Nuclear Medicine Technologists' Motivations to Pursue Post-Primary Credentials

Donna C. Mars

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NUCLEAR MEDICINE TECHNOLOGISTS’ MOTIVATIONS TO PURSUE POST-PRIMARY CREDENTIALS

by

Donna C. Mars

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Submitted in Partial Fulfillment of the
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Abstract

The purpose of this quantitative study was to examine the motivations guiding nuclear medicine technologists to pursue post-primary credentials in computed tomography (CT) or magnetic resonance imaging (MRI) through the framework of the expectancy-value theory. A survey was used to answer the research question: Do the values nuclear medicine technologists associate with a post-primary certification in CT or MRI predict their intention to pursue a post-primary credential? The study included certified nuclear medicine technologists from eight states in the southeastern regions of the United States. The answers from 237 respondent, which equates to 8.6% of the population, were used in the final analysis for the study. Multiple regression analysis was used to examine which predictor variables (i.e. years of experience, type of nuclear medicine technology program, expectancy belief, and subjective task values) may predict the intent to pursue a post-primary credential in CT or MRI.

Findings show that attainment value, or importance of the task, was a predictor of future intent to pursue a CT credential. In addition, ‘years of experience’ was identified as a statistically significant contributing factor of whether nuclear medicine technologists pursue post-primary credentials in CT or MRI. The ‘years of experience’ predictor variable was inversely related with a technologist’s intent to pursue a post-primary credential, suggesting as the technologist’s years of experience increases by one standard deviation, the perceived intent to pursue a post-primary credential would likely decrease. Three implications were drawn from this study: 1) as the technologist increases in years, the likelihood of pursuing post-primary credentials decreases; 2) a post-primary credential in CT must have attainment value, meaning the credential must be important or
personally significant; and 3) perceived barriers to pursing a post-primary credential are possible to overcome. Based on these implications, to increase the number of post-primary credentialed technologists, colleges and universities should focus recruitment efforts on early career technologists while increasing the technologist’s attainment value associated with multiple credentials and the future of nuclear medicine technology.
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Chapter 1

Introduction

Hybrid imaging has created new challenges for health care professionals in the workforce over the past decade. In the field of nuclear medicine technology, new hybrid imaging technologies have resulted in the need for multi-skilled technologists. The term “hybrid imaging” refers to the physical fusion of more than one diagnostic imaging tool to provide anatomical and functional imaging information in one environment” (Griffiths & Dawson, 2015, p. 5). As a result of the new imaging technology, health care professionals are challenged with developing new knowledge and skills to work in this new health care environment. This challenge is especially true for the nuclear medicine technologist.

The traditional roles of a medical radiographer and a nuclear medicine technologist have blended with the new advances in imaging technology. Computed tomography (CT) has traditionally been considered an imaging modality solely performed by medical radiographers; however, the CT technology is now included in the entry-level educational requirements of a nuclear medicine technologist due to hybrid imaging systems such as SPECT/CT (Single Photon Emission Computed Tomography/Computed Tomography) and PET/CT (Positron Emission Tomography/Computed Tomography). This physical combination of independent imaging modalities has resulted in “improved diagnostic accuracy and confidence” for the radiologist reading the studies (Cal-Gonzalez et al., 2018, p. 1). For the patient, the hybrid systems have improved patient comfort and satisfaction, since hybrid imaging potentially can eliminate two separate imaging procedures (Cal-Gonzalez et al., 2018). However, for the nuclear
medicine technologist, the development of new hybrid technology, although exciting for the profession, results in new challenges.

The new hybrid imaging environment has placed additional pressure on the nuclear medicine technologist since a large portion of the current workforce has not had training or experience with CT (Griffith & Dawson, 2015). With the recent addition of PET/MRI (Positron Emission Tomography/ Magnetic Resonance Imaging) hybrid systems, the pressure to gain new knowledge and skills has become even greater since PET/MRI would require the technologist to have expertise in both PET and MRI imaging (Latour, 2016). As a result of these new hybrid imaging systems, nuclear medicine technologists must increase their level of knowledge and skills to remain current in the profession.

Background of the Study

In the 1990s, the trend toward specialized health services resulted in a rapid growth in human resource job categories, especially in the area of allied health careers (Fottler, 1996). According to the Association of Schools of Allied Health Professionals (ASAHP, 2017), allied health professions represent as much as 60% of the U.S. healthcare workforce. With the introduction of hybrid imaging in this era of specialized services, the question concerning which professional domain should actually own the technology has developed (Griffiths, 2015). The advances in hybrid images has resulted in an interest for a multi-skilled health care professional in the healthcare setting.

Entry-Level Education

Colleges and universities are often faced with the challenge of preparing individuals for multi-skilled roles (Sherrill & Keels-Williams, 2005). Although education
needs to address the current shortfall in developing technologists with hybrid imaging expertise (Beyer et al., 2018), Owen et al. (2005) state the knowledge and skills needed to address multimodal imaging is “not easily delivered within the current structure for entry-level educational programs in nuclear medicine technology” (p. 186). Nuclear medicine technology programs are currently offered in a wide variety of formats. The terminal degree offered in entry-level nuclear medicine programs includes certificate, associate, bachelors, and masters. The lack of consistent educational standards has the potential to weaken the reputation of the profession, which may result in exclusion from policy decisions within the health care institution (CHWS, 2006).

The entry-level, primary pathway for graduates of nuclear medicine technology programs is certification through either the Nuclear Medicine Technology Certification Board (NMTCB) or The American Registry of Radiologic Technologists (ARRT). Due to the emergence of hybrid imaging systems, the NMTCB in 2011 added questions relating to CT imaging as part of the NMTCB entry-level, primary-pathway examination (Pagnanelli, 2011). An analysis report prepared by the Center for Health Workforce Studies of the University at Albany (2006), the report states that hybrid-imaging technologies are certain to replace multiple imaging using different modalities. The reports warns “[i]f NMTs [Nuclear Medicine Technologists] do not acquire traditional imaging skills and certifications to complement their NM [Nuclear Medicine] skills, radiologic technologists (RTs) and other hybrid professionals will increasingly be asked to perform tasks now reserved of NMTs” (CHWS, 2006, p. 245). To address the need for additional expertise in CT, in 2014, the NMTCB developed a post-primary certification exam for CT (Nielson, 2014). The NMTCB(CT) exam was developed “to establish
competency of nuclear medicine technologists to perform CT procedures” (NMTCB, 2017b). Despite the emphasis on CT certification, a study conducted by the NMTCB in 2018 found only 18% of nuclear medicine technologists were dual certified in nuclear medicine technology and CT (Passmore, 2019).

**Workplace Knowledge Gap**

The National Academies of Science, Engineering, and Medicine (NASEM, 2019) point out that much of the discussion about training future health care workers is “focused on redesigning the curricula used to prepare students to enter the work environment”; however, in the current work environment, new graduates represent a small percentage of the overall workforce (p. 10). A large portion of the current nuclear medicine technology workforce have not had training or experience with CT or MRI (Griffiths & Dawson, 2015). As a result, new entrants to the healthcare system will not transform the workplace (NASEM, 2019). Technologists who graduated ten years ago are working with new imaging technologies and radiopharmaceuticals that did not exist when they received their nuclear medicine education (Middlebrooks, 2020).

**Barriers in the Workplace**

For allied health professionals, the education and training necessary to develop the new knowledge and skills can occur either within or external to the workplace (Golder et al., 2016). Within the workplace, allied health professionals face several challenges. Lloyd et al. (2014) state allied health professionals frequently point to “heavy workloads, insufficient staffing, and lack of access to peers and expert knowledge” as key barriers to workplace learning (p. 5). Barriers to education provided external to the workplace may include the added cost to the health care system or the health care
professional (Curran et al., 2006; Lloyd et al., 2014; NASEM, 2019). Healthcare providers are unable to educate the current workforce mainly because they do not have the curricula or processes in place to address the rapidly changing healthcare environment (NASEM, 2019).

**Statement of the Problem**

Nuclear medicine technologists face several workforce challenges relating to training in the new hybrid-imaging environment. Advances in hybrid imaging technology have resulted in the need for multi-skilled technologists within the nuclear medicine technology workforce; however, few nuclear medicine technologists take advantage of the educational opportunities to pursue post-primary credentials associated with the new imaging systems (Beyer, et al., 2018). As a result, nuclear medicine technologists may lack the imaging skills and knowledge to fully operate the hybrid imaging systems.

The traditional roles of a medical radiographer and a nuclear medicine technologist have blended with the new hybrid imaging technology. CT has traditionally been considered an imaging modality solely performed by medical radiographers; however, due to hybrid imaging systems such as SPECT/CT and PET/CT, the CT technology is now included in the entry-level educational requirements of a nuclear medicine technologist. Most recently, PET/MRI was added as a new hybrid imaging system, requiring the nuclear medicine workforce to become familiar with MRI.

For the nuclear medicine technologist, the knowledge and skills required to meet the educational requirements for post-primary certification in CT or MRI is difficult to obtain in the workplace environment. Barriers relating to the training of healthcare professionals across disciplines often relate to busy work schedules and lack of access to
the training (Mada et al., 2020). The role of higher education in workforce development is still undefined (Gallagher, 2016).

The bachelor’s degree is often view as the entry-level standard for many professionals, especially since many employers valued the degree due to the skillset demonstrated, including both soft skills and technical skills (Gallagher, 2016). Entry-level nuclear medicine technology programs are currently offered at the certificate, associate, bachelor’s, and master’s degree levels. The question arises whether all current program levels can sufficiently include in their curriculum the additional knowledge and skills required of the entry-level technologist in today’s workforce.

Based on workforce needs, the Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRCNMT) requires hybrid imaging to be included in the minimum didactic content areas of nuclear medicine technology programs. Likewise, the minimum certification requirements, to become credentialed as a nuclear medicine technologist, demand applicants demonstrate the necessary knowledge and skills to perform the duties required to work in this hybrid-imaging environment. As a result, nuclear medicine technology programs implemented changes in the curriculum in order to comply; however, the programs were still required to work within the limitations of the college or university systems sponsoring the program. While some programs embedded diagnostic CT into the nuclear medicine curriculum, others added limited information as it related to using CT for attenuation correction.

**Significance of the Study**

This study will help educators gain a better understanding of the factors associated with the motivations for nuclear medicine technologists to achieve multiple
credentials. Historically, nuclear medicine technologists were only required to have the credential CNMT or ARRT(N) to practice in nuclear medicine. With the development of new hybrid imaging systems, it is becoming increasingly more important for technologists to become multi-credentialed. Post-primary pathways for nuclear medicine technologists to obtain a CT or MRI certification are available. Obstacles faced by nuclear medicine technologists must be identified to develop the proper training and credentialing needed to be successful in this hybrid-imaging environment (Mann, 2014). Using this information, health sciences colleges and universities could investigate different pathways to gain didactic and clinical education required for practicing technologists to become candidates for post-primary certification in CT or MRI.

**Purpose and Research Question**

The purpose of this study is to examine the motivations guiding nuclear medicine technologists to pursue post-primary credentials in CT and MRI through the framework of the expectancy-value theory. The study examines how the technologists’ perception of value and cost affect their own expectations for success in obtaining the post-primary credentials. The research question is: Do the values nuclear medicine technologists associate with a post-primary certification in computed tomography (CT) or magnetic resonance imaging (MRI) predict their intention to pursue a post-primary certification?

This quantitative study examines the motivational factors of nuclear medicine technologists to pursue advanced credentials in the field of CT or MRI. This study involves the administration of a web-based survey in which nuclear medicine technologists in the southeastern region of the United States, as defined by the Society of Nuclear Medicine and Molecular Imaging (SNMMI), are contacted via e-mail. The
southeast region of the United States was selected since the region includes colleges and
universities offering nuclear medicine technology programs representing each entry-level
degree program.

Theoretical Framework

The theoretical framework for this study is grounded in Eccles and Wigfield’s
expectancy-value theory of achievement motivation (Eccles, 1993; Eccles & Wigfield,
2020; Wigfield & Cambria, 2010; Wigfield & Eccles, 2000; Wigfield et al., 2009;
Wigfield et al., 2017). The study examines the motivational factors of nuclear medicine
technologists to pursue post-primary credentials. Based on this purpose, it is appropriate
for the study to be grounded in theory related to motivation and achievement.

Eccles (1993) proposed that expectancy value theory asserts that expectations and
values, or beliefs, affect our achievement choices (Wigfield & Cambria, 2010; Wigfield
& Eccles, 2000). In addition to affecting our achievement choices, Wigfield and Eccles
(2000) state these expectations and values “also influence performance, effort, and
persistence” (p. 69). Eccles and Wigfield (2002) define expectancy as an individual’s
beliefs on how well they will perform a specific upcoming task. Task values are divided
into four components: attainment value, intrinsic value, utility value, and cost (Eccles &
Wigfield, 2002; Leaper, 2011; Wigfield et al., 2009). Eccles and Wigfield define
attainment value as the personal importance of doing well on a task while intrinsic value
relates to one’s enjoyment in doing the task. Utility value is defined as how well the task
relates to the individual’s goals (Eccles & Wigfield, 2002). Cost is often referred to as
what must be given up to perform the task, as well as the anticipated effort it will take to
do the task (Wigfield et al. 2009). Eccles et al. (1983) believe that the perceived cost of
performing a task can negatively impact its overall value. This concept is supported by Soleas (2020), stating that for some students, the impact of the cost is a higher consideration than expectancy and values associated with the task.

Expectancy-value theory is an applicable framework for this study since research has shown that examining the expectancies and values of an individual toward a task can be used to predict outcome (Wigfield et al., 2009). Expectancy beliefs refers to one’s belief that they have the ability to perform a task and be successful in the task whereas task values refer to an individual’s value and interest in a given task (Schunk et al., 2014). The intent of the current research is to examine technologists’ perceived value associated with obtaining post-primary certification in order to predict the factors that influence a technologist to achieve multi-credentialed status. According to Schunk et al. (2014), expectancies and values are important in predicting “future choices, engagement, persistence, and achievement” (p. 47).

Applying the expectancy-value perspective, expectancy beliefs are tied to an individual’s past achievements and engagements whereas value beliefs relate to one’s choice in participating in the task (Schunk et al., 2014). For example, if a technologist is interested in pursuing a post-primary credential, but they think they will not be successful, they are likely not to pursue the additional credential. Likewise, if a technologist feels there is no value in a post-primary credential, they are less likely to pursue the additional credential. Task values have a motivational aspect and are considered subjective since a task may be viewed valuable by some and not valuable by others (Wigfield et al., 2009). Task values can be used to predict both the intention and actual decision to continue with an activity (Wigfield et al., 2009). By examining the four
components of task values, as perceived by nuclear medicine technologists, administrators in higher education can better determine their role in educating the current workforce.

Summary

Chapter 1 provided a background for this study relating to the need for nuclear medicine technologists to pursue post-primary credentials in order to remain current with the advances in technology associated with hybrid imaging. Issues relating to the reasons why nuclear medicine technologists are currently in this dilemma were proposed including the variety of entry-level educational programs in nuclear medicine technology and the knowledge gap that exist in the current workplace due to advances in technology. Barriers to overcoming this knowledge gap were introduced and will be addressed in greater detail in Chapter 2.

Chapter 1 also provided a statement of the problem, including why the problem is significant for nuclear medicine technologists. With the purpose to examine the motivations of nuclear medicine technologists to pursue post-primary credentials, the value and cost of pursing a post-primary certification, as examined through the lens of the expectancy-value theory, may help guide administrators and educators concerning new educational pathways to narrow the current knowledge gap. Chapter 2 will provide a review of literature relating to the topics introduced in Chapter 1. Appendix A contains the definition of terms to help clarify the terminology used in this study.
Chapter 2

Literature Review

Nuclear medicine technologists have faced several workforce challenges relating to training in the new hybrid-imaging environment. As a result, nuclear medicine technologists may lack the skills and knowledge to work in this new environment. This review of literature presents a historical documentation of the evolution of imaging instrumentation in nuclear medicine technology. From the early technology of the 1950s to the hybrid imaging systems used today, the review outlines the rapid advances that have taken place in the field of nuclear medicine technology.

This chapter addresses the workforce challenges faced by nuclear medicine technologists. These challenges include operational and credentialing challenges associated with hybrid imaging, emphasizing the importance of post-primary certification. The chapter also identifies the barriers in the workplace potentially preventing the current workforce from pursuing post-primary credentials. Barriers associated with the scope of practice, licensure legislation, workforce training, and the current work environment, show the difficulties faced by technologists when trying to pursue a post-primary credential. Educational issues relating to the training and certification of an entry-level technologist are presented, emphasizing the lack of a standard entry into the profession.

Eccles and colleagues’ expectancy-value theory is the theoretical lens to examine the motivations for nuclear medicine technologists to pursue post-primary credentials. This chapter will provide a brief background of expectancy-value theory and define the
constructs of the model: expectancy beliefs and subjective task values. The chapter will also address how expectancy-value theory relates to adult learning.

