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Patient Awareness and Knowledge of Medically Induced Radiation Exposure

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Abstract

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by

Travis Mann

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

The level of knowledge and awareness among patients about the concepts and implications of medical radiation is unknown. The purpose of this qualitative, case study was to explore patients' awareness and knowledge of information regarding this topic from their perspectives. The health belief model provided the framework for the study. A total of 20 individuals were recruited using purposive sampling. All participants were above the age of 18 in central North Carolina and had undergone or are currently undergoing medical radiation exams. Data were collected using semistructured interviews and analyzed using Yin's 5-phased cycle, which involved compiling, disassembling, reassembling, interpreting, and concluding. According to study findings, patients were generally aware of the harmful effects and seriousness of medical radiation if uncontrolled. Patients also cited the importance of having the proper information and resources to educate oneself, being more careful with their bodies to avoid examinations with radiation, and hearing reports about individuals getting ill from medical radiation exposure as cues to action that may benefit patients who are about to undergo medical radiation exams. The findings of this study may contribute to positive social change by illustrating ways to improve information dissemination and involvement of patients in understanding medical radiation and its perceived risks. The results of this study may help health practitioners in developing strategies to encourage patients to discuss their medical radiation exposure concerns proactively.

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Dedication

This work is dedicated to my Wife and Children whose overabundance of love, support, and patience has made this possible. You are my everything, my world, and everything I do is for you. Thank you for always believing in me even when I didn't believe in myself and never giving up on me. I love you more than you will ever know.

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Chapter 1: Introduction to the Study

Introduction

Technology has instigated advancements in the field of medical diagnosis. Because of these advancements, healthcare providers can now have a visual image of a patient's illness or injury with tools such as radiation imaging. Radiation imaging has become a standard procedure in the field of medicine (Ditkofsky et al., 2016; Gargani & Picano, 2015). Patients' exposure to radiation has increased as medical imaging has expanded and new radiation technologies have arisen (Ditkofsky et al., 2016; Gargani & Picano, 2015; Sahiner et al., 2018). These procedures are essential in the medical profession because they are used for several purposes. These include the depiction and diagnosis of illness and injury and aiding in therapeutic interventions into disease and disability (Awosan et al., 2016; Matsuhashi & Ishioka, 2018; Rai et al., 2017). Despite being helpful in illness detection and intervention, there are other implications for the health of patients when it comes to the use of medical radiation (Awosan et al., 2016). Patients may not be aware of such implications.

There is little information about patients' current knowledge regarding medical imaging radiation exposure. In this study, I explored the perceptions of patients regarding the implications that medical radiation has on an individual's health. I addressed the problem through a qualitative case study. The results of this study can be used to promote a better understanding and awareness among public health leaders about how patients perceive radiation and its implications for their health. This implication will

hopefully drive changes in public health policy, physician interaction and communication, and patient empowerment.

In this chapter, I discuss the problem that will be central to this study. This chapter will include the following major sections: (a) background, (b) problem statement, (c) purpose of the study, (d) research questions, (e) theoretical framework, (f) nature of the study, (g) definitions, (f) assumptions, (g) scope and delimitations, (h) limitations, and (i) significance. The chapter will then end with a summary of the problem and these major discussion points.

Background

To understand patients' knowledge, or lack thereof, on medical imaging radiation, the development and the particulars of radiation must be explored first. At the advent of increasing exposure of artificial radiation to human beings, studies were conducted to determine the annual radiation dose limits for individuals, the sources of radiation, and the associated biological risks (Doses in Our Daily Lives, 2017; Hill & Einstein, 2015). The average artificial radiation exposure rate for a person in the United States is 0.62 to .63 rem (6.2 mSv) per year, almost half of which comes from medical imaging, exceeding the average annual limit of 3.0 mSv (Doses in Our Daily Lives, 2017; Sherer, Visconti, Ritenour, & Haynes, 2018). The radiation an individual is exposed to from an x-ray, CT scan, and nuclear imaging is called ionizing radiation. This type of radiation involves high-energy wavelengths or particles that penetrate tissue to reveal the body's internal organs and structures, thus potentially damaging the DNA of an individual (Sherer et al., 2018). Such damage to DNA and other internal organs can potentially

increase an individual's risk for cancer. For instance, individuals exposed to multiple CT scans within approximately 9.5 years had an increased incidence of cancer of 24% (Hill & Einstein, 2015). The threat to a person's health may be acquired from medical radiation.

