of becoming a multi-credentialed technologist upon graduation may not be as appealing since many technologists typically only work in one modality. In sum, the industry is not requiring formal four-year training for Radiologic Science.

A heartbreaker for the four-year programs is that many two-year programs offer additional certifications after the completion of the associate degree. Unfortunately, the associate degree programs offer the same certifications as the four-year programs. Further, with the majority of additional certifications being offered online through two-year programs, this has proven to be an area of concern for the in-person four-year programs.

Second is the equity in assessment outcomes between degree programs. Specifically, the

ARRT examination pass rates are nearly identical (90% vs 91%) for both associate and baccalaureate degree programs. Consequently, students ponder whether to incur extra costs when the quality of the assessment outcomes (i.e., certification) are equal?

Lastly, if the other factors were not influential enough, the final primary factor why students may lean towards an associate degree program is cost. Namely, baccalaureate tuition rates are higher than associate degree programs; plus, there is an extra cost of clinical internship relocation fees for the four-year programs that the two-year programs do not incur.

Recommendations to the Profession

Collaborations: Based upon these conclusions, the future of four-year Radiologic Science as an academic discipline could be in real trouble unless they are ready to make some programmatic changes. Collaborations between two-year and four-year programs are very important to the survival of four-year programs. Therefore, anything four-year programs can do to work together with two-year programs could benefit not only the students, but also the healthcare institutions during this critical staffing shortage era. Unfortunately, it can be difficult not to antagonize the two-year programs since many are offering the same additional certifications, just without the bachelor degree. By recommending students to the four-year programs, it could be the demise of the associate degree advanced certification programs. These are difficult conversations, but they could prove beneficial if both parties are willing to work together for the benefit of the healthcare staffing shortages.

Additional Certifications: Only two of twenty-two associate degree programs in this study offered the nuclear medicine certification. Upon further evaluation, there were only eight programs in Illinois that offer the nuclear medicine certification. Four-year programs could benefit from adding this modality to their curriculum.

Four-year programs could also benefit by adding an online tract into leadership rather than an additional modality. This could be a huge benefit for technologists that would like to pursue a leadership role and need a bachelor degree to meet the minimum job requirements. An online program like this could still allow the technologist to work full-time while continuing their education.

Mode of Teaching: Many hospital administrators felt that the senior year advanced modality certification should be online. This concept not only allows the students to be working full-time as a technologist while learning another modality, but is also beneficial to the hospital because they are learning another modality in order to fill the staffing shortage gaps, thus removing the burden of cross-training. Unfortunately, one concern that four-year programs must consider is that if they switch to an online program, there is potential that the ARRT national examination pass rates could suffer, as students do not have the in-class teaching with the instructor. For the survival of the four-year programs, it is crucial to consider these program changes.

Marketing and Recruitment: Furthermore, marketing efforts need to be increased for the four-year programs to showcase future career opportunities that can arise with a bachelor degree. Most students do not fully understand what career advancements are available with the addition of a bachelor degree. These marketing efforts should be illustrated during open houses and student recruitment campaigns.

Student Awareness

To stay competitive, four-year programs need to showcase that the advanced modality programs are JRCERT-accredited, because many of the associate degree advanced modality programs are not JRCERT-accredited. Four-year programs also need to find ways to educate

students on the importance of accredited programs as well as considering an online portion of the program as a way to increase enrollment.

Future Research

- One future study of most interest to the researcher is to assess the ARRT advanced modality national pass rates for post-primary (those that cross train) versus primary route (those that attended an educational program). Furthermore, examining ARRT advanced modality pass rates between associate degree programs versus bachelor degree programs.
- Researchers may benefit from conducting a document analysis among radiologic science programs throughout different states. Additionally, a comparison study between those different states could be done.
- Another research opportunity could be interviewing graduates from two-year and four-year programs to learn why they chose their degree route.
- Universities could benefit from researching the impact of collaboration efforts with two-year institutions and what students feel would make for a smoother transition to a four-year institution.
- Lastly, a research study on the cost difference between bachelor and associate degree programs could be beneficial. Furthermore, was the vast cost difference between private versus public bachelor degree programs worth the additional costs?

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APPENDIX A

LIST OF ILLINOIS BACHELOR DEGREE AND ASSOCIATE DEGREE RADIOLOGIC SCIENCE PROGRAMS

80 Bachelor Degree Programs for Radiologic Science in the U.S. accredited by JRCERT

- 5 Bachelor of Science Degree Programs in Illinois for Radiologic Science
    - Each have different Baccalaureate Tracts
    - Blessing-Rieman College of Nursing & Health Sciences, Quincy, IL-**Radiography**
    - Oak Point University, Oak Brook, IL-**Radiography**
    - Southern Illinois University, Carbondale, IL-**CT/MRI**
    - Southern Illinois University, Carbondale, IL-**Radiation Therapy**
    - University of St. Francis, Joliet, IL-**Radiation Therapy**