**History of Nuclear Medicine Technology**

Nuclear medicine technology contributes its origin to scientists from a variety of different fields such as chemistry, engineering, science, medicine, and physics (Mandal, 2015). Although the beginning of nuclear medicine is difficult to identify due to the involvement of various disciplines, many date its origin to 1896 when Henri Becquerel discovered a puzzling ray from uranium. The next year, Marie Curie named this mysterious ray “radioactivity” (Fahey, 2014). Other historians believe the origin of nuclear medicine began with the first production of artificial radioactivity, $^{13}$N, in 1934 by Irene Curie and Frederic Joliot (Fahey, 2014; Mandal, 2015). Sam Seidlin, in the *Journal of the American Medical Association*, made the first description of nuclear medicine as a medical specialty in 1946 when Seidlin used radioactive iodine ($^{131}$I) to treat patients with thyroid cancer (Mandal, 2015). The American Medical Association officially recognized nuclear medicine as a medical specialty in 1971 (SNMMI, 2017).

**Early Technology**

Imaging systems capable of detecting gamma radiation have been used in nuclear medicine since the early 1950s. The first radionuclide studies focused on two-dimensional radionuclide distribution in organs using hand-held Geiger-counter detectors to plot the count rate from an organ onto a graph paper (McCready, 2019). In 1950, Benedict Cassen developed the first nuclear medicine imaging device, the rectilinear scanner, which used a typewriter ribbon to place “dots” on a page with each detection of radioactivity (Fahey, 2014; Mandal, 2015). The rectilinear scanner consisted of a
scintillation detector attached to a single photomultiplier (PM) tube that was then coupled to a mechanical scanner. To acquire an image, the scintillation detector of the rectilinear scanner would slowly move back and forth over the patient, registering a count rate on a piece of film directly proportional to the amount of energy deposited in the scintillator. From the 1950s to the early 1970s, the rectilinear scanner became the “standard instrument used for nuclear imaging” (Anderson et al., 2019, p. 18).

In 1957, Hal Anger developed the first gamma camera, which could acquire an entire image (Fahey, 2014). The invention of the Anger gamma camera changed nuclear medicine radionuclide “scanning” to “imaging” (McCready, 2019, p. 2416) and helped to establish nuclear medicine as a medical imaging specialty (Mandal, 2015). The Anger gamma camera included an array of PM tubes, allowing for increased detector efficiency and improved localization of the scintillation events.

David Kuhl, in 1963, introduced emission reconstruction tomography, which later became known as Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) (SNMMI, 2017). The word tomography is derived from the Greek word tomos, which means “sections”. The term tomography is used to refer to anatomical slices of the body (Burrell & Christian, 2017). A computer was used to create the tomographic images, displaying slices of tracer distribution in tissues (Delbeke et al., 2006).

The first commercially available tomographic imaging camera, the SPECT gamma camera, was made by Nuclear Chicago and introduced in 1963 (Fahey, 2014). The use of tomographic imaging helped to improve “the contrast ratio between a lesion and the radioactive background” (McCready, 2019, p. 2416). In the late 1970s, John
Keyes and Ron Jaszczak developed the first rotating gamma camera. General Electric made this imaging technology commercially available in 1983 (Fahey, 2014). In 1995, ADAC Laboratories shipped the first SPECT camera that was capable of offering coincidence detection for imaging Fluorine -18 fluorodeoxyglucose ($^{18}$F-FDG), a widely used positron-emitting radiopharmaceutical used in nuclear medicine to determine the extent of disease in the body (Fahey, 2014). In addition, in the late 1990s, PET moved from mainly being a research tool to being used routinely in clinical practice (Christian, 2017). Commercially available PET cameras had the technology to operate in coincidence mode, allowing the imaging of positron emitting radiopharmaceuticals (Fahey, 2014). The commercial use of PET imaging “represented a major leap in our ability to detect, diagnose, stage, and restage malignancies” (Middlebrooks, 2020, p. 40S).

**Hybrid Imaging Systems**

During the early 1990s, SPECT/CT, the first hybrid or multimodality imaging camera, was developed by Bruce Hasegawa and his colleagues at the University of California, San Francisco (Fahey, 2014; Hutton, 2014). The term “hybrid imaging” refers to “the physical fusion of more than one diagnostic imaging tools”, in this case, CT to a SPECT gamma camera (Griffiths, 2015, p.262). CT is a tomographic imaging technique that produces 3-dimensional anatomical images of the body by using an external x-ray source (Delbeke et al., 2006). Hasegawa’s hybrid imaging system fused CT, a diagnostic imaging device used in medical radiography, to the nuclear medicine instrumentation environment. Hybrid SPECT/CT combines the functional images of SPECT with the anatomical images of CT, allowing both studies to be performed in one imaging session.
Cal-Gonzalez et al. (2018) states, “[B]y combining anatomical and functional imaging within a single, hybrid imaging system, complementary diagnostic information can be obtained in order to gather a comprehensive picture of the disease” (p. 2).

The first SPECT/CT system used a dual head gamma camera with an external x-ray transmission system mounted on the gantry of the gamma camera, allowing for both attenuation correction and anatomical imaging when the SPECT and CT images were fused together (Delbeke et al., 2006). Later, more state-of-the-art systems were developed which combined a multi-head gamma camera and a multi-detector CT scanner side-by-side, using a common imaging table. This combination of imaging systems allowed for physiological information obtained from a SPECT camera to be combined with the anatomical information from a CT scanner in one single examination (Delbeke et al., 2006). According to Delbeke et al. (2006), studies have shown that “the information obtained by SPECT/CT is more accurate in evaluating patients than that obtained from either SPECT or CT alone” (p. 1). In the early years of SPECT/CT, the hybrid system was not quickly received except when visualization of the anatomy was needed in application (Gilmore et al., 2013).

The concept of combining a PET camera and a CT scanner was also proposed in the early 1990s (Ocampo et al., 2015). In 1998, Siemens made the first PET/CT device. Like SPECT/CT, the hybrid PET/CT systems allowed for the fusion of functional and anatomical images in a single scan. This technique allowed “good simultaneous visualization of the anatomic detail from the CT and physiologic detail from PET” (Gilmore et al., 2013, p. 108). Prior to this time, PET images and CT images were acquired separately and then fused together using computer processing technology. The
Siemens Biograph, which combined PET and CT on a single concentric gantry, was introduced in the year 2000 and named the medical invention of the year by *Time* magazine (Fahey, 2014; SNMMI, 2017). In 2001, whole-body PET/CT was introduced followed by multiple generations of PET/CT cameras, including PET/CT cameras with diagnostic quality CT components (Beyer et al., 2018). The PET/CT scanners gained rapid acceptance and is currently in widespread use, resulting in stand-alone PET units no longer being sold commercially after 2006 (Ocampo et al., 2015).

Hybrid imaging technology continues to advance as current medical equipment manufacturers are now marketing PET/MRI, combining PET with magnetic resonance imaging (MRI). MRI relies on the magnetic properties of the nucleus of the atom. Using magnetic fields and high radiofrequency electromagnetic waves, the chemical makeup of tissues in the body can be observed, allowing superior spatial resolution and soft tissue contrast of organs as well as musculoskeletal and cardiac systems (Kennedy & Turner, 2017; Cal-Gonzalez et al., 2018). The first MRI whole-body scanner used to scan the first human was built and used by Raymond Damadian in 1977 (Kennedy & Turner, 2017). The original image took five hours to acquire; however, modern MRI scanners can produce a single image in seconds (Kennedy & Turner, 2017).

The first FDA commercially approved PET/MRI scanner, the Siemens Biograph mMR system, was developed in 2012, allowing the functional imaging of MRI to be combined with physiologic images of PET (Kaplan, 2013). PET/MRI holds significant advantages over the other hybrid imaging systems utilizing CT. PET/MRI provides better soft-tissue contrast compared to PET/CT and allows for less radiation exposure (Cal-Gonzalez et al., 2018, Latour, 2016). According to Gilmore et al.(2013), PET/MR will
have “a significant role in the diagnostic capabilities in oncology and neurologic diseases” (p. 108). Currently, multiple medical equipment vendors are marketing the PET/MR system in the United States with the expectation that PET/MRI will be as widely accepted as PET/CT for imaging whole-body and organ- and region-specific areas of the body (Gilmore et al., 2013). Even with increased marketing, large-scale adoption of PET/MRI has been a challenge due to the financial cost and lack of staff training (Latour, 2016). Despite the challenges with PET/MRI, hybrid-imaging systems have become “the modality of choice in both the medical imaging and their research communities because of the unmatched levels of diagnostic information provided by these hybrids (Bolus et al., 2009, p. 64).

**Workforce Challenges Related to Hybrid Imaging**

Advances in the delivery of healthcare places the healthcare worker in an environment that is constantly changing, resulting in new challenges for the workforce. Nuclear medicine technologists are not exempt from these challenges. The introduction of hybrid imaging technology has redefined the role of nuclear medicine technologists and changed their relationship with other healthcare professionals (Griffiths, 2015). While these changes have provided excellent opportunities for growth in the field of nuclear medicine, the new environment has presented several challenges for the nuclear medicine technologist that must be addressed relating to hybrid imaging.

**Operational Challenges**

The emergence of hybrid imaging systems has resulted in several operational challenges including “physical installation, technologist training, reimbursement issues, and shared responsibilities among technologists and physicians” (Ocampo et al., 2015, p.
These challenges are especially true for the nuclear medicine technologist as it redefines working practices (Griffiths, 2015). Hybrid images allows for a single examination to take place in one environment, providing the physician with the anatomical and physiological information needed as part of a patient’s initial diagnosis or response to surgery or therapy (Griffiths, 2015). As a result, the nuclear medicine technologist may be working alongside radiation therapists, radiographers, and nurses in a multidisciplinary approach to health care (Griffiths, 2015).

Collaboration from multiple departments may be necessary as personnel consider the appropriate environment to install the new hybrid systems. For example, due to the large size of PET/MRI scanners, a PET/MRI scanner may not fit in the existing structure thus requiring extensive construction costs (Ocampo et al., 2015). Once the scanner is installed, it may be necessary to share staffing responsibilities between two departments. For example, nuclear medicine and MRI departments are generally managed separately; however, a PET/MR system may require technologists from both departments to be present (Gilmore et al., 2013; Ocampo et al, 2015). For a single technologist to perform the study, the person would need MRI education and safety training along with nuclear medicine/PET education and radiation exposure training (Gilmore et al., 2013).

**Credentialing Challenges**

Hybrid imaging has rapidly become the modality of choice for both the medical imaging and research communities (Bolus et al., 2009). In a 2005 survey conducted by the Center for Health Workforce Studies (2006), the nuclear medicine technology profession was warned of the risk of being left behind due to new fusion imaging technologies. The Center for Health Workforce Studies (2006) stated the following:
Especially important risks are those related to new technologies. Fusion imaging technologies seem certain to take over from the multiple machine imaging modalities typically in place today. If NMTs [nuclear medicine technologists] do not acquire traditional imagine skills and certification to complement their NM [nuclear medicine] skills, radiologic technologists (RTs) and other hybrid professionals will increasingly be asked to perform task now reserved for NMTs. (p. 245)

Seven years after the warning, in a 2012 study conducted by the Nuclear Medicine Technology Certification Board (NMTCB), only 7.18% of active NMTCB certified technologists had CT certification while only 1.9% had MRI certification (Perry, 2013). This study once again warned the nuclear medicine community of the need to acquire the additional imaging skills to complement their nuclear medicine skills.

In 2014, The American Registry for Radiologic Technologists (ARRT) reported 13,238 nuclear medicine technologists were credentialed by the ARRT while there were 30,239 credentialed MRI technologists; however, the number of technologists who hold dual certification in both MRI and nuclear medicine was only 569 (Young, 2014). This study did not consider nuclear medicine technologists who may be certified by the NMTCB and hold ARRT certification in MRI.

In 2018, the NMTCB conducted a survey that focused on technologist salaries. In this survey, about 28% of the technologists responding held specialty certifications with 18% holding dual certification in nuclear medicine technology and CT (Passmore, 2019). The percentage of technologists certified in both NMT and MRI was not reported. Although the number of dual certified technologists in NMT and CT increased over the
five years since the 2012 NMTCB study, it has not kept pace with the number of hybrid systems being used in nuclear medicine departments. Market scenarios for unit sales from 2013 to 2017 reported SPECT/CT cameras will represent approximately 40% of the planned purchases of nuclear medicine cameras to replace older systems (ITN, 2013).

Barriers in the Workplace

Commercial hybrid imaging has expanded beyond SPECT/CT, PET/CT, and PET/MRI to include PET mammography and breast specific gamma imaging (Bires et al., 2012). A risk identified by Griffiths (2015) in this hybrid-imaging environment is the possibility of role erosion for the nuclear medicine profession. As the profession strives to stay ahead, barriers within the workplace create hurdles that must be overcome.

Scope of Practice

Nuclear medicine technology was once recognized as somewhat a “single modality”; however, the profession has now become “the profession of multimodalities and emerging technologies known as molecular imaging, with the emphasis on hybrid imaging” (Bires et al., 2012, p. 265). The overlap of skill sets among the professions and the competition for job placement has resulted in “turf wars over which profession may offer which set of skills in their legal scope of practice” (Frogner & Stillman, 2016, p. 56). Recognizing the importance of CT in the nuclear medicine workplace, the Society of Nuclear Medicine and Molecular Imaging – Technologist Section (SNMMI-TS) added CT content to the SNMMI-TS Scope of Practice for nuclear medicine technologists (Anderson et al., 2010). Although CT was included in the nuclear medicine technologist’s scope of practice, state licensure and regulations often affect the nuclear medicine technologist’s ability to perform diagnostic CT or operate the CT component of
a PET/CT or SPECT/CT system. As Frogner and Stillman (2016) pointed out, “scope-of-
practice laws may hinder team-based environments by limiting practice flexibility that
could otherwise enhance delivery of patient care” (p. 57). Professional organizations, such
as the SNMMI, are working at the grass-roots level to address some of the concerns.

According to Delbeke et al. (2006), professional organizations have the
responsibility to establish standards, delineate mechanisms to promote a qualified
workforce, and collaborate with other organizations to solve practice issues. As an
example of this collaboration to address education needs of technologists, the American
Society of Radiologic Technologists (ASRT) and the SNMMI-TS developed a PET/CT
curriculum. The PET/CT curriculum was endorsed by numerous professional
organizations and was distributed to program directors throughout the United States
(Delbeke et al., 2006).

Licensure and Credentials

Licensure has an important role in health professions in that it protects the safety
of the public and increases the status of the profession (CHWS, 2006). Licensure
requirements for nuclear medicine technologists vary throughout the United States.
Currently, nuclear medicine technology does not have a uniform licensure requirement in
all 50 states. In states that do have a license for radiological imaging, some require
specific credentials to operate the CT or MRI component of a hybrid imaging system.

To become certified in CT or MRI, technologists must meet the minimum
didactic and clinical requirements established by the certification boards. Since hospital
administrators develop job descriptions based on state licensure requirements, working
nuclear medicine technologists are often prevented from gaining the clinical experience
required in CT or MRI to sit for the registry or board exam. Turf battles relating to who should perform the study and in which department the hybrid system should be housed have developed between nuclear medicine and radiology departments (Kaplan, 2013).

Identifying the policies that prohibit the nuclear medicine technologists from fully functioning in their professional role may help lead to a uniform licensure standard which protects the role of a nuclear medicine technologist. Credentials required to practice in health care may vary from state to state or by occupation, making it difficult to move to another state or follow a career ladder or grow their skillset toward a new occupation (Frogner & Stillman, 2016). In 1981, the U.S. Congress adopted the Consumer-Patient Radiation Health and Safety Act that directed the Secretary of Health and Human Services to establish minimal standards for state certification and licensure for any personnel who administers ionizing radiation in medical or dental procedures (ASRT, 2017). Unfortunately, the law allowed for voluntary enforcement of minimum education standards or credentialing standards, which allows individuals in some states to perform radiologic procedures using ionizing radiation, such as medical radiography, radiation therapy, and nuclear medicine, without any formal education (ASRT, 2017; SNNMI, n.d.). According to the ASRT (2017), radiography has state licensure requirements in 42 states, radiation therapy in 38 states, nuclear medicine in 37 states, magnetic resonance in six states, and computed tomography in ten states.

The Consumer Assurance of Radiologic Excellence (CARE) bill, if passed and enacted, would address this issue by requiring “uniform regulations for personnel operating diagnostic equipment” (Gilmore et al, 2013, p. 112). Although the CARE Bill was introduced in the 109th Congress, the legislation was not enacted by the end of the
session and was cleared from the books (Civic Impulse [S.2322], 2017). Since that time, the bill, reintroduced as the Consistency, Accuracy, Responsibility, and Excellence in Medical Imaging and Radiation Therapy Act, was introduced to the 110th, 111th, 112th, and 113th Congresses with no legislative action (Civic Impulse [S. 642], 2017).