The dangers of medical radiation have been established in previous literature. Most patients with a broad spectrum of afflictions benefit from these types of imaging procedures (Sherer et al., 2018). However, exposure to these forms of radiation also has adverse implications (especially with excessive exposure, which is dependent on the medically recommended limits for safe use; Sherer et al., 2018). The increased exposure of patients to medical radiation has led to the prediction of several radiation-induced cancers and cancer deaths in the U.S. population in future years. Desouky, Ding, and Zhou (2015) asserted that ionization radiation might produce hydroxyl radicals that may cause strand breaks or base damage to DNA, which, to some extent, is associated with cancer risks. A supralinear increasing use of medical radiation has an increase in the incidence of papillary thyroid cancer (Veiga et al., 2016). Considering these dangers, it is vital for patients to be aware of both the benefits and risks of medical imaging. It is for this reason that I investigated patients' knowledge and awareness on this issue.

Patients' knowledge and awareness regarding medical radiation would allow them to weigh the risks and benefits of undergoing radiation imaging. On the extreme level, the sensationalism of the ill-effects of radiation exposure provokes anxiety in patients and families, which may make them reluctant to agree to undergo imaging procedures that may be in their best interests (Thornton et al., 2015). In contrast, some patients may

underestimate the amount of radiation each imaging exam emits, leading them to overuse these exams (Evans et al., 2015). These two contrasting situations may arise from different factors, such as patient education or their sources of information (Al Ewaidat et al., 2018; Thornton et al., 2015). Even patients who completed higher education may not be familiar with medical terminologies and jargon that are used in the medical radiation field (Thornton et al., 2015). Patients who were not professionally trained in medical and radiation courses need reliable sources of knowledge and information in a level that they can understand, which may not always be readily available.

Radiologists and referrers may not always provide patients with enough information regarding medical imaging and radiation risks; thus, patients may be obliged to seek information on their own. Most patients were also reported to lack the proper level of understanding regarding radiation dosage and the potential risks associated with being exposed to these doses (Bohl et al., 2016; Guena, Nguemeleu, Ndah, & Moifo, 2017). Patients who undergo medical radiation for illness detection and treatment have limited knowledge of the implications of radiation exposure when undergoing these radiation treatments (Guena et al., 2017). In Guena et al.'s (2017) study, only 7.1% of patients who underwent CT scans were informed about the risks and benefits of the procedure—mostly due to the medical professionals' lack of time. Furthermore, Bohl et al. (2016) assessed spinal condition patients' knowledge and awareness of radiation dose and whether they were informed about these doses and found that these patients' knowledge and awareness of medical radiation and its associated risks were unsatisfactory; thus, it is crucial to increase patient radiation awareness and to provide

them with the necessary information to make informed decisions regarding their health. There is a need for a more generalized inquiry into the overall understanding of radiation exposure in medical imaging, its associated risk factors, and the patients' need for a better understanding (Bohl et al., 2016; Guena et al., 2017). This is the phenomenon or problem that I explored.

Problem Statement

Medical imaging has become popular as a helpful tool in the diagnosis of several diseases and health concerns. Despite being helpful in illness detection and intervention, there are cases when medical radiation has had counterintuitive effects on the health of patients (Awosan et al., 2016; Dobrescu & Rădulescu, 2015). The damage caused by radiation to a patient's DNA may lead to serious diseases such as cancer (Desouky et al., 2915). These unwanted effects may manifest to the frequency of undergoing radiation treatments and imaging or the kind of radiation used.

The level of knowledge and awareness among patients about the concepts and implications of medical radiation is unknown. It is unknown whether patients are aware of the extent to which they can be exposed to such radiation (Lam, Larson, Elsenberg, Forman, & Lee, 2015). Singh, Mohacsy, Connell, and Schneider (2017) conducted a study to determine the health awareness of patients regarding cancer-associated risk of medical radiation exposure and found that approximately 40% of the sampled patients either did not know anything about medical radiation exposure or did not believe the health dangers that medical radiation exposure involves. Thornton et al. (2015) reported that the lack of knowledge of patients regarding medical radiation exposure was because

they did not know whom to ask or what to ask, and they were not trained to understand medical terminologies. Patients who are about to undergo medical imaging with radiation may be oblivious to its risks and may not have access to resources that would increase their knowledge and awareness.