472 Associate Degree Programs for Radiologic Science in the U.S. accredited by JRCERT

- 22 Associate Degree Programs in Illinois for Radiologic Science
    - College of DuPage, Glen Ellyn, IL
    - College of Lake County, Grayslake, IL
    - Danville Area Community College, Danville, IL
    - Elgin Community College, Elgin, IL
    - Harper College, Palatine, IL
    - Heartland Community College, Normal, IL
    - Illinois Central College-Peoria Campus, Peoria, IL
    - Kaskaskia College, Centralia, IL
    - Kishwaukee College, Malta, IL

- Lincoln Land Community College, Springfield, IL
- Malcolm X College, Chicago, IL
- Moraine Valley Community College, Palos Hills, IL
- Northwestern College, Bridgeview, IL
- Olney Central College, Olney, IL
- Parkland College, Champaign, IL
- Rend Lake College, Ina, IL
- Richland Community College, Decatur, IL
- Sauk Valley Community College, Dixon, IL
- Southern Illinois University, Carbondale, IL
- Southwestern Illinois College, Belleville, IL
- Trinity College of Nursing and Health Sciences, Rock Island, IL
- Triton College, River Grove, IL

APPENDIX B

CONSENT AGREEMENT

Consent Form

My name is Jennifer Walker. I am a graduate student in the School of Education at Southern Illinois University. I am asking you to participate in my research study.

The purpose of my study is: Given the continued demand for Radiologic Science services, it is important that future radiologic technologists are properly trained and ready for the workforce. Since higher education training programs differ in their curricular requirements, it is important to study the similarities and differences between what two-year and four-year programs offer. Further, I am interested in learning the differences in the curriculum between four-year Radiologic Science programs and if these program graduates are better prepared to work in various modalities throughout the imaging department.

Participation is voluntary. If you choose to participate in the study, it will take approximately 30 minutes of your time. You will be asked 7 interview questions via Zoom. The interview will be recorded and transcribed afterwards. For those individuals who decline to be recorded, they will be ineligible to participate in the study. The minimum requirement of the study is to be a Registered Radiographer.

All participants must be at least 18 years old to participate in the study.
There is no penalty for not participating or for withdrawing from the study. If you choose to withdraw, you will just need to send me an email of decline. Any information submitted prior to your withdrawal will be deleted.

All your responses will be kept confidential within reasonable limits. No participant name or hospital affiliation will be revealed in the study. Only those directly involved with this project will have access to the data. I will take all reasonable steps to protect your identity.

You may decline any interview question that you would prefer not to answer.

There are no anticipated risks associated with this study. The benefits of the participation will be to study the similarities and differences of Radiologic Science programs and further to see if there are areas of improvement that the SIU CT/MRI Program can incorporate to make the program stronger while increasing enrollment.

I agree/disagree that Jennifer Walker may quote me anonymously or with a pseudonym in her research.

Signature of Participant _____ Date _____

If you have any questions about the study, please contact me or my advisor.

Jennifer Walker
Jennifer.walker@siu.edu
618-453-8812

Brad Colwell
School of Education
Educational Administration and Higher Education
bcolwell@siu.edu
618-453-7309

Thank you for taking the time to assist me with my research.

This project has been reviewed and approved by the SIUC Institutional Review Board. Questions concerning your rights as a participant in this research may be addressed to the committee chairperson, Office of Research Compliance, SIUC, Carbondale, IL 62901. Phone (618)453-4534. E-mail: siuhsc@siu.edu

APPENDIX C

INTERVIEW QUESTIONS

1. What are some similarities and differences on the readiness of work for two-year vs four-year radiologic science graduates?
2. What are the benefits of two-year and four-year programs? What are some reasons additional education is or is not supported at your organization?
3. Does your facility prefer to employ technologists who are multi-credentialed, why or why not?
4. What are some pros and cons of having technologists capable of working in more than one modality?
5. Is it preferred to hire technologists who are already trained in multiple modalities or is it preferred to hire technologists that will need to be cross trained in other modalities, and why?
6. What could four-year programs do to attract future students to their programs?
7. Why do you think more students enroll into two-year programs? Is it worth the cost to continue your education?

APPENDIX D

INSTITUTIONAL REVIEW BOARD OF SOUTHERN ILLINOIS UNIVERSITY
CARBONDALE APPROVAL FORM

To: Jennifer Walker
From: M. Daniel Becque
Chair, Institutional Review Board

Date: November 21, 2022
Title: Evaluating Educational Degree Options Within Radiologic Science Programs
Protocol Number: 22202

The SIUC Institutional Review Board has approved the above-referenced study. The study is determined to be exempt according to 45 CFR 46.104. This approval does not have an expiration date. However, this approval is valid only for as long as you are a student or employee of SIUC. Additionally, any future modifications to your protocol must be submitted to the IRB for review and approval before implementation.

The IRB requests updates on exempted studies every three years. Failure to file a project update report may lead to the premature closure of your protocol.

When your study is complete, please fill out and return a study close-out form. A study is considered complete when you are no longer enrolling new participants, collecting or analyzing data.

Best wishes for a successful study.

This institution has an Assurance on file with the USDHHS Office of Human Research Protection. The Assurance number is FWA00005334.

MDB:eb
cc: Brad Colwell

VITA

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Associate of Applied Sciences and Arts, Radiologic Science, 2000

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Evaluating Educational Degree Options Within Radiologic Science Programs

Major Professor: William Bradley Colwell, Ph.D., J.D.