Workforce Training

According to Griffiths (2015), the introduction of hybrid imaging has resulted in “opportunity for new working practices, professional identifies, and role development” (p. 268). Griffiths describes the introduction of hybrid imaging as a “cause and effect relationship” with the effect including “professional ripple and reorder, occupational shift in terms of domain ownership, and potential new roles” for the nuclear medicine technologists (p. 267). Griffith states, “the role of the nuclear medicine practitioner is evolving, with the potential for greater autonomy, decision-making capabilities, and increased professional recognition” (p. 263). In addressing the external pressures on the field of nuclear medicine technology, Mann (2014) warns:

As technologies advance toward hybrid models, we must identify the obstacles facing nuclear medicine technologists in order to develop strategies for proper training and credentialing. These efforts will provide the field with technologists who are better prepared for imaging of the future and will outline various career paths available within the field today. (p. 8A)

In the current environment, a cross section of health care professionals may work within the hybrid imaging environment; however, it is often unclear which professional domain actually “owns” the hybrid imaging equipment and whether or not “a new hierarchy within this imaging modality” is being created (Griffiths, 2015, p. 263).
Delbeke et al. (2006) state the introduction of new hybrid systems, such as PET/MRI, SPECT/CT and PET/CT, all present similar practice issues for nuclear medicine technologists concerning “the education, training, and certification to become appropriately qualified and competent to perform the CT [or MR] portion of the study” (p. 6). Other issues that arise in the hybrid imaging environment including “ensuring competency, standardizing the educational experience of the individual, and barriers place by licensure at the state level” (Delbeke et al., 2006, p. 6).

**Career Advancement**

New hybrid imaging and emerging positions has made the pathway to an allied health career unclear (Frogner & Stillman, 2016). Traditional professional relationships with other health care departments have changed as new hybrid imaging systems have emerged and redefine working practice (Griffiths, 2015). Griffiths points to the need of developing a “clear trajectory for nuclear medicine practitioners working within the realms of hybrid imaging” as being “crucial to the future of the workforce” (p. 268). However, the career ladder must be clarified if the health care industry wants to attract and retain a competent workforce (Frogner & Stillman, 2016). According to Frogner and Stillman (2016):

The career ladder in health care may be better characterized as a career “lattice”, and the myriad education and training choices with different consequences can make career growth and professional development daunting for entrants with minimal education and training or lacking mentors and role models. (p. 53)

Dawson et al. (2010) supports the utilization of a formal mentoring framework for the ongoing development of nuclear medicine technologists. According to Dawson et al.,
a mentoring program would allow the technologist “to discuss problems, reflect on personal strengths and weaknesses, and importantly it encourages goal focus, thus encouraging the individual to meet targets and overcome difficulties” (p. 47). However, even with a strong mentoring program, accreditation, credentialing, and scope-of-practice measure put in place to ensure quality care and patient safety may “discourage potential allied health workers seeking to follow a career ladder” (Frogner & Stillman, 2016, p. 56).

**Work Environment**

A common characteristic among rural healthcare landscapes is a lack of basic health care services (Hart et al., 2002). Rural radiology departments are faced with the fiscal responsibility of running the department while still trying to offer subspecialty services that utilize the most advanced technology (Lerner, 2013). In a study conducted to determine employment preferences of radiology managers in Nebraska, sixty-one percent indicated multi-credentialed technologists were very important, especially in hospitals with the smallest number of beds (Michael et al., 2016).

In nuclear medicine departments, technologists are often required to work independently and may be the only technologist on staff (Bires et al., 2012). As a result, nuclear medicine technologists have been challenged with developing new knowledge and skills to operate the hybrid imaging systems. Technologists that are multi-credentialed will have the best employment opportunities (Weening, 2012), especially in rural communities (Michael et al., 2016).
The Entry-Level Technologist

Changes in healthcare delivery has resulted in changes in skills, roles, and educational pathways of allied health professionals (Frogner & Stillman, 2016). Due to the complexities of the health care system, a trend has developed toward elevating the educational requirements of healthcare professionals (Bires et al., 2012). Educational programs in nuclear medicine technology play a central role in introducing the new technologies and other healthcare advances of the profession at the entry-level of the profession (CHWS, 2007).

Entry-level Education

The current structure of nuclear medicine educational programs makes it difficult to address the knowledge and skills needed to address the multimodality-imaging environment (Owen et al., 2005; Bolus, 2020). The new technology associated with hybrid images is identified as a new entry-level skill that must be learned. To prepare entry-level nuclear medicine technologist, nuclear medicine programs must cover “all elements of the many generations of cameras, image delivery, and now hybrid imaging” (Bolus, 2020, p. 64S).

In a 2005 position paper published by the SNMMI-TS, the SNMMI-TS proposed that the baccalaureate degree become the required standard for entry-level nuclear medicine technologists by 2015 (Bires et al., 2012). In 2006, the Center for Health Workforce Studies conducted a survey of nuclear medicine program directors. Among the issues identified in the study, several directly related to entry-level education including a lack of standard in entry-level education for the profession and gaps in educational curricula especially relating to new and emerging technologies (CHWS,
2006). As part of the recommendations from the survey, the Center for Health Workforce Studies recommended “standardiz[ing] the learning objectives, curricula, and educational levels” for all nuclear medicine technologists, with the credential being a minimum of a bachelor’s degree (CHWS, 2006, p. 47). In the 2012 Nuclear Medicine Technologist Performance Standards, the SNNMI-TS also recommended the entry-level for nuclear medicine technologists should be at the baccalaureate level, identifying the “complexity of knowledge and skill that must be acquired before the graduate enters the workplace (SNMMI-TS, 2012, p. 5).

The recommendation of the baccalaureate degree becoming the minimum entry-level standard for the profession has not taken place. Currently, nuclear medicine educational programs are offered at the one- or two-year certificate program, a two-year associate degree, a four-year bachelor’s degree, or a master’s degree. According to the JRCNMT, as of July 2021, the number of accredited nuclear medicine technology programs is as follows: certificate, 18; associate, 23; baccalaureate, 29; and master’s 2 (Winn, 2021).

The need for a multi-skilled workforce creates new challenges for colleges and universities (Sherrill & Keels-Williams, 2005). As stated by Bires et al, “the goal for the profession must be to prepare individuals for the field tomorrow, not for what is happening today” (p. 267). However, the knowledge and skills needed to address multimodality imaging would be difficult to add to the current entry-level educational programs (Owen et al., 2005). Bires et al. described PET/CT as “the perfect example of how the profession was not ready for new technology”, stating the profession “began to scramble on how both to provide CT education to current technologists and to
incorporate the didactic material into educational programs” (p. 267). As technology continues to advance at a fast rate, students need to move forward with the new technology and be encouraged to become lifelong learners (Bires et al., 2012). According to Bires et al., a twelve-month certificate program “can no longer sufficiently cover the material that needs to be added” (p. 257).

**Certification**

The two certification organizations for nuclear medicine technology, the ARRT and the NMTCB, adjusted their educational requirements as a result of the SNMMI-TS recommendations. Although not fully complying with the SNMMI-TS recommendations, the ARRT states an applicant for registry in nuclear medicine technology must have an associate degree or higher to sit for the registry (ARRT, 2020). In January 2016, the NMTCB changed their eligibility requirements to state the student must graduate from a programatically accredited academic institution, trying to address the need for a standardized curriculum (Weening, 2012). In the United States, the JRCNMT is recognized by the NMTCB as the programmatic accrediting agency.

Graduates of nuclear medicine technology programs may gain certification in nuclear medicine through either the ARRT or the NMTCB. Upon successful passing the ARRT primary examination in nuclear medicine technology, the examinee earns the right to use the credential RT(N)(ARRT). Candidates who are successful in passing the NMTCB examination earns the right to use the credential CNMT, meaning Certified Nuclear Medicine Technologist. Due to the emergence of hybrid imaging systems, the NMTCB added a CT component to the entry-level, nuclear medicine primary pathway examination in 2011 (Pagnanelli, 2011). The CT component included content relating to
attenuation correction, anatomical localization, and diagnostic CT imaging procedures (NMTCB, n.d.). In 2011, the ARRT also added CT content to the entry-level nuclear medicine examination; however, the CT content assesses CT used for attenuation correction and anatomical localization and not for diagnostic CT (Pagnanelli, 2011).

The ARRT and the NMTCB offer post-primary certification in CT. Originally, only ARRT certified technologists in radiology were eligible to sit for the ARRT(CT) post-primary examination. However, due to emergence of new technologies such as SPECT/CT and PET/CT, in 2003, the ARRT began allowing individuals certified in nuclear medicine technology to sit for the post-primary CT examination (Collins & Having, 2005). The NMTCB also felt the need for nuclear medicine technologists to demonstrate additional expertise in CT. In 2014, the NMTCB developed a post-primary certification exam in CT (Nielson, 2014).

In 2011, the first meeting between the SNMMI-TS and the Section for Magnetic Resonance Technologists (SMRT) took place to identify the challenges with the merger of MRI and PET (Gilmore et al., 2013). As a result of meetings between the two organizations, eight consensus statements were issued. The organizations agreed that although both modalities included some content from the other, the MRI curriculum and the nuclear medicine technology curriculum were already filled to capacity. As a result of these finding, the recommendation was that additional education needed for PET/MR be in the form of advanced-level education (Gilmore et al., 2013). Gilmore et al., stated the ultimate goal relating to PET/MR was for technologist to be fully trained in both modalities; however, this would go beyond “hybrid-only training”, requiring “more rigorous training, education, and certification” (p. 112). As is the case with the post-
primary certification in CT, nuclear medicine technologists are eligible for post-primary certification in MRI offered through the ARRT.

**Expectancy-Value Theory**

Expectancy-value theory (EVT), now labeled Situated Expectancy Value Theory (SEVT), addresses “achievement-related choices, persistence and performance” (Eccles & Wigfield, 2020, p.1). Models of expectancy-value have been used as a framework to describe motivational processes. In this section, a brief history of the EVT model will be presented along with a description of the more modern version of the theory, specifically Eccles and Wigfield’s (2020) Situated Expectancy-Value Theory, and include the expectancy and value constructs of the model.

**Brief History**

The expectancy-value theory dates back to theoretical models based on motivational processes (Plante, et al., 2013; Wigfield et al, 2009). For example, Lewin’s level of aspiration theory proposed an individual’s level of aspiration, relating to expectancies and values, influence their decision to take part in an activity (Schunk et al., 2014; Wigfield et al., 2009). Schunk et al. (2014) defined level of aspiration as “the goal or standard that individuals set for a task based on their past experiences and familiarity with the task” (p. 48). Based on the Lewin’s theory, researchers found participants felt more successful when they set their own goals. In addition, an individual’s prior experience with the task, whether a success or failure, influenced the level of aspiration (Schunk et al., 2014).

Atkinson proposed a theory of achievement motivation which stated, “behavior was a multiplicative function of three major components: motives, probability of success,
and incentive values” (Schunk et al., 2014, p. 49). Atkinson’s achievement motivation theory was “the first, formal mathematical expectancy-value model of achievement motivation” (Wigfield et al., 2009, p. 55). Atkinson felt the motives to strive for success and avoid failure were independent of each other (Schunk et al., 2014). In addition, Atkinson stated the probability or expectancy for success were based on the task difficulty and the individual’s beliefs (Schunk, 2014). The component of Atkinson’s theory related to “incentive value of success, defined as one’s pride in accomplishment” (Schunk, 2014, p. 50). Based on Atkinson’s work, modern expectancy-value theory of achievement motivation “link achievement performance, persistence, and choice most proximally to individuals’ expectancy-related and task value beliefs” (Wigfield et al., 2009, p. 56). One such model, EVT, based on the works of Eccles, Wigfield, and colleagues (Eccles, 1993; Eccles & Wigfield, 2020; Wigfield & Cambria, 2010; Wigfield & Eccles, 2000; Wigfield et al., 2009; Wigfield et al., 2017), focuses on expectancies and values in the academic setting.

**Eccles’ Situated Expectancy-Value Model**

Eccles et al. (1983) expectancy-value model of achievement-related choices expanded on Atkinson’s model. Eccles et al. model proposed that choices students make can be based on their expectancy for success, which, in turn, are based on their ability beliefs and subjective task values (Wigfield & Eccles, 2000). In defining the constructs in the model, ability beliefs refer to “how well they will do on an upcoming task” whereas expectancies focused on future tasks. The subjective values construct refers to “the qualities of the task that will increase or decrease their selecting that task” (Conley, 2012, p. 34).
Eccles and Wigfield (2020) updated the expectancy-value model, which was based in the social sciences, to include “ideas from social cognition, developmental sciences, and sociocultural perspectives” (p. 1). Now labeled Situated Expectancy Value Theory (SEVT), Eccles and Wigfield (2020) updated their expectancy-value model of achievement motivation so that each box represented “a general category or level of constructs” meant to guide current and future research efforts (p. 3). The renaming of the theory to Situated Expectancy-Value Theory suggests that context and task change over time; meaning, an individual’s immediate context will affect their expectancies and values (Anderman, 2020; Nolan, 2020). In framing the SEVT model, Eccles and colleagues examined “psychological beliefs and values that impact individuals’ performance and choice, and a variety of socialization and other factors that influence them” (Wigfield et al., 2020, p. 263). Eccles et al. (1983) suggest an individual’s performance and engagement in a selected activity is based on the individual’s expectancies for success (belief about one’s ability to succeed at a task) and their subjective task values (importance of the task).

**Expectancy Belief.** Although expectancies for success has always had a prominent role in all cognitive theories of motivation, ability and expectancy beliefs are vital to the expectancy-value theory (Wigfield & Eccles, 2000). Expectancies relate to whether an individual believes they will be successful in the task. If a person thinks they will fail at a task, they are less likely to engage in the task. Schunk et al. (2014) explains that expectancy answers the question “can I do the task?” (p. 47). Although a person may be interested in the task, if they try it and are unsuccessful, they are less like to continue in the task.
**Subjective Task Values.** Values relate to “individuals’ belief about the reason they might engage in tasks”, answering the question, “Do I want to do this task and why?” (Schunk et al., 2014, p. 47). Eccles and colleagues define values based on their qualities and influence on the individual to take part in the task (Wigfield et al., 2009). According to Wigfield et al. (2009), these values are “subjective because various individuals assign different values to the same activity” (p. 57). Subjective task values have several components: attainment value (importance of the task), intrinsic value (enjoyment from the task), utility value (usefulness of the task), and cost (what is given up, effort involved, emotional) (Wigfield & Eccles, 2000). Eccles and colleagues proposed that each subjective task value component influences whether the task is valued by the individual (Wigfield et al., 2020). According to Eccles (2009), she and her colleagues predicted and supported with evidence that “life defining choices such as those linked course enrollments, college majors, and occupational choices are influenced by the value individuals attach to the various achievement-related options they believe are available to them” (p. 82). More recently, Eccles has linked subjective task values to “personal and collective/social identities and the identity formation processes underlying the emergence of these identities” (Eccles, 2009, p. 82).

**Attainment Value.** Initially, attainment value was perceived as “the importance of the task to the individual in terms of its ability to satisfy key aspects of the individual’s core self-schema and life goals/values” (Wigfield et al., 2020, p. 665). Wigfield and colleagues (2020) simplified attainment value by stating “it is often measured simply in terms of how important the individual thinks succeeding at the task is for them personally” (p. 665). Eccles (2009) stated attainment value could refer to the “value an
activity has because engaging in it is consistent with one’s self-image and personal and collective/social identities” (p. 82). This is a change from how Eccles previously conceptualizes the value. Previously, Eccles (2009) described attainment value in terms of fulfilling one’s needs or personal values; whereas now, Eccles states a person’s self-image of who they are or what they want to be “influence the value the individual attaches to various educational or vocational options” (Eccles, 2009, p. 83). As an example, Eccles states “if helping other people is a central part of an individual personal or collective identity, then this individual should place higher value on ‘helping’ occupations than on ‘non-helping’ occupations” (p. 83). Eccles emphasizes that individuals perceive task based on characteristics of the task as it relates “to their needs, values, and both personal and collective identities” (p. 83). This requirement can be seen as an opportunity or burden, based on the individual’s “needs, motives, personal values (i.e., their personal identity) and on the individual’s desire to demonstrate these characteristics both to himself or herself and to others” (p. 83). If the individual sees a task as an opportunity to fulfill their identity and help meet long-range goals, they are more likely to select the task, especially if it has high subjective value (Eccles, 2009).

**Intrinsic Value.** Intrinsic value, also called interest value, refers to “the anticipated enjoyment one expects to gain from doing the task for purposes of making choices and as the enjoyment one gets when doing the task” (Eccles & Wigfield, 2020). This component of value relates directly to the activity and the enjoyment from participating in the activity (Eccles, 2009). When a task is intrinsically valued, the individual will be engaged in the activity and will remained engaged for a long period of time (Wigfield et al., 2020). In fact, Eccles (2009), states “a task that begins being valued
primarily because of interest can over time become valued because of its attainment value” (p. 83). When this occurs, it may be necessary “to incorporate this domain into one’s personal identity structure” in order to maintain the motivation to continuing engaging in the task to become an expert in that particular skill (Eccles, 2009, p. 83).

**Utility Value.** Utility value is defined as “the value a task has because it fulfills a less personal central goal” (Eccles, 2009, p. 83). Eccles and Wigfield (2020) further define utility value in terms of its usefulness, meaning “how well a particular task fits into an individual’s present or future plans” (p. 5). While utility value is closely linked to extrinsic motivation, it also can reflect important personal goals of an individual, making the differences between attainment values very subtle (Eccles & Wigfield, 2020).