As service providers and referrers, medical and health professionals are ideally the first sources of information regarding medical radiation. Despite the research based on medical radiation exposure risks, medical professionals still employ poor radiation protection practices (Awosan et al., 2016). Furthermore, there appears to be a knowledge gap between the different stakeholders of medical radiation imaging, which is troubling because it involves the lack of knowledge of providers themselves (Azman, Shah, & Ng, 2019). If providers are unaware of the risks involved in medical radiation technologies, then they would not be able to provide correct information to their patients. Lumbreras et al. (2017) also noted the gap in research about the general knowledge of patients regarding medical radiation. There is a need to understand patients' levels of awareness and knowledge of information regarding medically induced radiation exposure from patients who either have undergone or are currently undergoing medical radiation exams in the United States. For this study, the focus area was central to North Carolina.

Purpose of the Study

The purpose of this qualitative, case study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina. The focus was on the patients' perceptions of

medically induced radiation exposure effects, which Singh et al. (2017) claimed to influence patients' decision to undergo different medical radiation procedures and their anxiety regarding the procedures. The general knowledge and perception of these patients about the implications and benefits of radiation to their health remain unknown (Lumbreras et al., 2017; Ria et al., 2017). The topic of this study was the knowledge and perceptions of patients about the effects of medically induced radiation exposure.

I used a qualitative case study design because the purpose was to explore a phenomenon in depth based on perceptions of individuals using semistructured interviews. According to Yin (2011), the case study research design is used when the focus is on exploring perceptions about a phenomenon. The sample for this study included those patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina. I used face-to-face, semistructured interviews with selected participants to collect all data. I used Yin's (2011) prescribed five-phased analysis cycle for case studies to analyze the data.

Research Questions

There is little known information regarding patients' current perceptions and knowledge base concerning medical imaging radiation exposure, the associated terminologies used in the medical radiation field, accessibility to information regarding general and personal radiation information, and where this information is available. The purpose of this qualitative, case study was to examine and understand patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing

medical radiation exams in central North Carolina. To address the problem and accomplish the purpose of this study, the following research questions guided this study:

RQ1: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive their susceptibility to medical radiation procedures?

RQ2: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the seriousness associated with medical radiation exposure?

RQ3: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the benefits of taking action associated with medical radiation exposure?

RQ4: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the barriers to taking action related to medical radiation exposure?

RQ5: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the cues to action associated with medical radiation exposure?

Theoretical Framework for the Study

To guide this study's purpose and methodology, a theoretical framework was selected and applied to all components of this research. This study was guided by the health belief model (HBM), which is the current leading theory in the health education and health promotion field (Mahbobi, Sayadi, Shabani, & Asadpour, 2015; Mo, Chong,

Mak, Wong, & Lau, 2016). The concept behind HBM is that people's perceptions and beliefs determine the health behavior of individuals about disease and strategies available to decrease its occurrence and effects (Hochbaum, 1958). The HBM involves five key constructs: (a) perceived susceptibility, (b) perceived seriousness, (c) perceived benefits of taking action, (d) barriers to taking action, and (e) cues to action (Hochbaum, 1958). These constructs are discussed in more detail below.

To understand these constructs more clearly, it is vital that those be defined. Perceived susceptibility refers to personal beliefs regarding the likelihood of experiencing a condition that would adversely affect a person's health (Hochbaum, 1958). Perceived seriousness refers to personal beliefs about the impact of a given disease or condition on the same person (Hochbaum, 1958). Combined, these two constructs comprise a general construct called the perceived threat (Hochbaum, 1958). These two constructs reflect patients' perceptions regarding threats to their health (Mellor, McCabe, Ricciardelli, Mussap, & Tyler, 2016). Perceived benefits of taking action refer to the prevention of disease after an individual has accepted the susceptibility of disease and recognized that it is dangerous (Hochbaum, 1958). Barriers to taking action exist regardless of the belief of susceptibility and seriousness because of the characteristics that are innate to treatment or preventive measure, such as inconvenience, expensiveness, or unpleasantness (Hochbaum, 1958). These two constructs describe the two sides of health behavior that an individual must weigh before facilitating changes (Mellor et al., 2016). Cues to action refer to instances or signals that provide the path of action (Hochbaum, 1958). The present study's focus and research revolved around these five constructs.