**Cost.** The value of a task is often determined by the cost of participating in the activity (Eccles, 2009). All choices made are assumed to have cost since selecting one choice means you are eliminating another choice (Wigfield et al., 2020). Wigfield et al. (2000) defines cost as “what the individual has to give up to do a task, as well as other negative consequences for engaging in any particular task” (p. 665). Eccles (2009) identifies some of the negative factors that influence cost including “anticipated anxiety, fear of failure, and fear of social consequences of success.” Cost can also include the loss of time for other activities that may be of interest to the individual (Eccles, 2009).

The cost construct has been given more attention recently by scholars (Anderman, 2020). Based on Eccles’ model, education psychologists have continued to research cost, suggesting cost has a role in student motivation (Flake et al, 2015). Flake and colleagues conducted a literature review to address how to measure cost. Their research found that cost, although salient to individuals, contains multiple dimensions that are separate from
expectancy and value components. In a broad conceptualization of cost from their literature review, Flake and colleagues defined cost as “what is invested, required or given up to engage in a task” (p. 235). Based on the literature review, the specific theoretical dimensions of cost were as follows: task effort; outside effort; loss of value alternatives; and emotional. Three of these dimensions were consistent with the work of Eccles and colleagues: effort, loss of valued alternatives, and psychological / emotional (Flake et al., 2015).

**Expectancy-Value Theory and Adult Learning**

In researching the motivational factors of subjective task values, much of the work of Eccles and colleagues has been related to “school children’s achievement and course choices, emphasizing the influence of family and teachers as social agents” (Gorges & Kandler, 2012, p. 611). According to Gorges (2016), “Eccles’ expectancy-value theory has not found its way into the adult education literature yet, neither does research on adults’ motivation to engage in ongoing learning constitute an important area of research in education psychology” (pp. 26 – 27). Adults participating in educational activities is largely voluntary (Merriam et al., 2007); whereas children’s participation in education is compulsory in the United States, typically to age 16 in most states, extending to 17 or 18 in the remaining states (Francies & Perez, 2020). Due to the voluntary nature of most adult education, Merriam et al., (2007) points out:

Knowing who is participating, reasons for participating, and what conditions are likely to promote greater participation can help providers better serve adult learners. An understanding of participation patterns can also raise important
question about assumptions underlying what is offered, who is benefiting from participating, and whose needs are not being met. (p. 53)

National surveys have been used to better understand the reasons adults participate in various learning activities; however, understanding motivational factors or barriers to participation can prove useful to administration and policy makers (Merriam et al. 2007). Subjective task values may prove useful to help address these issues (Gorges, 2016). Gorges states “[a]dapt[ing] existing measures from expectancy-value research to adult learning would enable theory-driven research on adults’ motivation to participate in further education” (p. 36).

The value of post-primary certifications was studied because professional advancement of nuclear medicine technologists in the hybrid-imaging environment can be linked to attainment of post-primary credentials. To guide this research effort, task choices grounded in Eccles and colleague’s expectancy-value theory were linked to two sets of beliefs: the expectancy for success and the value attached to various tasks as perceived by nuclear medicine technologists. According to Wigfield and Eccles (2000), expectancies and values are “assumed to be influenced by task-specific beliefs such as ability beliefs, the perceived difficulty of different tasks, and individual goals, self-schema, and affective memories” (p. 69).

Summary

Chapter 2 began with a brief history of the technology used in nuclear medicine technology. The history began with the description of a non-imaging Geiger counter, which detected radioactivity and plotted count rates on graph paper. Next, imaging technology was introduced with Anger’s invention of the gamma camera, making whole
body imaging possible. Imaging technology continued to advance with Kuhl’s invention of a tomographic imaging system which displayed slices of tracer distribution in tissues. The history of imaging technology concluded with the introduction of hybrid imaging systems, specifically SPECT/CT, PET/CT, and PET/MRI.

The chapter continued by addressing how the introduction of hybrid imaging has created new challenges for health care professionals. These challenges are especially true for the nuclear medicine technologist who may be unfamiliar with all the working principles of hybrid imaging. As a result of the new hybrid environment, tensions between the different modalities have developed as they battle over who should own the new equipment. For the nuclear medicine technologist to work in this environment, it will be necessary to learn new skills relating to the technology; however, issues exist which possibly could affect the learning of the new skills. Although a few of the issues have been addressed, chapter two identified potential barrier that still exists relating to licensure and continuing education needs. Higher education can play a role in addressing some of the education needs of entry-level technologist and technologist currently practicing in the workforce.

Chapter 2 concluded with a review of Eccles and colleague’s expectancy-value theory. Eccles and colleagues’ model proposed that choices students make may be based on their expectancy for success, which, in turn, are based on their ability beliefs and subjective task values (Wigfield & Eccles, 2000). Eccles (2009) defined expectancy for success as “confidence in one’s abilities to succeed”, which is recognized as important to one’s choice of behavior (p. 81). An individual’s achievement related beliefs are influenced by past performance and their perception concerning the expectations and
attitudes of society (Battles & Wigfield, 2003). Educators of adults must recognize that individuals bring their own experiences and prior knowledge to the learning environment (Merriam et al., 2007). Based on past experiences, a person’s self-confidence can have an impact on whether the adult participates in a new learning experience (Merriam et al., 2007).

Based on the expectancy-value theory as the framework for exploring the motivation of nuclear medicine technologist to pursue post-primary credentials, chapter three will describe the methodology used to conduct this research, including the sample population, survey instrument, and data analysis.
Chapter 3  
Methodology

The current quantitative study used Eccles and colleague’s expectancy-value theory as the framework for examining the motivations of nuclear medicine technologists toward pursuing post-primary credentials. The development of these new hybrid-imaging technologies, such as SPECT/CT, PET/CT, and PET/MRI, has brought together imaging systems once confined to either nuclear medicine technology (e.g. PET) or medical radiography (e.g. CT and MRI). As a result, a knowledge gap exists for nuclear medicine technologists who have not had training in CT or MRI. Although the need exists for nuclear medicine technologists to obtain training relating to the new hybrid systems, approximately 18% are multi-credentialed in nuclear medicine technology and CT (Passmore, 2018). For administrators and educators to make proper decisions on how to address this knowledge gap, an examination of the perceived values and cost of nuclear medicine technologists toward pursuing post-primary credentials would aid the decision-making process. The research question for this study is: Do the values nuclear medicine technologists associate with a post-primary certification in computed tomography (CT) or magnetic resonance imaging (MRI) predict their intention to pursue a post-primary certification?

Research Design

Adapting the work of Battle and Wigfield (2003), a seven-point Likert response scale survey instrument was designed to examine the perceived values and cost associated with pursuing a post-primary certification. In their study, Battle and Wigfield examined “how college women’s valuing of graduate education predicted their intentions
to attend graduate school” (p. 57). The Battle and Wigfield survey was a modification of the work of Eccles et al. (1983) which studied children and adolescents’ valuing of math. Other researchers have adapted the original work of Eccles et al. (1983). For example, Eccles and Wigfield (1995) adapted the model to access adolescents’ achievement-related beliefs and self-perceptions; while Perez et al. (2014) adapted both the Eccles and Wigfield (1995) and Battle and Wigfield (2003) work to study college STEM (science, technology, engineering, and math) retention.

Battle and Wigfield’s survey, named the “Valuing of Education Scale (VOE)”, contained fifty-one items relating to the valuing of graduate education. Following the format of their survey, questions were adapted for nuclear medicine technologists in order to “provide a more in-depth assessment of each proposed task value component” (Battle & Wigfield, 2003, p 61). The questions were divided into five parts: expectancy, attainment value, intrinsic value, utility value, and cost. Since Battle and Wigfield’s study focused on task values, questions relating to expectancy were adapted from the work of Eccles and Wigfield (1995). Eccles and Wigfield described expectancy as a “motivating behavior” (p. 216), identifying a “predicted positive association between the expectancy/ability constructs and the value constructs” (p. 218).

Similar to Battle and Wigfield (2003), an additional question was added to address the likelihood of nuclear medicine technologists obtaining post-primary credentials. Battle and Wigfield stated the additional question was used “as a dependent variable in analyses of how task value subcomponents predicted … intention” (p. 61). A Likert scale allowed participants to select one of seven responses indicating their likelihood of obtaining a post-primary credential.
A final question asked participants to select a category which best describes their reason for pursuing post-primary credentials. This question was modified from Battle and Wigfield (2003) question which asked respondents to select their “most important personal reason they had for attending graduate school” (p. 62). A scale consisting of five categories of reasons why the technologist plans to pursue a post-primary credential assessed this question. Respondents were asked to identify their first and second most important reason for obtaining post-primary credentials. As in the study by Battle and Wigfield, each option was worded “to reflect specific or pragmatic examples of central concepts associated with each of the task value orientations” (p. 62).

Utilizing the framework of the expectancy-value theory, this study examined how the technologist’s perception of values and cost predict their motivations in obtaining the post-primary credentials. Using this information, health sciences colleges and universities could investigate different pathways to offer didactic and clinical education required for technologists to become candidates for post-primary certification in CT or MRI.

**Population**

The population from which this study was drawn were certified nuclear medicine technologists in the southeastern region of the United States as defined by the Society of Nuclear Medicine and Molecular Imaging (SNMMI). The southeast region, identified as the Southeastern Chapter by the SNMMI, comprises the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and southern Ohio (SNMMI, 2020). The southern Ohio region was excluded from the survey since it does not represent the entire state of Ohio.
According to the Bureau of Labor and Statistics (2020), an estimate of the number of nuclear medicine technologists employed in the southeastern region is 4,410. The state with the largest number of nuclear medicine technologists is Florida (n = 1600), followed by Georgia (n = 550), and Tennessee (n = 520). The smallest population of nuclear medicine technologists employed in the southeastern region is in the state of Mississippi (n = 240).

**Sample**

A representative sample of nuclear medicine technologists, identified as working in the region of the United States defined by the SNMMI as the Southeastern Chapter, was surveyed for this quantitative study. External validity, defined as “the extent to which the results of an investigation can be generalized to other samples or situations” (Polgar & Thomas, 2008, p. 39), must be considered when selecting the sample population. Threats to external validity are related to the method used to select participants for a survey (Coughlan et al., 2009).

For the purpose of this study, the Southeastern Chapter of the SNMMI was chosen since the region includes colleges and universities offering nuclear medicine technology programs representing each entry-level degree program. According to the JRCNMT (2020), the states representing the Southeastern Chapter, after excluding Ohio, house 18 colleges/ universities with nuclear medicine technology programs. Of this list of colleges and universities, two offer a master’s degree, five a bachelor’s degree, eight an associate degree, and seven a certificate degree in nuclear medicine technology. The two master’s degree programs are the only two offered in the United States (Winn, 2021).
The e-mail addresses of technologists credentialed as certified nuclear medicine technologists (CNMT) were requested from the NMTCB for technologists in each state identified in the sample population. The NMTCB was selected based on its recognition in the nuclear medicine profession as the “examination of choice for the NMT [Nuclear Medicine Technologist]” (Neal, 2020, p. 67S). Within the United States, 22,519 nuclear medicine technologists are certified by the NMTCB and have the credential CNMT (A. Shellman, personal communication, October 5, 2021). A total of 2,824 technologists are certified by the ARRT in nuclear medicine technology and have the credential RT(N)ARRT (ARRT, 2020).

**Survey Instrument**

A seven-point Likert survey was designed to address the research questions. The data collected from the survey enables a researcher “to generalize the findings from a sample to a population so that inferences can be made about some characteristic, attitude, or behavior of this population” (Creswell, 2014, p.157). In addition to producing a description of the respondents, surveys are also a way to compare one group to another (Sapsford, 2006).

Since the survey instrument in this study used questions adapted from Battle and Wigfield (2003) and Eccles and Wigfield (1995), it was necessary to test the validity and reliability of the questionnaire. Validity refers to the ability of the instrument to measure what it intends to measure while reliability refers to the consistency of the instrument (Tavakol & Dennick, 2011). Evaluation of validity and reliability is important “when it is a newly developed questionnaire or where a previously tested questionnaire is to be used with a different cultural group or environment” (Coughlan et al., 2009, p.13). Umbach
(2005) suggests failure to achieve validity and reliability can lead to measurement errors in which responses do not address the research questions, processing errors relating to data entry, and representation errors.

Cronbach’s alpha was computed to assess the reliability of the expectancy/value scale questions on the survey. A Cronbach alpha score measures the internal consistency of the set of scale items in the survey (Morgan et al., 2011; Tavakol & Dennick, 2011). Tavakol and Dennick define internal consistency as the “inter-relatedness of the items within the test” (p. 53). Since an instrument must be reliable to be considered valid, the internal consistency of the instrument must be determined to ensure validity (Tavakol & Dennick, 2011).

The Cronbach’s alpha score was determined using IBM SPSS Statistics 23 software. The software uses a correlation matrix in which the score for each scale item is correlated with the summed score for each observation, comparing that score to the variance of all individual scores (Salkind, 2008). The score was conveyed as a number between 0 and 1. Internal consistency or reliability of the survey instrument is supported with a positive alpha score that is .70 or greater (Morgan et al., 2011).

In order to test the validity of the responses, a draft of the survey instrument was submitted for review and feedback to not only experts on survey design but also to experts in the field of nuclear medicine technology. By submitting the questions to both experts in survey design and experts in the subject area, content and design validity can be evaluated (Umbach, 2005). Artino et al., (2014) defines an expert as “someone who has the experience or knowledge of the construct being measured” (p. 467). As part of the validation process, the expert panel assessed the survey instrument for
“representativeness, clarity, relevance, and distribution” (Artino et al., 2014). Artino et al. provides a definition for each validation domain by stating representativeness is “how completely the items (as a whole) encompass the construct, clarity is how clearly the items are worded and relevance refers to the extent each item actually relates to specific aspects of the construct” (p. 467). The evaluation of content validity is important “to ensure that all strategies relevant to the target population are covered” (Petric & Czárl, 2003, p. 193).

For this study, the panel of experts to assess content validity included educators in the field of nuclear medicine technology and educators whose expertise is in quantitative methodology. The nuclear medicine technology educators included both program directors and clinical coordinators. The nuclear medicine educators commented on the survey and gave their opinion on the relevance of the survey questions to the purpose of the study. In addition, the educators provided feedback relating to the wording and interpretation of the questions. The experts in methodology provided additional feedback based on their areas of expertise. This small-scale pretest allowed survey design experts to evaluate the quantitative responses so that issues relating to the survey questions can be addressed (Artino et al., 2014; Umbach, 2005).

**Data Collection**

Data was gathered using the online survey software Qualtrics. Online surveys may be either web-based, where the respondent must visit a website, or in the form of an e-mail survey, in which the survey is embedded in the text of the e-mail or sent as an attachment (Granello & Wheaton, 2004; McPeake et al., 2014). To help ensure ease of response, the electronic survey for this study was in the form of an e-mail containing an
embedded link to the survey. The researcher was responsible for developing the survey in Qualtrics.

Online surveys have several advantages over paper-pencil surveys including “reduced time, lowered cost, ease of data entry, flexibility in format, and ability to capture additional response-set information” (Granello & Wheaton, 2004, p. 387). The survey can be configured to distribute data directly to a spreadsheet, reducing both time and potential errors associated with rekeying data (Coughlan et al., 2009; Granello & Wheaton, 2004). It is important that the researcher is familiar with the identified population, ensuring the selected sample has access to and knowledge of the technology required to complete the survey (Granello & Wheaton, 2004). Key strategies used to improve response rate include personalizing the e-mail, providing information relating to completion time, and sending at least two reminder e-mails (Coughlan et al., 2009; McPeake et al., 2014).

Recruitment of potential participants took place over four weeks. To improve response rates, an email announcing the opportunity to participate in the survey was sent to the e-mail addresses provided by the NMTCB. The initial email helped to inform the nuclear medicine technologists of the purpose of the survey and provide an opportunity to ask questions of the researcher. One week later, a link to the actual Qualtrics survey was sent to all potential participants. As part of the survey design, a consent form was placed on the first page of the survey. Each participate was required to confirm their acknowledgement of the form, indicating informed consent to participate in the research. Two weeks later, a reminder email sent thanking those who participated in the survey and reminding the others of the opportunity to participate.
Post-Primary Certification Motivation Scale

The survey instrument, named the Post-primary Certification Motivation Scale; (Appendix B) was designed for this research study. The survey has two parts: (a) demographic questions and (b) expectancy/value scale questions, which includes a supplementary value scale question. The demographic questions asked respondents for information relating to years of experience in nuclear medicine technology, type of nuclear medicine program from which they graduated, place of employment, and nuclear medicine equipment they currently operate. In addition, respondents were asked if they are currently certified or working towards certification in CT or MRI. This question was used to determine eligibility for completing the scale item questions.