The purpose of this study was to develop a better understanding of patients' levels of awareness and knowledge of information regarding medically induced radiation exposure from patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina. The HBM was well suited to address these issues. Also, the constructs (perceived susceptibility, perceived seriousness, perceived benefits of taking action, barriers to taking action, and cues to action) revolving around HBM are essential to understanding the existing knowledge on the topic at hand. This study was done to increase the understanding of medical radiation exposure and the perceived risks involved for patients.

Nature of the Study

The nature of this study was a qualitative case study. A qualitative method is often used when a researcher is attempting to understand individuals' personal experiences, perceptions, and opinions about a phenomenon (Leedy & Ormrod, 2010; Merriam & Tisdell, 2015). Qualitative research allows for an in-depth investigation or exploration of a particular set of issues within an uncontrolled environment (Merriam & Tisdell, 2015). A quantitative or mixed methods approach would be inappropriate for this study because the purpose and research questions of the study do not require establishing a relationship between two or more variables. A case study research design is appropriate for this study because such an approach aims to explore the perceptions of individuals regarding a phenomenon using semistructured interviews (Yin, 2014).

Other qualitative research designs were inappropriate for this study because the purpose of these designs (phenomenology, grounded theory, and narrative research) did

not align with the problem, purpose, and research questions for this study. According to Yin (2014), there are four criteria in choosing a case study approach: (a) it must answer "why" and "how" questions, (b) it has no need to manipulate the behavior and action of the target population, (c) it has a need to explore contextual conditions, and (d) it has no clear boundaries of the phenomenon. Given these criteria, a case study was the most appropriate design for this research. Nevertheless, using a qualitative case study limits the generalizability of the findings. This limitation is allowable for the study, provided that the findings apply to the target population.

This qualitative case study was based on the existing knowledge of patients who had recently undergone (within the last 12 months) or were undergoing medical radiation exams. Participants were asked about their knowledge of medical radiation exposure, access to radiation dosage reports, and the risks associated with medical radiation exposure. Furthermore, purposive sampling was used to select participants for interviews. Purposive sampling was appropriate for this study because the participants needed to be chosen based on criteria that were particular to the purpose of this study, thus increasing the effectiveness of including participants who were able to present thorough descriptions of their related experiences and issues on the topic under investigation (see Sharma, 2017).

Qualitative research involves typically small sample sizes that range from five to 25 participants (Creswell, 2009). However, Leedy and Ormrod (2010) stated that there are no rules for sample size if the saturation point is set and accomplished. Saturation was determined based on the amount of new information added to the pool of data with

the addition of each new participant. Yin (2014) claimed that recruiting at least six participants, who are directly involved with the phenomenon being explored, will be enough to reach data saturation for most case studies. For this study, the sample size was 20 participants.

Definitions

Medical radiation: Medical radiation refers to a procedure that is performed with the involvement of emitting radiant energy in the form of waves or particles (Adler & Carlton, 2019). For this study, the focus was on medical radiation imaging or testing procedures, such as a CT scan, and x-ray.

Patient awareness: Patient awareness refers to the level of correct and proper knowledge that a patient has concerning a medical or health-related concept or procedure (e.g., medically induced radiation; Al Ewaidat et al., 2018).

Radiation exposure: Radiation exposure refers to being subjected to radiant energy in the form of waves or particles. Medical radiation exposure has a relevant biological effect on humans from being subjected to x-rays and gamma rays, which are secondary to ionization (Pezella, Tavassoli, & Kerr, 2019).

Assumptions

The first assumption of this study was that patients are aware that they are undergoing radiation in the different medical procedures that they have undergone or are currently undergoing. This assumption was important because, without it, patients were not able to know if they are qualified as participants for the study. The screening of participants was performed by asking them a series of questions (see Appendix B) to help

determine their eligibility for participating in this study. The second assumption was that participants exhibited integrity and truthfulness. The third assumption was that all of the participants were willing to contribute to the study by openly discussing their perceptions to provide data for the study. Before conducting any interviews, all study participants were informed of the intent and purpose of the study while reinforcing the need for total honesty in sharing personal experiences and perceptions during the interview process. The fourth assumption of this study was that the participants provided answers based on their perceptions that best align with the interview questions. A final assumption was that the study has uncovered themes and patterns concerning the phenomenon that was being studied.

Scope and Delimitations

The purpose of this qualitative case study was to explore patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina. The scope of the study was focused on the knowledge of patients regarding the implications of medically induced radiation exposure. The perceptions of patients regarding the phenomenon was the focus of the study because these may affect their decision to undergo different medical radiation procedures (Singh et al., 2017). Moreover, the actual knowledge and perception of these patients about the implications and benefits of radiation to their health is not yet known (Lumbreras et al., 2017; Ria et al., 2017).