Questions relating to the valuing of post-primary credentials were modified based on the expectancy-value theory framework (Appendix C). The expectancy-value theory was developed by Eccles, Wigfield, and colleagues (Eccles et al. 1983; Battles & Eccles, 2003; Eccles & Wigfield, 1995; Eccles & Wigfield, 2020; Wigfield & Eccles, 2000; Wigfield et al., 2016) to better understand “how expectancies, values, and their determinants influence choice, persistence, and performance” (Wigfield et al., 2016, p. 56). The expectancy construct refers to one’s belief on how well they expect to do a given task, while the subjective value constructs stress the motivational aspect of task-value (Wigfield et al., 2016). These values are “subjective because various individuals assign different values to the same activity” (Wigfield et al., 2016, p. 57).

Subjective task values were further divided into four different components: attainment value, intrinsic value, utility value, and cost (Wigfield, et al., 2016). Wigfield et al., defines cost as “what the individual has to give up to do a task, … as well as the
anticipated effort one will need to put into task completion” (p. 57). Cost is especially important when choices are being made. Wigfield et al. states “choices are influenced by both negative and positive task, characteristics, and all choices are assumed to have cost associated with them, because one choice often eliminates other choices” (pp. 57-58).

A supplemental value question was added to the end of the survey asking the likelihood of pursuing a post-primary credential in CT or MRI. The subjective task value responses were examined based on the response to the question “How likely is it that you will pursue a post-primary certification in CT or MRI?”. Respondents were asked to select one of five responses indicating their likelihood of pursuing post primary credentials including 1 = definitely will not, 2 = will not, 3 = not sure, 4 = will pursue, or 5 = definitely will pursue.

A final question was added to the survey to indicate the respondents’ first and second most important reason for pursuing post-primary credentials. Based on the work of Battle and Wigfield (2003), these questions were worded to reflect the central concepts of each value. For example, the first category, “money, status, career”, relates to utility values of having a post-primary credential in CT or MRI, and included as examples “It will advance my career”, “I will enjoy the status of having multiple credentials”, and “I will have more job opportunities”. Similar to Battle and Wigfield (2003), this information allowed a greater analysis of task values and can be “analyzed to see how closely respondents’ score on the task value subscales reflect their answers to a simplified, or less configured measure of the constructs” (p. 62).
Data Analysis

This study examined whether the values nuclear medicine technologists associate with post-primary certification in CT or MRI predict their intention to pursue a post-primary certification. Statistical analysis of the data helped determine if there was a predictable relationship among the variables (Mertler & Vannatta, 2010). The aim of the analysis was to examine the significance of each predictor variable to predict the dependent variable (Mertler & Vannatta, 2010).

Multiple Regression Analysis

Multiple regression was used to analyze the data collected from administering the Post-primary Certification Motivation Scale in the current study. Multiple regression analysis was applicable for this study because it allows the researcher to analyze multiple predictor variables in order to predict an outcome. According to Morgan et al., (2011), the intent of multiple regression is to “predict a normal (i.e., scale) dependent variable from a combination of several normally distributed and/or dichotomous independent/predictor variables” (Morgan et al., 2011, p. 140). In this study, regression analysis was used to determine if a nuclear medicine technologist’s pursuit of a post-primary credential can be predicted from a combination of several variables: demographics, expectancy for success, and subjective task values. Mertler and Vannatta (2010) explain regression analysis has the primary purpose of “predicting values on some [dependent variables] for all members of a population” and a secondary purpose “of using regression analysis as a means of explaining causal relationships among variables” (p. 159). These variables (i.e., demographics, expectancy for success, and
subjective task values) will be explained more fully in the independent variables section of this study.

**Assumptions.** The mathematical assumptions of multiple regression analysis must be satisfied before drawing a conclusion about the population. The assumptions to consider when using multiple regression includes “the relationship between each of the predictor variables and the dependent variable is linear, the errors are normally distributed, and the variance of the residuals (differences between actual and predicted scores) is constant” (Morgan et al., 2011, p. 141). Another assumption that should be satisfied is multicollinearity. Multicollinearity can be an issue if there is high intercorrelation between predictor variables (Morgan et al., 2011).

**Linearity.** To test the assumption of linearity, bivariate scatterplots were examined to determine the relationship between the independent and dependent variables. According to Osborn and Waters (2002), if there is non-linearity between the independent variable (IV) and dependent variable (DV), the true relationship between the variables will be under-estimated in the regression analysis results. When applied to multiple regression analysis, the underestimation can “increase the risk of Type I errors (over-estimation) for other IVs that share variance with that IV” (Osborn & Waters, 2002, p. 1).

**Normality.** Normality was tested by assessing the values for skewness and kurtosis. Mertler and Vannatta (2010) state skewness measures “the degree of symmetry of a distribution about the mean” while kurtosis measures “the degree of peakedness of a distribution” (p. 30). Multiple regression assumes “errors are normally distributed for any combination of values on the predictor variables” (Williams et al., 2013, p. 2). Williams
et al. defines errors as “difference between subjects’ observed values on the response variable and the values predicted by the true regression model for the population as a whole” (p. 3). Osborn and Watson (2002) point out that “non-normally distributed variables ... can distort relationships and significance tests” (p. 1).

Skewness and kurtosis values of zero indicate a perfectly normal, symmetrical distribution (Kerr et al., 2002; Mertler & Vannatta, 2010; Pallant, 2016). A skewness value > 0 is considered positively skewed, meaning the distribution is clustered to the left with a right tail containing a few values, whereas a skewness value < 0 is considered negatively skewed, with the distribution clustered to the right with a left tail containing few values (Mertler & Vannatta, 2010). A positive kurtosis, referred to as leptokurtic, indicates the frequency distribution is more peaked than the normal curve (Mertler & Vannatta, 2010, Morgan et al., 2011). A kurtosis that is “relatively flat with heavy tails”, is considered negative and referred to as platykurtic (Morgan et al., 2011, p. 51). Values between ± 1.96 suggest at least 95% confidence that the distribution is normal, indicating the values are not positively or negatively skewed (Kerr et al., 2002).

Outliers can refer to individual members of the sample who have “highly unusual values on one or more variables under analysis, or a highly unusual combination of values” (Williams et al, 2013, p. 11). Outliers, once removed, will reduce the probability of Type I and Type II errors, improving the accuracy of the estimates (Osborn & Watson, 2002).

**Homoscedasticity.** Likewise, residuals scatterplots can be used to examine if the variance of the residuals (i.e., homoscedasticity) is constant (Mertler & Vannatta, 2010). According to Osborn and Watson (2002), homoscedasticity implies the variance of error
is constant across all levels of the predictor variable. Heteroscedasticity is indicated when the variance of errors differs at different values of the predictor variable. When viewing the scatterplot, any pattern that shows a systematic pattern of scores (e.g. curvilinear, or funnel shaped) indicates the assumption of homoscedasticity has been violated (Pallant, 2016).

**Multicollinearity.** Multicollinearity will occur if multiple predictor variables are measuring the same or similar information (Daoud, 2017; Morgan et al., 2012). Multicollinearity becomes problematic if two or more predictor variables are shown to have moderate to high intercorrelations (Mertler & Vannatta, 2010). Multicollinearity should be determined prior to using the regression analysis (Mertler & Vannatta, 2010). To determine if multicollinearity exists, the predictor values should be examined using a correlation matrix to identify moderate or high correlation ($r = .9$ and above) (Pallant, 2016). Models with high correlation should be ignored since the results are consider uninterpretable (Daoud, 2017). Pallant (2016) suggests not including “two variables with a bivariate correlation of .7 or more in the same analysis” (p.159). If the situation occurs, one of the variables could be omitted or the scores of the two highly correlated variables could be combined forming a composite variable (Pallant, 2016).

Multicollinearity can also be identified by inspecting the Tolerance/Variance inflation factor (VIF) values as part of the multiple regression analysis. Pallant (2016) states consulting the Tolerance and VIF can identify issues with multicollinearity not previously noted when checking correlations. Tolerance is an indication of “how much of the variability of the specified independent is not explained by the other independent variable in the model” (Pallant, 2016, p. 159). Tolerance values of less than 0.1 indicate
multicollinearity may be a problem (Mertler & Vannatta, 2010; Pallant, 2016). VIF is the inverse of the Tolerance value. VIF values greater than 10 would be an indicator of multicollinearity issues (Mertler & Vannatta, 2010; Pallant, 2016).

**Dependent Variable**

The dependent variable in this study was the question: How likely is it that you will pursue a post-primary credential? This question was based on a similar question used by Battles and Wigfield (2003) to assess college women’s intentions of pursuing graduate school. Participants were asked to check one of seven responses indicating their likelihood of pursuing a post-primary certification. The scale used for the question was 7 = most definitely will pursue to 1 = most definitely will not pursue.

The post-primary credentials of CT and MRI was assessed separately due to the current market in the United States for PET/CT and PET/MRI hybrid systems. PET/MRI is a relatively new medical imaging technology, with the first commercially approved system installed in 2012 (Ehman et al., 2017). In contrast, the used of CT in hybrid imaging systems, such as SPECT/CT and PET/CT, has been commercially available since the early 1990s (Hutton, 2014). Since the first commercially approved PET/MRI system was installed, only 30 PET/MRI systems were in use five years later in the United States compared to over 1,600 for PET/CT (Ehman et al., 2017). With SPECT/CT and PET/CT systems being more widely available, nuclear medicine technologists are more likely to have experience with a hybrid imaging system utilizing CT. This experience may influence their interest in pursuing one post-primary credentials over another.
**Predictor Variables**

The predictor variables were grouped into three blocks: (a) demographics, (b) expectancy value; and (c) subjective task values.

**Demographics.** Demographic data comprised the first block of input variables. Within this block, the primary predictor variables include type of nuclear medicine program of the respondent and primary job description. Since entry-level educational programs are offered at the certificate, associate, bachelor’s, and master’s degree levels, analysis of the data may predict if program education background influences intent to pursue a post-primary certification. In addition, the primary job description of a technologist may influence their decision to become multi-credentialed in CT or MRI. For example, a nuclear medicine technologist who works primarily in a general imaging area, that does not utilize hybrid imaging, may believe a credential in CT or MRI will not advance their career. Other variables within the first block include years of experience, place of employment, and equipment operated daily.

**Expectancy for Success.** The second block contained questions addressing the construct of expectancy. Expectancy beliefs relates to self-perception of success or ability (Schunk et al, 2014). According to Schunk et al, “[s]elf-concept influences achievement and actual achievement shapes and constrains self-concept” (p. 60). In other words, if one has achieved in the past, they are more motivated to continue to improve.

The predictor variables relating to expectancy for success were questions seven through 10 of the motivation questionnaire. The expectancy beliefs were operationalized as a factor scale to determine the technologist’s self-perception of their ability to learn and be successful in a post-primary certification. The overall value for the expectancy
predictor variables have both positive and negative characteristic (e.g. 1 = very strongly disagree and 7 = very strongly agree). The items in this block are divided between CT and MRI and ask “how well” they would do learning CT or MRI from their own perspective and when compared to other technologists. For example, question seven has the respondent score the statement “How well do you think you would do learning CT?” Another example is item question 10 stating, “Compared to other nuclear medicine technologists, how well do you think you would do learning MRI?”

**Subjective Task Values.** To explore the subjective task values, the third block examined the value subscales of attainment, intrinsic, utility, and cost. Subjective task values address whether the technologist wants to earn a new credential and why. The task values are defined as being “subjective” since “the same task can be valued quite differently by different individuals and tasks with equivalent levels of difficulty can be valued quite differently by any one person” (Eccles & Wigfield, 2020, p. 4). Survey questions relating to subjective task values are composed of four different “person-task characteristics/constructs: intrinsic value, attainment value, utility value, and cost” (Eccles and Wigfield, 2020, p. 4). The overall value of each task has both positive and negative characteristic (e.g. 1 = very strongly disagree; 7 = very strongly agree).

**Attainment.** The first predictor variable in the subjective task value block was attainment. A factor scale created from questions 11 through 22 of the motivation questionnaire were operationalized to determine to what degree is pursuing a post-primary credential important. An example of items from examining attainment include question 12, which states, “I feel that being credentialed in CT is necessary for me in the future to be employed as a nuclear medicine technologist.”
**Intrinsic.** The second subjective task value of intrinsic were operationalized as a factor scale created from questions 23 through 28 from the motivation questionnaire. All twelve questions asked respondents to what degree is pursuing a post-primary credential appealing. For example, item question 24 has the respondent score the statement “It is exciting to think about the challenge of earning a CT credential”. Another example is item question 26 stating, “I find the idea of earning a credential in MRI very appealing”.

**Utility.** The third predictor variable in the subjective task value block was utility. Utility refers to “how well a particular task fits into an individual’s present or future plans” (Eccles & Wigfield, 2020, p. 5). This factor scale was created from questions 29 through 32 of the motivational questionnaire. All four questions relate to the usefulness of pursuing a post-primary credential. An example of utility value is item question 31 which states “being good at MRI will be important to advance my career”.

**Cost.** The final predictor variable in the subjective task value block was cost. Cost refers to what might be given up pursuing the task, as well as the effort that might be required to complete the task (Battle & Wigfield, 2003). This factor was created from questions 33 through 44 of the motivation questionnaire. All twelve questions asked respondents the degree of cost in pursuing a post-primary credential. Examples of items from the questionnaire included question 33, “when I think of all of the work involved with earning CT credential, I’m not sure that becoming multi-credentialed is worth it” or question 35 which states, “I’m concerned that working toward a CT credential will prevent me from focusing on myself or family”. Potential barriers to pursuing a post-primary certification, as mentioned in chapter two, were included in the cost value task.
Other barriers, such as lack of money and lack of time, have been identified as reasons adults do not participate in formal adult education (Merriam et al., 2007).

Multiple regression analysis, using the variables described above, answered the research question of interest for the current study: Do the values nuclear medicine technologists associate with a post-primary certification in CT or MRI predict their intention to pursue a post-primary certification? In addition, descriptive analysis identified which values emerge as important reasons for pursuing post-primary credentials.

Summary

Chapter 3 addressed the methodology used for this study. The chapter begins by reviewing the research design. Utilizing the framework of the expectancy-value theory, the research design includes administering a survey identified as the Post-Primary Certification Motivation Scale. This survey will examine the expectancy and subjective task values of nuclear medicine technologists to predict their achievement motivation for pursuing post-primary certification in CT or MRI. Since the survey was adapted from a survey by Battle and Wigfield (2003), the validity and reliability of the adapted survey were addressed in the chapter.

Chapter 3 also identified the population for the study, specifically nuclear medicine technologists who work in the southeast region of the United States as defined by the SNMMI-TS. A representative sample of certified nuclear medicine technologists from this region will be surveyed electronically using the adapted scale. The advantages and limitations of collecting data by use of an electronic survey were addressed along with strategies to improve response rates.
The chapter concluded by addressing data analysis. Data collected from the survey was analyzed using multiple regression analysis. Assumption to consider when using multiple analysis were identified to include linearity, normality, and variance of residuals. The dependent and predictor variables were then identified. The dependent variable for this study addresses the likelihood nuclear medicine technologists to pursue post-primary credentials in CT or MRI. The predictor variables were grouped into three blocks: (a) demographics, (b) expectancy value; and (c) subjective task values. Along with the expectancy value construct, the subjective task value constructs of attainment, utility, intrinsic, and cost were examined using a seven-point Likert scale. Results from the survey will be address in Chapter 4.
Chapter 4

Results

The purpose of the study was to examine the motivations guiding nuclear medicine technologists to pursue post-primary credentials in CT and MRI through the framework of the expectancy-value theory. The study examined how the technologists’ perception of value and cost affect their own expectations for success in obtaining post-primary credentials. The research design grouped the predictor variables for both CT and MRI into three blocks: demographics, expectancy for success, and subjective task values. The demographic questions provided information relating to years of experience in nuclear medicine technology, type of nuclear medicine program from which graduated, place of employment, and nuclear medicine equipment they currently operate. The expectancy-value predictor variable was operationalized as a factor scale to determine the technologist’s self-perception of their ability to learn and be successful in a post-primary certification. Subjective task values examined the value subscales of attainment, utility, intrinsic, and cost, addressing whether the technologist wants to earn a new credential and why.

This chapter presents the results addressing the research question for this study: Do the values nuclear medicine technologists associate with a post-primary certification in computed tomography (CT) or magnetic resonance imaging (MRI) predict their intention to pursue a post-primary certification? To address the research question, multiple regression analyses were conducted.
Survey and Data Collection

The survey instrument (see Appendix B) contained two sections, demographic questions and expectancy/subjective task value questions, which included supplementary value scale questions. Qualtric software with branch logistics was used to create the survey instrument. Branch logistics allows the survey to change based on the response to a specific question. Questions which relate to the respondent’s situation will appear while those that do not apply will be skipped. All participants answered the demographic questions.

The question “are you currently certified or working towards your certification in CT or MRI” was used to qualify the participant’s inclusion in the study. Participants who self-reported post-primary certifications in both CT and MRI were branched to the end of the survey. Participants who self-reported no post-primary certification were branched to the expectancy/subjective task value questions relating to CT and MRI. Participants who self-reported a post-primary certification in CT were branched to MRI expectancy/subjective task value questions while those who self-reported post-primary certification in MRI were branched to CT expectancy/subjective task value questions.