Furthermore, as part of the scope of the study, 20 participants were selected to gather data through semistructured interviews. Semistructured interviews were used because they allowed me to collect in-depth data through follow-up questions and further discussions about a topic or question (see Merriam & Tisdell, 2015). Because recruiting 20 participants could not be achieved using purposive sampling (Etikan, 2016), snowball sampling (Palinkas et al., 2015) was done by asking for recommendations (from existing participants or members of my social network) for people who may be considered as participants for the study. The participants selected for the study were patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina.

Patients who had not undergone or were not currently undergoing radiation exams, such as a CT scan or x-rays, were not included. To ensure transferability for populations outside of this population, transferability measures must be implemented. Transferability may be achieved through providing in-depth descriptions of the phenomena being investigated to provide readers with the ability to understand the context of the phenomena, enabling them to compare the instances of the phenomena described in this study with those that they have seen emerge in their research and case studies.

Limitations

There were several limitations to this study. One of these limitations was the data gathering; analyses are vulnerable to personal biases. Because the study data were collected from human beings, the participants may have had personal biases that

influenced their answers to the questions (see Roulston & Shelton, 2015). To address this limitation, I reminded the participants to answer as accurately and as honestly as possible.

Moreover, data saturation was the basis for making sure that the sample produces similar and saturated answers. Another limitation was that personal biases might come from me as the interviewer and analyst (see Roulston & Shelton, 2015). To address this limitation, I acknowledged my expectations regarding the outcome and findings of the study so that I was cautious of including these in any interpretations and conclusions without support from the data obtained in this study.

Another limitation of the study was that the results may not apply or be generalizable to other groups or populations. Because data were gathered from a specific group of people, the study results may not be generalized as applicable to other groups. The research methods, the context of method application, participant information, data collection, and data analysis were given in detail so that other researchers who may want to replicate the study in another population may be able to do so. I assisted future researchers in repeating the work and assessing the extent to which appropriate research practices were followed.

Significance

Medical radiation has its benefits, especially when using results for disease diagnosis (Lam et al., 2015). However, frequent exposure to radiation may pose health risks to patients (Kruger et al., 2014; Lam et al., 2015). Having patients aware of these risks will make them more conscious of tracking their exposure frequency and amount of radiation. Patients need to understand general and personal radiation information and to

know the dose levels associated with the exposure to medical radiation. Through the understanding of patients' level of awareness and knowledge of information regarding medically induced radiation exposure, this study may contribute to methods for improving information dissemination and involvement of patients in understanding medical radiation and its perceived risks. The findings of this study may also help health practitioners in developing strategies to encourage patients to discuss their medical radiation exposure concerns proactively. The results of this study may also help in highlighting the need to understand the perspectives and opinions of patients as essential stakeholders in health education and management.

The findings of this study may contribute to social change by illustrating ways to improve information dissemination and involvement of patients in understanding medical radiation and its perceived risks. By conducting this study, information about potential methods of promoting awareness of patients regarding the effects of medical radiation may be made known to the public. Members of a society may then address possible misconceptions and lack of awareness about standard health procedures that involve radiation. Positive social change may be reflected with the improvement in the knowledge of the potential readers by the elimination of misconceptions and the promotion of awareness about the truths of radiation exposure. Because the influential primary sources of information about medical radiation are discussed in this study, members of society may become aware of potential sources of false information. Moreover, the sources for reliable and valid information about medical radiation will also be made known to the reading public.

Summary

The level of knowledge and awareness among patients about the concepts and implications of medical radiation is unknown. For instance, it is unknown if patients are aware of the extent to which they can be exposed to such radiation (Lumbreras et al., 2017; Ria et al., 2017). Their level of knowledge can influence proper decision making in terms of choosing whether to undergo radiation treatment procedures. The purpose of this qualitative case study was to explore patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina. This study was guided by the HBM (Glanz, Rimer, &Viswanath, 2015). A qualitative case study research design was used, and data were collected through semistructured interviews. These interviews were done with patients who either had undergone or were currently undergoing medical radiation exams in central North Carolina.

More details and themes related to the phenomenon of focus are covered in Chapter 2.