The participants ranked the expectancy/subjective task value questions on a seven-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7= strongly agree). The question “how likely are you to pursue a post-primary credential” determined whether the survey branched to the supplementary value scale questions. Participants who answered the question “will pursue” or “definitely will pursue” ranked their most important reason for pursing a post-primary certification.
Sample

A total of 2,768 nuclear medicine technologist from the southeastern region of the United States were invited to participate in the survey (Alabama = 226; Florida = 1018; Georgia = 316; Kentucky = 189; Mississippi = 123; North Carolina = 369; South Carolina = 199; Tennessee = 328). No compensation was offered for participation. For all invitations to participate in the study, 282 (10.2%) technologists responded to the survey, 2,487 (89.8%) technologists did not complete the study, and 37 (1.3%) were undeliverable.

Of the 282 respondents, 19 (6.7%) were incomplete, and 32 (11.3%) indicated they were either retired or no longer working in nuclear medicine technology. The answers from 237 respondents were used in the final analysis for this study. This equates to 8.6% of the total population.

Demographic Characteristics of the Population

The sample consisted of 237 nuclear medicine technologists working in the southeastern region of the United States. The type of nuclear medicine program the respondent graduated was nearly equally distributed among certificate, associate, and bachelor’s degree programs with 30.8% certificate, 30.8% associate, and 33.8% bachelor’s. Participants from master’s degree programs represented 0.8% of the population. The participants’ years of experience ranged from one to 47 years with a mean of 20.5 years and median of 20 years. The type of imaging equipment operated daily, primary job description, and place of employment are identified in Table 1. Thirty percent of the participants indicated they were currently certified or working towards
certification in CT or MRI with 22.8% indicating CT, 3.4% indicating MRI, and 3.4% indicating both CT and MRI.

**Table 1**

*Demographics Characteristics of the Sample*

<table>
<thead>
<tr>
<th>Baseline Characteristics</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging equipment operate daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planar</td>
<td>121</td>
<td>51.0</td>
</tr>
<tr>
<td>SPECT</td>
<td>178</td>
<td>75.1</td>
</tr>
<tr>
<td>SPECT/CT</td>
<td>76</td>
<td>32.1</td>
</tr>
<tr>
<td>PET</td>
<td>22</td>
<td>9.3</td>
</tr>
<tr>
<td>PET/CT</td>
<td>90</td>
<td>38</td>
</tr>
<tr>
<td>PET/MRI</td>
<td>4</td>
<td>1.7</td>
</tr>
<tr>
<td>Primary job description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff technologist (General imaging, No PET, No cardiac)</td>
<td>18</td>
<td>7.6</td>
</tr>
<tr>
<td>Staff technologist (General imaging including PET and cardiac)</td>
<td>111</td>
<td>46.8</td>
</tr>
<tr>
<td>Staff technologist (PET only)</td>
<td>22</td>
<td>9.3</td>
</tr>
<tr>
<td>Staff technologist (Cardiac only)</td>
<td>32</td>
<td>13.5</td>
</tr>
<tr>
<td>Staff technologist (administration, educator, sales, pharmacy, etc.)</td>
<td>52</td>
<td>21.9</td>
</tr>
<tr>
<td>Place of Employment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small hospital (fewer than 100 beds)</td>
<td>21</td>
<td>8.9</td>
</tr>
<tr>
<td>Medium hospital (100 – 499 beds)</td>
<td>76</td>
<td>32.1</td>
</tr>
<tr>
<td>Large hospital (500 or more beds)</td>
<td>50</td>
<td>21.1</td>
</tr>
<tr>
<td>Outpatient Center</td>
<td>43</td>
<td>18.1</td>
</tr>
<tr>
<td>Other</td>
<td>47</td>
<td>19.8</td>
</tr>
</tbody>
</table>

**Data Cleaning and Variable Preparation**

Results of the Qualtrics survey were uploaded into SPSS data file for analysis.

Respondents who identified as retired or no longer working in nuclear medicine technology were excluded from the data set. The missing variables were replaced with a system-missing code in the SPSS data file in order to prepare the data set for analysis.

Five factor scales were created for both CT and MRI responses for the expectancy and subjective task value variables: attainment value, extrinsic value, utility value, and cost.

An analysis of the standardized residuals was completed to determine the presence of
outliers in the data set. A standardized residual is a ratio that measure the strength of the difference between observed and predicted values (Glen, 2022). Standardized residuals greater than ±3 standard deviations should be evaluated for outlier (Laerd Statistics, 2015). The standard residuals showed that the data contained no outliers (Std. Residual Min = -2.98, Std. Residual Max = 2.86). Finally, the data set was tested for the assumptions of linearity, normality, homoscedasticity, and multicollinearity. When the assumptions of multiple regression are not met, the results may be considered not trustworthy. As a result, Type I or Type II errors may occur indicating an “over- or under-estimation of significance or effect size(s)” (Osborne & Waters, 2002, p. 1).

**Reliability of Survey**

Cronbach’s Alpha was used to test the internal consistency reliability of the survey. The survey consisted of expectancy and subjective task value variables (i.e., attainment value, extrinsic value, utility value, and cost) for both CT and MRI. Internal consistency or reliability of the survey instrument is supported with a positive alpha score that is .70 or greater (Morgan et al., 2011). Based on the Cronbach’s Alpha results for both CT and MRI, the internal consistency of the survey was acceptable (see Tables 2).

**Table 2**

*Subscales from expectancy belief and subjective task values*

<table>
<thead>
<tr>
<th>Subscale</th>
<th>N</th>
<th>Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Computed Tomography (CT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expectancy</td>
<td>164</td>
<td>2</td>
<td>.71</td>
</tr>
<tr>
<td>Attainment</td>
<td>164</td>
<td>6</td>
<td>.82</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>164</td>
<td>3</td>
<td>.90</td>
</tr>
<tr>
<td>Utility</td>
<td>164</td>
<td>2</td>
<td>.78</td>
</tr>
<tr>
<td>Cost</td>
<td>164</td>
<td>6</td>
<td>.75</td>
</tr>
</tbody>
</table>
Table 2 (Continued)

Subscales from expectancy belief and subjective task values

<table>
<thead>
<tr>
<th>Subscale</th>
<th>N</th>
<th>Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Resonance Imaging (MRI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expectancy</td>
<td>211</td>
<td>2</td>
<td>.87</td>
</tr>
<tr>
<td>Attainment</td>
<td>210</td>
<td>6</td>
<td>.85</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>211</td>
<td>3</td>
<td>.92</td>
</tr>
<tr>
<td>Utility</td>
<td>210</td>
<td>2</td>
<td>.79</td>
</tr>
<tr>
<td>Cost</td>
<td>210</td>
<td>6</td>
<td>.75</td>
</tr>
</tbody>
</table>

Assumptions

The survey data was tested for assumptions related to multiple regression analysis. According to Morgan et al. (2011), testing for assumptions determines if it is reasonable to use or not use as a particular statistical test. Multiple regression analysis requires the testing of the following assumptions: linearity, independence, normality, homoscedasticity, multicollinearity.

**Normality.** Normality of the distribution was tested by assessing the values for skewness and kurtosis. Skewness is a quantitative measure which refers to “the degree of symmetry of a distribution about the mean” while kurtosis addresses “the degree of peakedness of a distribution” (Mertler & Vannatta, 2010, p. 30). In addition, histograms and a P-P Plots were produced for CT and MRI to check for normality. The histogram compares the standardized residuals to a normal curve. The P-P Plot indicates whether the residuals are normally distributed.

According to Kerr et al. (2002), values for skewness and kurtosis between ± 1.96 suggest a 95% confidence that the distribution is normal. The skewness values for the expectancy predictor variable for both CT and MRI, although negatively skewed, indicate the distributions were not outside the range of normality (see Table 3). However, the
kurtosis value for the CT expectancy is leptokurtic, indicating the frequency distribution is heavy-tailed or more peaked than normal. This negatively skewed (or left-skewed) distribution was not surprising in that the CT expectancy value examines the technologist’s self-perception for success or ability to learn CT. Since CT has been a component of the PET/CT systems for over twenty years, it is not surprising that nuclear medicine technologists would have confidence in their ability to learn CT.

The subjective task values examine the value subscales of attainment, intrinsic, utility, and cost. Skewness analysis of the CT subjective task values for attainment value, intrinsic value, utility value, and cost, indicated the distribution was not outside the range of normality. The skewness of the subjective task values for MRI, indicates the distribution, for attainment value, intrinsic value, utility value, and cost, is approximately symmetric. The kurtosis of the subjective task values for CT, all values are less than ±1.96, indicating a normal distribution. The kurtosis of the subjective task values for MRI indicated the distribution was not outside the range of normality (See Table 3).

The histogram of standardized residuals indicated the data contained normally distributed errors, as did the P-P plot of standardized residuals, which showed some data points were not completely on the line but there was no drastic deviation.

Table 3

*Predictor Values*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Expectancy</th>
<th>Attainment</th>
<th>Intrinsic</th>
<th>Utility</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computed Tomography (CT)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>-1.43</td>
<td>-.21</td>
<td>-.27</td>
<td>-.61</td>
<td>-.27</td>
</tr>
<tr>
<td>Standard error of skewness</td>
<td>.20</td>
<td>.20</td>
<td>.20</td>
<td>.20</td>
<td>.20</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>3.56</td>
<td>-.38</td>
<td>-.44</td>
<td>-.33</td>
<td>-.32</td>
</tr>
<tr>
<td>Standard Error of kurtosis</td>
<td>.40</td>
<td>.40</td>
<td>.40</td>
<td>.40</td>
<td>.40</td>
</tr>
</tbody>
</table>
Table 3 (Continued)

*Predictor Values*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Expectancy</th>
<th>Attainment</th>
<th>Intrinsic</th>
<th>Utility</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skewness (Magnetic Resonance Imaging (MRI))</td>
<td>-.81</td>
<td>-.05</td>
<td>-.15</td>
<td>-.11</td>
<td>-.27</td>
</tr>
<tr>
<td>Std. error of Skewness</td>
<td>.18</td>
<td>.18</td>
<td>.18</td>
<td>.18</td>
<td>.20</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>.23</td>
<td>.03</td>
<td>-.73</td>
<td>-.60</td>
<td>-.32</td>
</tr>
<tr>
<td>Standard Error of Kurtosis</td>
<td>.35</td>
<td>.35</td>
<td>.35</td>
<td>.35</td>
<td>.40</td>
</tr>
</tbody>
</table>

*Homoscedasticity*. The assumption of homoscedasticity is that the “variance of the residuals about the predicted DV scores should be the same for all predicted scores” (Pallant, 2016, p. 152). To test for homoscedasticity, the standardized residuals were plotted against the unstandardized predicted values for both CT and MRI. To meet the assumption of homoscedasticity, the residuals should appear randomly scattered along the predicted value providing a relatively event distribution. (Laerd Statistics, 2015; Osborne & Waters, 2002). Both scatterplots assessing standardized residuals versus unstandardized predicted values were visually inspected and met the assumption of the homoscedasticity.

*Multicollinearity*. Multicollinearity refers to the relationship among predictor variables. Multicollinearity exist when two or more predictor variables are highly correlated ($r = .9$ and above) (Pallant, 2016). Pallant (2016) suggests not including “two variables with a bivariate correlation of .7 or more in the same analysis” (p.159). To check for multicollinearity, the predictor variables were examined using the correlation matrix. The data for the CT variables met the assumption of collinearity, indicating multicollinearity was not an issue. For the MRI, a collinearity issue may exist between the intrinsic and attainment predictor variables (Correlation = .81).
Tolerance and Variance Inflation Factor (VIF) allows for an additional check for multicollinearity. Tolerance values less than .10 indicates a high correlation with other variables, suggesting multicollinearity. VIF values greater than 10 would indicate multicollinearity. Test to determine if the data met the assumption of collinearity indicated multicollinearity was not an issue (see Table 4).

**Table 4**

*Collinearity Statistics*

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Tolerance</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Computed Tomography (CT)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of experience</td>
<td>.90</td>
<td>1.11</td>
</tr>
<tr>
<td>Type NMT program</td>
<td>.87</td>
<td>1.15</td>
</tr>
<tr>
<td>Expectancy</td>
<td>.79</td>
<td>1.26</td>
</tr>
<tr>
<td>Attainment</td>
<td>.32</td>
<td>3.10</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>.36</td>
<td>2.78</td>
</tr>
<tr>
<td>Utility</td>
<td>.40</td>
<td>2.47</td>
</tr>
<tr>
<td>Cost</td>
<td>.87</td>
<td>1.14</td>
</tr>
<tr>
<td><strong>Magnetic Resonance Imaging (MRI)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of experience</td>
<td>.92</td>
<td>1.08</td>
</tr>
<tr>
<td>Type program</td>
<td>.89</td>
<td>1.12</td>
</tr>
<tr>
<td>Expectancy</td>
<td>.80</td>
<td>1.25</td>
</tr>
<tr>
<td>Attainment</td>
<td>.25</td>
<td>4.04</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>.30</td>
<td>3.33</td>
</tr>
<tr>
<td>Utility</td>
<td>.33</td>
<td>2.99</td>
</tr>
<tr>
<td>Cost</td>
<td>.93</td>
<td>1.08</td>
</tr>
</tbody>
</table>

**Multiple Regression Analysis**

After testing for assumptions, multiple regression analyses were run to predict technologists’ intent to pursue post-primary certification in CT and MRI. In multiple regression, $R^2$, also known as the coefficient of determination, measures the portion of the variance in the dependent variable explained by the independent variables within the model (Pallant, 2016). $R^2$ is considered “a positively-biased estimate” of the true value in
the population (Laerd Statistics, 2015, p. 16). The measure ‘adjusted $R^2$’ corrects the bias, providing a value that is expected in the population (Pallant, 2016).

The $R^2$ for the overall CT model was .35 with an adjusted $R^2$ of .31. The $R^2$ for the overall MRI model was .35 with an adjusted $R^2$ of .32. The multiple regression model significantly predicted intent to pursue a CT credential, $F(7,130) = 9.956, p < .001$. The variables ‘years of experience’ ($p < .001$) and ‘attainment value CT’ ($p < .05$) significantly contributed to the ‘intent to pursue CT credential prediction’. Regression coefficients and standard error for the CT model can be found in Table 5.

Table 5

*Multiple regression results for Intent to Pursue CT credential*

<table>
<thead>
<tr>
<th>Intent</th>
<th>$B$</th>
<th>95% CI for $B$</th>
<th>$SE$</th>
<th>$β$</th>
<th>$R^2$</th>
<th>$ΔR^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td></td>
<td>$LL$</td>
<td>$UL$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of experience</td>
<td>-.03***</td>
<td>-.04</td>
<td>-.02</td>
<td>.01</td>
<td>-.33***</td>
<td></td>
</tr>
<tr>
<td>Type NMT program</td>
<td>-.10</td>
<td>-.28</td>
<td>.08</td>
<td>.09</td>
<td>-.09</td>
<td></td>
</tr>
<tr>
<td>Expectancy CT</td>
<td>.026</td>
<td>-.05</td>
<td>.10</td>
<td>.04</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Attainment CT</td>
<td>.035*</td>
<td>.00</td>
<td>.07</td>
<td>.02</td>
<td>.25*</td>
<td></td>
</tr>
<tr>
<td>Intrinsic CT</td>
<td>.056</td>
<td>.00</td>
<td>.11</td>
<td>.03</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Utility CT</td>
<td>.004</td>
<td>-.07</td>
<td>.08</td>
<td>.04</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Cost CT</td>
<td>-.006</td>
<td>-.03</td>
<td>.02</td>
<td>.01</td>
<td>-.04</td>
<td></td>
</tr>
</tbody>
</table>

Note: Model = “Enter” method in SPSS Statistics; $B$ = unstandardized regression coefficient; CI = confidence interval; $LL$ = lower limit; $UL$ = upper limit; $SE$ = standard error of the coefficient; $β$ = standardized coefficient; $R^2$ = coefficient of determination; $ΔR^2$ = adjusted $R^2$.

Likewise, the multiple regression model significantly predicted intent to pursue a MRI credential, $F(7, 124) = 9.681, p < .001$. For this group, ‘years of experience’ was the only variable that significantly predicted the intent to pursue MRI credential ($p < .001$). Regression coefficients and standard error for the MRI model can be found in Table 6.
Table 6

Multiple regression results for Intent to Pursue MRI credential

<table>
<thead>
<tr>
<th>Intent</th>
<th>B</th>
<th>95% CI for B</th>
<th>SE B</th>
<th>β</th>
<th>R²</th>
<th>ΔR²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years of experience</td>
<td>-.04***</td>
<td>-.05</td>
<td>-.02</td>
<td>.01</td>
<td>-.38***</td>
<td>.35</td>
</tr>
<tr>
<td>Type NMT program</td>
<td>-.13</td>
<td>-.30</td>
<td>.05</td>
<td>.09</td>
<td>-.11</td>
<td></td>
</tr>
<tr>
<td>Expectancy MRI</td>
<td>-.05</td>
<td>-.30</td>
<td>.07</td>
<td>.02</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>Attainment MRI</td>
<td>.03</td>
<td>-.01</td>
<td>.07</td>
<td>.02</td>
<td>.22</td>
<td></td>
</tr>
<tr>
<td>Intrinsic MRI</td>
<td>.03</td>
<td>-.03</td>
<td>.07</td>
<td>.02</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>Utility MRI</td>
<td>.06</td>
<td>-.02</td>
<td>.14</td>
<td>.04</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>Cost MRI</td>
<td>-.02</td>
<td>-.04</td>
<td>.01</td>
<td>.01</td>
<td>-.10</td>
<td></td>
</tr>
</tbody>
</table>

Note: Model = “Enter” method in SPSS Statistics; B = unstandardized regression coefficient; CI = confidence interval; LL = lower limit; UL = upper limit; SE B = standard error of the coefficient; β = standardized coefficient; R² = coefficient of determination; ΔR² = adjusted R².

***p < .001

Years of Experience

The predictor variable years of experience was identified as a statistically significantly contributing predictor of whether nuclear medicine technologists pursue post-primary credentials in CT or MRI (p < .001). For both the CT and MRI models, years of experience made the strongest unique contribution to explain a technologist’s intent to pursue a post primary credential in CT or MRI. The analysis of the models indicated the predictor variable was inversely related with a technologist’s intent to pursue the post-primary credential, suggesting as the technologist’s years of experience increases by one standard deviation, the perceived intent to pursue a post-primary credential would likely decrease.

Although the introduction of hybrid imaging has changed the role of nuclear medicine technologists, this study suggests technologists with more years of experience are less likely to pursue the additional training associated with the new technology. Adult
education has historically responded to the needs of adult learners. However, age is a factor relating to whether a person participates in the learning opportunity (Merriam et al., 2007). Most employees welcome the opportunity to learn throughout their career; however, the older employee is less likely to pursue additional learning opportunities when compared to younger employees (Finkelstein et al., 2015). According to Finkelstein et al., employees who have long tenures in the workforce are less motivated to make the changes necessary to maintain employment or transition to a new job responsibility.

**Type of Nuclear Medicine Program**

The findings from the current study indicated the educational level of the nuclear medicine program that the technologist completed is not a statistically significant predictor of whether a nuclear medicine technologist pursues post-primary credentials. The current non-standard entry-level education structure of nuclear medicine technology programs makes it difficult to address the educational needs of entry-level technologists in the new hybrid-imaging environment (Owen et al., 2005; Bolus, 2020); however, the level of the nuclear medicine program does not appear to influence the working technologist to pursue additional educational opportunities in CT or MRI.

**One-Way ANOVA Analysis**

Primary job description, place of employment, and imaging equipment operated daily were also variables of interest in the study. To further investigate the relationships between these categorical variables and the dependent variable, one-way analysis of variance (ANOVA) was conducted to compare the means of the categorical variables in order to make inferences about the population mean.
The categorical variable ‘imaging equipment operated daily’ did not meet an assumptions of ANOVA which requires each participant to be “in only one group ... [with] only one score for each measure” (Morgan et al., 2011, p. 164). Therefore, two independent groups were created to show difference in probability based on whether the respondent operated a PET/CT imaging system on a daily basis. Since PET/CT imaging systems are capable of performing diagnostic quality CT images, respondents who identified PET/CT as the only imaging equipment operated daily were placed in one group while those that did not operate PET/CT equipment were grouped together.

**Primary Job Description**

A one-way ANOVA was conducted to determine ‘likelihood to pursue post-primary credentials’ was different for groups who had different primary job descriptions. Participants were classified into five groups: general imaging with no PET and no cardiac (n = 15), general imaging including PET and cardiac (n = 89), PET only (n = 18), cardiac only (n = 30), and non-clinical (n = 43). There were no statistically significant differences in intentions to pursue post-primary credential and primary job description, $F(4,190) = 1.196, p = .314$.

**Place of Employment**

A one-way ANOVA was conducted to determine ‘likelihood to pursue post-primary credentials’ was different for groups based on place of employment. Participants were classified into five groups: Small hospitals, fewer than 100 beds (n = 16), medium hospitals, 100 to 499 beds (n = 65), large hospitals, 500 or more beds (n = 35), outpatient centers (n = 39), and other (n = 41). There were no statistically significant differences in
intentions to pursue post-primary credential and place of employment, \( F(4,191) = .299, p = .878. \)

**Type Equipment Operated Daily**

A one-way ANOVA was conducted to determine ‘likelihood to pursue post-primary credentials’ was different for groups based on type of equipment operated daily. Participants were classified into two groups: PET/CT only \((n = 72)\) and no PET/CT \((n = 124)\). There was no statistically significant differences in intentions to pursue post-primary credential and type of equipment operated daily, \( F(4,194) = 1.086, p = .299. \)

**Analysis of Supplemental Value Scale**

Similar to the research conducted by Battle and Wigfield (2003), a final question asked nuclear medicine technologists to choose a category that best described their first and second reason for pursuing a post-primary credential. Each category was worded in a way that reflected the central concepts associated with a task value. Technologists \((n=46, \text{ or } 23.5\% \text{ of the sample})\) who indicated that they “will pursue” or “definitely will pursue” a post-primary certification in CT or MRI completed this portion of the survey. An analysis of the responses to this measure indicate attainment issues emerge in this frequency analysis as somewhat more important than intrinsic or utility concerns (Table 7). This finding was consistent with multiple regression analysis which found attainment value significantly contributed to the intent to pursue a CT credential.
Table 7

*Frequency of reasons to pursue post-primary credential*

<table>
<thead>
<tr>
<th>Category/value orientation</th>
<th>#1 choice</th>
<th>#2 choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Money, status, career / utility</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>2. Family concerns/ cost</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>3. Knowledge and learning / intrinsic</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>4. Professional growth/ attainment</td>
<td>22</td>
<td>10</td>
</tr>
</tbody>
</table>

Summary

Chapter 4 includes the results of the multiple regression analyses that examined the motivations guiding nuclear medicine technologists to pursue post-primary credentials in CT and MRI through the framework of the expectancy-value theory. All of the assumptions for multiple regression analysis were met. The multiple regression model was statistically significant in predicting intent to pursue a CT credential. The variables ‘years of experience’ and ‘attainment value’ proved to be statistically significant in the intent to pursue a CT credential. Likewise, the multiple regression model statistically significantly predicted intent to pursue a MRI credential. The variable ‘years of experience’ added statistically significantly to the intent to pursue MRI credential. For the supplementary value scale, an analysis of the responses indicate attainment issues emerge in this frequency analysis as somewhat more important than intrinsic or utility concerns. The final chapter of this study will provide a discussion of the findings. The significance of the findings will be presented along with suggestions for further research.
Chapter 5

Discussion

This chapter provides an interpretation of the research findings presented in Chapter 4. The purpose of the study was to examine the motivations guiding nuclear medicine technologists to pursue post-primary credentials in CT and MRI through the framework of the expectancy-value theory. The study examined how nuclear medicine technologists’ valuing of post-primary credentials in CT or MRI predicted their intentions to pursue post-primary certification. Multiple regression analysis was used to examine the relationship between the predictor variables and the technologists’ likelihood to pursue post-primary credentials. The predictor variables included in the analysis were based on demographic data along with the expectancy value and subjective task values as defined by Eccles et al. (1993). Subjective task value components included attainment value (importance of the task), intrinsic value (enjoyment from the task), utility value (usefulness of the task), and cost (what is given up, effort involved, emotional effort) (Wigfield & Eccles, 2000).

Overview of the Study

Hybrid imaging systems, such as SPECT/CT, PET/CT, and PET/MRI, are changing the traditional role of the nuclear medicine technologist. Once seen as imaging modalities solely performed by medical radiographers, nuclear medicine technologists are often being asked to perform diagnostic CT and MRI with the new hybrid imaging systems. As a result, the need for multi-skilled technologists within the nuclear medicine workforce has emerged. The purpose of this study was to examine the extent that demographic data, expectancy values, and subjective task values predict nuclear medicine
technologists’ pursuit of post-primary credentials in CT or MRI to determine the factors that may motivate a nuclear medicine technologist to pursue multiple credentials. The results may be important to health sciences colleges and universities to investigate different pathways to offer didactic and clinical education required for practicing technologists to become candidates for post-primary certification in CT or MRI.

**Interpretation of Findings**

Expectancy-value theory proposes that individuals make choices based on their expectancy for success, which is based on their ability beliefs, and subjective task values such as attainment, intrinsic, utility, and cost (Wigfield & Eccles, 2000). Multiple regression analysis was used to examine which predictor variables, identified as years of experience, type of nuclear medicine technology program, expectancy belief, and subjective task values, may predict the intent to pursue a post-primary credential in CT or MRI.

**Expectancy Beliefs**

Expectancy beliefs refers to whether an individual believes they will be successful in a task, focusing on the self-concept of ability (Gorges, 2016). Both the CT and MRI models tested the influence of expectancy on whether a technologist pursues a post-primary credential. Although belief in one’s ability is a prominent component of different motivational theories (Eccles & Wigfield, 2002), this study suggests expectancy beliefs were not a predictor of future intent to pursue post-primary credentials.

**Subjective Task Values**

According to expectancy-value theory, subjective task values, which focuses on “achievement-related choices”, addresses whether one wants to do a particular task and
why (Gorges, 2016, p.28). As mentioned in Chapter 2, subjective task values are composed of four different types of values: attainment value, utility value, intrinsic value, and cost. This section focuses on the results of the survey as it relates to each value.

**Attainment Value.** Attainment value is described as “the perceived importance of a task or the identity fulfillment and pride from completing a task” (Soleas, 2020, p. 139). Analysis of multiple regression results for both CT and MRI revealed attainment value was a predictor of future intent to pursue a CT credential but was not a predictor for intent to pursue a MRI credential. Analysis of the survey questions relating to the participants’ attainment value helps explain why pursuing a CT credential was considered important. Namely, it is necessary for future employment as a nuclear medicine technologist. The respondents indicated that technologists entering the field of nuclear medicine technology will be multi-credentialed which is important for technologists to operate a PET/CT camera.

**Intrinsic Value.** Intrinsic value refers to the enjoyment one gains from participating in a task in which they have interest (Eccles & Wigfield, 2002). Analysis of the of multiple regression results for both CT and MRI indicates a technologist’s intrinsic value did not predict the pursuit for post-primary credential in CT or MRI. Based on the study results, the concept of earning a post-primary credential is not an appealing or exciting challenge for technologists currently working in the profession.

**Utility Value.** Utility value refers to the usefulness of the task as it relates to fulfilling a personal goal or plan and is closely linked to extrinsic motivation (Eccles, 2009; Eccles & Wigfield, 2020). Utility value questions focused on technologists’ perceived usefulness of the multi-credential to advance their career in nuclear medicine
and provide better job opportunities. Results from the multiple regression analysis indicated utility value did not predict a technologist’s intent to pursue a post-primary credential in CT or MRI.

**Cost.** Cost refers to what has to be given up to engage in a task. Perceived costs in this study included the additional work involved, the energy required, and the time invested to pursue a post-primary credential. Analysis of the multiple regression results indicated that the cost relating to the pursuit of post-primary credentials in CT or MRI did not predict technologists’ intentions. Negative factors relating to cost, such as hospital policies, state licensure, and lack of educational programs, which may prevent the technologist from obtaining the requirements necessary to pursue post-primary credentials, were also included in the survey but did not predict their intentions.

**Implications of Findings for Practice**

Findings from this study create an opportunity to understand the values that motivate nuclear medicine technologists to pursue a post-primary credential in CT or MRI. Merriam et al. (2007) points out adult learning is mainly a voluntary activity. Understanding an adult’s decision to participate or not participate in a learning activity is important information for both educators and administrators (Gorges, 2016; Merriam et al., 2007). And understanding the motivations relating to why a nuclear medicine technologist decides to pursue or not pursue a post-primary credential can have important financial implications for an organization. In addition, the study helps administrators and educators to identify three key strategies to implement that may enhance educational opportunities for technologists.
**Implication One**

Although the study indicated the type of program the technologist graduates from was not a motivational factor in the decision to pursue a post-primary credential, the study did find as the technologist increases in years of experience (i.e., becomes older), the likelihood of pursuing a post-primary credential decreases. This finding is similar to a study conducted by Drabe et al. (2014) that found older employees place less emphasis on job security and advancement opportunities than younger employees, and they often mention as reasons they do not participate in formal higher education are lack of time and money (Merriam et al., 2007). According to O’Neill and Thomson (2013), the motivation to pursue additional educational opportunities is often short-lived when their academic loads begins to interfere with family, work, and finances.

If the goal is for working technologists to acquire the additional knowledge and skills to fully operate hybrid imaging systems that utilize CT or MRI, higher education administrators and educators can develop institutional policies that support the adult learner while identifying and addressing barriers that may prevent their success. Programs offered through the college or university should be relevant, connecting to the immediate needs of the workforce (Lumina Foundation, 2017). In addition, institutional policies that support flexible learning options, such as competency-based education, can help support the working adult. Competency-based education is a way for the adult learners to earn academic credit at their own pace while demonstrating their competence through assessment as they gain practical experience in the subject area (Aithal & Aithal, 2016). When offered online, the competency-based model allows the adult learner to
access the course material on their own time schedule, working around other obligations such as family and work.

Other potential opportunities for technologists to gain skills and knowledge while working is to develop partnerships between healthcare organizations and educational institutions. Often known as career ladder programs, these programs offer opportunities for health care workers to “advance their careers by providing compensated education and training” (Dill et al., 2014, p. 64). The educational partner receives funding to develop and implement career ladder programs to address specific needs of the health care organization.

**Implication Two**

The second implication from the study related to one of the values outlined in the expectancy-value theory. For this study, attainment value proved to be a strong predictor of pursuing a post-primary credential in CT. Attainment value implies that the post-primary credential must be important or personally significant to the technologist.

Several factors influence whether obtaining a post-primary credential in CT or MR is important to their career as a nuclear medicine technologist. O’Neil and Thomson (2013) point out that “while career goals are most salient to adult learners, they are not their sole focus or motivation for achievement” (p. 168). For the adult learner, short-term goals helps the adult learner “stay on track as well as measure progress towards their goal” (O’Neil and Thomson, 2013, p. 168).

Technologists who decide in favor of pursuing a post-primary credential must decide if the value of the credential is greater than the cost. Ultimately, the technologist is accountable for their professional development once in the workplace; however,
administrators and educators can have a role in increasing the technologist’s attainment value as it relates to achieving personal goals. According to a study by Arens et al., (2018), a person’s previous academic self-concept can positively influence their later attainment value. Based on this study, educators who are able to develop a student’s interest in a subject while emphasizing its importance are likely to enhance the student’s later attainment value (Arens et al., 2018).

As the technology associated with PET/CT expands to include simultaneous contrast-enhanced diagnostic CT with the PET (Subramaniam et al., 2013), earning a post-primary credential in CT may become more important to the nuclear medicine technologist. Health sciences colleges and universities that present to technologists a clear learning path to achieve a post-primary credential may be seen by technologist as a recognition of their past achievements and may contribute to their attainment value (Hong et al., 2012). Educators can have a role in increasing a technologist’s attainment value by promoting the value or importance of the CT credential to the future of nuclear medicine technology.

**Implication Three**

Finally, the study indicated that perceived barriers to pursuing a post-primary credential were possible to overcome. Barriers identified in ‘cost’ such as licensure, hospital policies, and lack of educational opportunities, were not significant predictors relating to the pursuit of a post-primary credential. For technologists in the sample population, licensure requirements varied depending on the state in which they worked. Technologists from Alabama, Georgia, Tennessee, and North Carolina currently have no licensure requirements. For the technologist working in these states, pursuing a post-
primary credential in CT may not be important in that it is not required to work on the new hybrid-imaging systems. However, a license is required for technologists who worked in Florida, Kentucky, Mississippi, or South Carolina. Of the states that require licensure, all except Kentucky, require a post-primary credential in CT to perform diagnostic CT (SNMMI, 2022). Based on licensure, pursuing a post-primary credential in CT would be an important factor to consider if the technologist operates hybrid-imaging systems. The uncertainty of licensure requirements in certain states may help explain why the majority of technologists who indicated they operated a hybrid imaging system with a CT component (i.e., SPECT/CT, PET/CT) stated “not certain” when asked if they plan to pursue a post-primary credential.

Universities must be responsive to the needs of the community when considering offering new programs or making program revisions. For colleges or universities offering health sciences programs, understanding the various needs of the stakeholders is important to make a positive impact on the community served. As the post-baby boom generation approaches retirement, addressing the needs of the labor market becomes critical as fewer young people enter the workforce (Kazis et al., 2007). The value of a postsecondary credential is expected to rise especially for future workers seeking to improve their wages and quality of life (Kazis et al., 2007). According to Kazis et al. (2007), traditional higher education policies “are not well-designed for the needs of adult learners, most of whom are ‘employees who study’ rather than ‘students who work’” (p. 1). In addition, Kazis et al., points out “the vast majority of adult learners are financially independent, work part time or full time, have dependents, and must juggle many responsibilities with school” (p. 2).
Changing the curriculum and/or modalities in which courses are offered (i.e., competency-based, asynchronous online, weekend intensives, hybrid education, etc.) can be a time-consuming overhaul. These are strategies that educators are exploring to increase enrollment by appeal to adult students. However, findings from the current study suggest that nuclear medicine technology program recruiters should spend time targeting early career nuclear medicine technologists, focusing their sales pitch on the “attainment value” of having the additional credentials to address the skills required to operate the hybrid-imaging systems. This demographic is most likely to be interested in returning for further education. Partnerships with local hospitals to make connections with their new employees and/or programs to recruit recent alumni who may want to return for further education would be more effective than targeting mid-career or more senior nuclear medicine technologists.