Chapter 2: Literature Review

Introduction

Medical radiation has been made popular due to its utility in diagnoses and prevention of disease. The knowledge base surrounding the effects of medical radiation exposure is limited. Despite the risks involved in receiving too much radiation (Demeter, Applegate, & Perez, 2016; Desouky et al., 2015), there is little information regarding patients' current knowledge base in relation to medical imaging radiation exposure, the associated terminologies used in the medical radiation field, accessibility to information regarding general and personal radiation information, and where these data are available (Lumbreras et al., 2017; Ria et al., 2017). Also, there is little knowledge and understanding regarding the level of comfort and questions that patients must ask their attending physician. The actual knowledge and perception of these patients on the implications and benefits of radiation to their health is not yet known (Lumbreras et al., 2017; Ria et al., 2017). The purpose of this qualitative, case study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina.

Literature Search Strategy

The following search engines, databases, and research resources were used to write the literature review: Google Scholar, Microsoft Academic Search, Educational Resource Information Center (ERIC), Virtual LRC, PubMed, JSTOR, iSEEK Education, and Web lens. To research these online databases, primary search terms needed to be

used. These were as follows: *patient radiation perception, patient perception, radiation risk, radiation awareness, radiation exposure, medical radiation, patient awareness, and patient knowledge of radiation, health belief model, history of health belief model, the origin of health belief model,* and *the use of the health belief model.* As they directly represented the problem, research questions, and the conceptual model of the present study, these terms enabled access to relevant studies that have been completed.

A large part of the literature included in this review was taken from studies published from 2015 to the present year to ensure that only the latest findings and developments were included. However, several seminal studies that dealt with the general theme of radiation awareness were also included to provide a complete picture of the topic. Additionally, older articles were used in the theoretical and conceptual framework of the study to present the foundational views and concepts about the origin of the HBM, developed by Rosenstock, Hochbaum, Kegeles, and Leventhal in the 1950s. The total ratio of studies published before 2015 formed 10.10% of the reviewed literature, whereas recent studies published from 2015 to the present year formed 89.90%. Additionally, as the perceptions of physicians and other medical professionals directly affect the awareness of patients, studies measuring the radiation exposure risk awareness of this demographic were included.

In this literature review, an extensive background to the research problem is presented. In the first section, I focus on the conceptual framework of the study, adopted from the HBM. This chapter will continue with an in-depth review of the relevant literature regarding radiation exposure and medical imaging. The second section

involves a discussion of the general and historical overview of studies on radiation exposure from medical imaging. In the third section, I focus on the relationship between education, experience, communication, and cultural differences in the awareness of radiation exposure risks. The level of awareness among medical professionals about radiation risk from medical imaging procedures is discussed in the fourth section. The fifth section includes the level of awareness in patients about radiation risk from medical imaging procedures. The final section of the literature review includes the research gap on this topic. The chapter ends with a conclusion of the literature review, which summarizes the findings.

Conceptual Framework

Concept of the Health Belief Model

The conceptual framework of the study was adopted from the HBM. According to Llewellyn et al. (2019) and Hochbaum (1958), there are five components of the HBM: (a) perceived susceptibility, (b) perceived seriousness, (c) perceived benefits of taking action, (d) barriers to taking action, and (e) cues to action. Skinner, Tiro, and Champion (2015) provided an extensive introduction to the concept of the HBM. According to Tarkang and Zotor (2015), the basic concept of the HBM is the observation that health behavior is determined by personal beliefs and perceptions about a disease or health concern. This concept also includes the available strategies to lessen its occurrence. The origins of the HBM, developed in the late 1950s, lie in a time when an emphasis was placed on screening programs for disease prevention. At that time, free screening for tuberculosis (TB) was provided; however, the public was not enthusiastic about getting

screened for symptoms of the disease that were not present (Tarkang & Zotor, 2015). This incident birthed the idea that perceptions about the risk of disease and the benefits of acting against it were vital in an individual's decisions regarding his or her health (Tarkang & Zotor, 2015). The origin of the HBM had two concepts similar to the present study. They are the screening program, which can be translated as medical imaging, and the reaction of the general public towards it, which can be translated into the lack of awareness among patients about risks associated with medical imaging radiation that I examined. These two concepts lie at the foundation of the HBM. Therefore, the use of this theory to examine the concepts of the present study was justified.