Limitations

Limitations of this study include self-selection bias since the technologists were able to decide whether they wanted to participate in the survey. In addition, the impact of inclusion of participants identified as “nuclear medicine technologists (administrators; educator; sales, pharmacy; etc.)” was not examined in this study. These participants, although certified as nuclear medicine technologists, may not work directly with patients in the clinical setting or on hybrid-imaging systems.

Finally, the general influence of the Covid-19 pandemic on technologists’ responses to the survey should be considered. The survey was administered the first three weeks of January 2022, during the rapid spread of the Covid-19 Delta and Omicron variants in the United States (Sencer, 2022). The Covid-19 pandemic had a significant
impact on healthcare facilities, including nuclear medicine departments, with many workers experiencing reduced hours due to the decreased number of procedures performed during the pandemic. The effects from the pandemic on technologists likely persisted at the time of the survey.

Future Research

The findings from this study contribute new insights into the values that motivate a nuclear medicine technologist to pursue a post-primary credentials in CT or MRI. However, the findings also reveal opportunities for further research. For example, the study indicated the type of nuclear medicine technology program the technologist graduated from was not a statistically significant finding relating to intent to pursue a post-primary credential. However, the current non-standard entry-level educational structure of nuclear medicine technology programs makes it difficult to include the educational needs of technologists to fully operate a hybrid imaging system (Owen et al., 2005; Bolus, 2020). To address the need, several nuclear medicine technology programs at the bachelor’s degree level are embedding the didactic and clinical education components of diagnostic CT into their curriculum requirements. Research relating to the impact of this revised curriculum would be useful information as it relates to entry-level education requirement for the nuclear medicine technology profession.

Second, this study did not give much attention to the reasons nuclear medicine technologists indicated the concept of earning a post-primary credential in CT or MRI was not appealing or useful to their careers. A qualitative study would be useful to obtain insight into the technologist’s perspective relating to hybrid imaging and the need for multiple credentials. Of the four subjective task values associated with the expectancy-
value theory, only attainment value or importance of CT was statistically significant. A qualitative study would provide a deeper understanding of the values the technologists have relating to earning a post-primary credential.

Next, this study focused on educational models based on earning a degree or certification from a higher education institute. Including competency-based or other non-traditional learning models as an alternative pathway to post-primary credential eligibility might interest technologists who have more years of experience. The findings from this study implies age is a factor relating to whether a person participates in learning opportunities. Merriam et al., (2007) suggests most adult learners are self-directed learners, meaning the individual takes on the responsibility of planning or continuing their learning experiences instead of using an external source, such as a teacher. Van Doom and Van Doom (2014) state access to lifelong learning has increased based on the “pedagogical paradigm shift in higher education to 24-h learning environments” composed of several different teaching delivery methods (p. 1). Examining the alternative pathways technologists have utilized to gain the necessary didactic and clinical education to pursue a post-primary credential would be useful for administrators considering alternative pathway models for the non-traditional student.

Finally, additional studies examining the impact of partnerships between healthcare organizations and educational institutions may help address the needs of a changing workforce. Healthcare workers face several barriers which prevent them from pursuing additional training. For example, many technologists are working full-time positions which already limits the time they may have with their family or friends. Healthcare organizations may not be equipped to address the educational needs of the
workforce. A partnership between healthcare organizations and educational institution may offer several benefits to both organizations.

**Summary**

This study examined how nuclear medicine technologists’ valuing of post-primary credentials in CT or MRI predicted their intentions to pursue post-primary certification in CT or MRI. Hybrid imaging in nuclear medicine technology has resulted in the need for multi-credentialed technologists. The study results indicated that fewer years of experience (i.e., age of the technologist) and higher attainment value (i.e., importance of the task) are both significant predictors of technologists pursuing post-primary credentials.

Health sciences colleges and universities may find the results of this study useful to investigate different pathways to meet the needs of the working technologist toward gaining the credentials and skills necessary to operate new hybrid imaging systems. Continued research into the potential of developing partnerships between healthcare organizations and educational institutions and their impact on advancing nuclear medicine technologists’ career development will ensure nuclear medicine technologists gain the new skills necessary to meet the specific needs of the healthcare organization.
REFERENCES


Bolus, N. (2020). From Dewey decimal system to internet search engines – education has greatly changed over the last 50 years. *Journal of Nuclear Medicine Technology, 48*(2, Suppl.1), 64S – 65S.


Contemporary Educational Psychology, 41, 232 – 244.


https://www.ecs.org/50-state-comparison-free-and-compulsory-school-age-requirements/


Gilmore, C. D., Comeau, C. R., Alessi, A. M., Blaine, M., El Fakhri, G. N., Hunt, J. E.,
Jordan, D. W., King, B. J. Sicignano, A. J., Stanley, C. T., Timpe, J. T., &
Wenzel-Lamb, N. (2013). PET/MR imaging consensus paper; a joint paper by the
society of nuclear medicine and molecular imaging technologist section and the
section for magnetic resonance technologist. *Journal of Nuclear Medicine

StatisticsHowTo.com: elementary statistics for the rest of us!

https://www.statisticshowto.com/what-is-a-standardized-residuals/

waste in allied health workplace education programs: A pragmatic operational

https://search-proquest-
com.bchs.idm.oclc.org/docview/1859415865?accountid=187146

Gorges, J. (2016). Why adults learn: Interpreting adults’ reasons to participate in
education in terms of Eccles’ subjective task value. *International Online Journal
of Education and Teaching*, 3(1), 26 – 42.


Gorges, J., & Kandler, C. (2012). Adults’ learning motivation: Expectancy of success,
value, and the role of affective memories. *Learning and Individual Differences*,
22, p. 610 – 617.


http://www.diagnosticimaging.com/pet-ct/petmri-reflections-two-years-after-fda-approval


https://doi.org/10.17226/25407


http://www.snmmi.org/AboutSNMMI/Content.aspx?ItemNumber=4175

Society of Nuclear Medicine and Molecular Imaging. (2022, Spring). Nuclear medicine technologist requirements by jurisdiction.


Society of Nuclear Medicine and Molecular Imaging – Technologist Section (2012).
Nuclear Medicine Technologist Performance Standards.


*Clinical Nuclear Medicine.* 83(10), 790 – 794.


Weening, R. H. (2012). Degree requirements and employment opportunity in radiologic science. *Radiologic Technology, 83*(6), 541 - 548


Young, L. (2019, March 20). *PET/CT drives PET scan volume to new heights*. IMV.

APPENDIX A

Definition of Terms

American Registry of Radiologic Technologists (ARRT)

The American Registry of Radiologic Technologist (ARRT) offers credentials in medical imaging, interventional procedures, and radiation therapy. Credentials are offered in over 15 disciplines via primary and post-primary pathways (ARRT, 2017).

Attenuation Correction

Mechanism to correct the distribution of the radiotracer in images by removing soft tissue artifacts such as breast attenuation in women and diaphragmatic attenuation in men (Waterstram-Rich & Gilmore, 2017)

Computed Tomography (CT)

Computed Tomography (CT) is a diagnostic imaging procedure which creates anatomical images of the internal organs, bones, soft tissue, and blood vessels. The CT scanner provides a source of x-rays which is transmitted through the patient, forming a three-dimensional image (Waterstram-Rich & Gilmore, 2017)

Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is an imaging modality which provides three-dimensional anatomical and morphologic images of the abdomen, pelvis, musculoskeletal system, cardiac system, nervous system, and circulatory system. MR uses magnetic field and radio wave pulses to form the image. (Waterstram-Rich & Gilmore, 2017)

Nuclear Medicine Technology Certification Board (NMTCB)

Founded in 1977, the Nuclear Medicine Technology Certification Board (NMTCB) is the recognized by the nuclear medicine profession as the “premier examination for nuclear
medicine technologists” (NMTCB, 2017). Upon certification, technologist are granted the right to use the title Certified Nuclear Medicine Technologist and the credential CNMT.

**Positron Emission Tomography (PET)**

Positron Emission Tomography (PET) is a diagnostic imaging modality which images biochemical or physiological processes within the body. Using very short-lived positron-emitting radiopharmaceuticals injected in a patient’s vein, the PET scanner is able to detect the radiation and create a three-dimensional images (Waterstrom-Rich & Gilmore, 2017).

**Post-primary Pathway**

The post-primary pathway is for applicants to the ARRT who are currently certified and registered in one of the primary pathways by either the ARRT, NMTCB, or ARDMS (American Registry for Diagnostic Medical Sonographers). The post-primary pathway provides opportunities to be certified in eight modalities including MRI and CT. (ARRT, 2020)

**Primary Pathway**

The primary pathway of eligibility refers to the first credential pursued toward ARRT certification and registration. Applicants who have met the ARRT-approved educational requirements in magnetic resonance imaging, nuclear medicine technology, radiation therapy, radiography, or sonography may become eligible to sit for the registry in those modalities (ARRT, 2020).
Radiopharmaceutical

A radiopharmaceutical is a radioactive drug that is used for a either diagnostic or therapeutic purpose (Waterstram-Rich & Gilmore, 2017)

Single Photon Emission Computed Tomography (SPECT)

Single Photon Emission Computed Tomography (SPECT) is a gamma camera capable of rotating around a patient, forming three-dimensional images. The camera detects gamma radiation which are emitted from a patient’s body following the injection of a radiopharmaceutical (Waterstram-Rich & Gilmore, 2017).
APPENDIX B

NUCLEAR MEDICINE TECHNOLOGY
POST-PRIMARY CERTIFICATION MOTIVATION SCALE

I am asking you to take part in a study concerning nuclear medicine technologist’s motivation to pursue a post-primary credential and how you perceive the values and costs related to pursuing the additional credentials.

The purpose of this questionnaire is to rate your interest in post-primary certifications along with your perception of the importance and usefulness of the credential. In addition, you will be asked to identify any barriers that may be present. The questionnaire will also ask you to provide some demographic information. The questionnaire should take approximately thirty minutes to complete.

1. How many years of experience do you have in nuclear medicine technology?

2. Type of NMT Program Graduated
   □ Certificate □ Associate □ Bachelors □ Masters □ Other: ________

3. Primary job description:
   □ Staff Nuclear Medicine Technologist (General Imaging; no PET; no cardiac)
   □ Staff Nuclear Medicine Technologist (General Imaging; including PET and cardiac)
   □ Staff Nuclear Medicine Technologist (PET only)
   □ Staff Nuclear Medicine Technologist (Cardiac only)
   □ Staff Nuclear Medicine Technologist (non-working and/or retired)
   □ Nuclear Medicine Technologist (Administrator; educator; sales, pharmacy, etc.)

4. Place of employment:
   □ Small hospital (fewer than 100 beds) □ Medium hospital (100 – 499 beds)
   □ Large hospital (500 or more beds) □ Outpatient Center
   □ Other_______________________

5. Identify the equipment you operate daily in your department:
   □ Planar □ SPECT □ SPECT/CT □ PET □ PET/CT □ PET/MR

6. Are you currently certified or working towards your credential in CT or MRI?
   □ *yes □ no *if yes, end of survey
Thinking about pursuing a post-primary certification, please circle the number that best corresponds to your answer to the following questions:

Key:
NMT = Nuclear Medicine Technology
CT= Computed Tomography
MRI = Magnetic Resonance Imaging

7. I think I would do well at learning CT.

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<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
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8. Compared to other nuclear medicine technologists, I think I would do well in learning CT.

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9. I think I would do well at learning MRI.

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10. Compared to other nuclear medicine technologists, I think I would do well at learning MRI.

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11. The amount of effort it will take to gain an additional credential in CT is worthwhile to me.

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12. I feel that being credentialed in CT is necessary for me in the future to be employed as a nuclear medicine technologist.

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14. I value the prestige that comes with being multi-credentialed in NMT and CT.

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23. I find the idea of earning a credential in CT very appealing.

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24. It is exciting to think about the challenge of earning a CT credential.

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25. I look forward to advancing my knowledge by learning about CT.

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29. Being good at CT will be important to advance my career in nuclear medicine technology.

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33. When I think of all the work involved with earning a CT credential, I’m not sure that becoming multi-credentialed is worth it.

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34. I am not sure I have the energy to work and do what is required to become eligible for a CT credential at the same time.

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35. I’m concerned that working toward a CT credential will prevent me from focusing on family or myself.

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36. Hospital policies prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the CT registry.

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37. State licensure prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the CT registry.

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38. Lack of educational programs offered prevent me from meeting the educational requirements for the CT registry.

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45. How likely is it that you will pursue a post-primary credential?

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Place a “1” next to the answer that comes closest to explaining your most important reason for attaining a post-primary certification, and “2” next to the second most important reason.

Money, status, career

For instance:
- I could make more money
- I will enjoy the status of having multiple credentials
- I will have more job opportunities

Family concerns

For instance:
- I feel my family expects it of me
- I will disappoint my family if I don’t earn the credential

Knowledge and learning

For instance:
- I love learning
- I really enjoy the learning process
- I strive for more knowledge

Professional goals

For instance:
- I cannot grow my professional life without adding an additional credential
- Having one credential in my field is becoming obsolete
- Hybrid imaging and the multi-credential technologists is future
APPENDIX C

Scale Items

**Ability / Expectancy** (Eccles & Wigfield, 1995)

7. I think I would do well at learning CT?
8. Compared to other nuclear medicine technologists, I think I would do well in learning CT?
9. I think I would do well at learning MRI?
10. Compared to other nuclear medicine technologists, I think I would do well in learning MRI?

**Attainment value/ Importance** (Battles & Wigfield, 2003; Eccles & Wigfield, 1995)

11. The amount of effort it will take to gain an additional credential in CT is worthwhile to me.
12. I feel that being credentialed in CT is a necessary for me in the future to be employed as a nuclear medicine technologist.
13. Knowing that I earned a credential in CT would make me feel good about myself.
14. I value the prestige that comes with being multi-credentialed in NMT and CT.
15. The main reason I want to earn a CT credential is because other technologists entering nuclear medicine will be multi-credentialed.
16. When performing PET/CT imaging, I feel that being credentialed in CT is important.
17. The amount of effort it will take to gain a credential is MRI is worthwhile to me?
18. I feel that being credentialed in MRI is necessary for me in the future to be employed as a nuclear medicine technologist.
19. Knowing that I earned a credential in MRI would make me feel good about myself.
20. I value the prestige that comes with being multi-credentialed in nuclear medicine and magnetic resonance imaging.
21. The main reason I want to earn a MRI credential is because other technologists entering nuclear medicine will be multi-credentialed.
22. When performing PET/ MRI imaging, I feel that being credentialed in MRI is important.

**Intrinsic/ Interest value** (Battles & Wigfield, 2003; Eccles & Wigfield, 1995)

23. I find the idea of earning a credential in CT very appealing.
24. It is exciting to think about the challenge of earning a CT credential.
25. I look forward to advancing my knowledge by learning about CT.
26. I find the idea of earning a credential in MRI very appealing.
27. It is exciting to think about the challenge of earning a MRI credential.
28. I look forward to advancing my knowledge by learning about MRI.

**Extrinsic/ Utility Value** (Battles & Wigfield, 2003; Eccles & Wigfield, 1995)

29. Being good at CT will be important to advance my career in nuclear medicine.
30. Being multi-credentialed in NMT and CT is important to me because it will provide better job opportunities.
31. Being good at MRI will be important to advance my career in nuclear medicine.
32. Being multi-credentialed in NMT and MRI is important to me because it will provide better job opportunities.

**Opportunity Cost** (Battles & Wigfield, 2003)

33. When I think of all the work involved with earning a CT credential, I’m not sure that becoming multi-credentialed is worth it.
34. I am not sure I have the energy to work and do what is required to become eligible for a CT credential at the same time.
35. I’m concerned that working toward a CT credential will prevent me from focusing on myself or family.
36. Hospital policies prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the CT registry.
37. State licensure prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the CT registry.
38. Lack of educational programs offered prevent me from meeting the educational requirements for the CT registry.
39. When I think of all the work involved with earning a MRI credential, I’m not sure that becoming multi-credentialed is worth it.
40. I am not sure I have the energy to work and do what is required to become eligible for a MRI credential at the same time.
41. I’m concerned that working toward a MRI credential will prevent me from focusing on myself or family.
42. Hospital policies prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the MRI registry.
43. State licensure prevent me from obtaining the clinical hours necessary to meet the clinical requirements for the MRI registry.
44. Lack of educational programs offered prevent me from meeting the educational requirements for the MRI registry.