HBM development in the literature. The HBM was noted as one of the most extensively used conceptual frameworks in health behavior research to explain a change of health behavior (Skinner et al., 2015). In terms of conceptual development, various researchers have made significant contributions to this field. Janz and Becker (1984) examined the effectiveness of the concepts of HBM by critically reviewing 46 HBM studies. Perceived barriers were found to be the most powerful of all of the HBM components in various behaviors (Janz & Becker, 1984). Gerend and Shepherd (2012) compared the concepts of the HBM and the theory of planned behavior in terms of the predictions they made on human papillomavirus vaccination and found that there was considerable overlap between the two theories. Groenewold, de Bruijn, and Bilsborrow (2012) found that the HBM theory of behavioral intentions provided components that could develop an awareness of migration intentions and that this would contribute to

further conceptual development. These past scholars have established HBM as a theoretical framework and as a theory connecting health beliefs and human behavior.

The development of the HBM provided a conceptual background to examine and analyze the problem that is presented in the current study. For instance, the HBM construct of a perceived barrier, which was found to be the most powerful of all the HBM components (Janz & Becker, 1984), can also help in understanding the reasons behind the lack of awareness of patients about the risk associated with medical imaging radiation. Furthermore, Gerend and Shepherd (2012) showed the interconnected nature of the HBM concerning other theories of health, which may provide knowledge about the theory's applicability to related constructs.

The purpose of the qualitative, case study was to examine and understand patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either have undergone or are currently undergoing medical radiation exams in the United States. The focus was on the perceptions of patients. Based on this purpose, it was essential to note the widely developed and used HBM as well as its flexibility to researchers who have used it before.

HBM concerning social learning theory and self-efficacy. The HBM has expanded as a theory since it was first conceptualized. Rosenstock, Strecher, and Becker (1988) reviewed the HBM and showed how it was related to social learning theory, self-efficacy, and locus of control. Rosenstock et al. also invented a revised descriptive model that contained self-efficacy in the HBM. This new proposal was expected to provide an account for health-related behavior compared to previous formulations

(Rosenstock et al., 1988). Janz and Becker (1984) provided a critical review of 29 investigations published between 1974 and 1984, tracing the historical development of the HBM along with a summary of 46 HBM studies.

Self-efficacy is a concept that determines the decision of individuals regarding the possibility of whether or not they will perform a task successfully (Rosenstock et al., 1988). As Rosenstock et al. (1988) showed, the HBM and the concept of self-efficacy present interconnections that provided development for the HBM. As the purpose of the present qualitative case study was to examine and understand patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina, the development and expansion of the HBM provided an essential conceptual framework for the study.

Historical analysis of HBM. Further exploration of the history and development of the HBM may also assist in fully understanding the theory. In their introduction to the HBM, Skinner et al. (2015) and along with Tarkang and Zotor (2015) provided an extensive historical analysis of the HBM. The roots of the HBM can be traced back in the late 1950s when an emphasis was placed on screening programs for disease prevention (Skinner et al., 2015; Tarkand & Zotor, 2015). However, despite the support of public health practitioners and the screening being free, the public was not enthusiastic about getting screened for symptoms of the disease in which they did not have any symptoms (Janz & Becker, 1984; Tarkang & Zotor, 2015). Tarkang and Zotor (2015) analyzed the historical origins of the HBM through the late 1950s and explained how the

TB screenings carried out at that time were not attracting those people who were suspected to be at the risk of it. These insights led to the development of the HBM constructs by finding the reasons behind people's reluctance to be screened for TB (Tarkang & Zotor, 2015). Cognitive theory, which valued thinking, reasoning, hypothesizing, and expecting as crucial elements of human behavior, also influenced and shared some principles of the HBM (Skinner et al., 2015). The history and development of the HBM have led to its utility in analyzing and predicting patients' health-related behaviors. Considering this history of the HBM, it appeared to be appropriate for the present study, particularly as it also examined patients' perceptions of medical radiation, which is present in some medical screening examinations.

HBM in various health-related contexts. The HBM has two constructs similar to the present study: the screening program, which can be translated in the present study as medical imaging, and the reaction of general public towards it, which can be translated in the present study into the lack of awareness among patients about the risks associated with medical imaging radiation that I explored in this study. The HBM has been used and developed in a large number of studies to analyze various aspects of behavior exhibited by people in relation to various diseases (Ahadzadeh, Pahlevan Sharif, Ong, & Khong, 2015; McArthur, Riggs, Uribe, & Spaulding, 2018; Mo et al., 2016; Shobeiri, Javad, Parsa, & Roshanaei, 2016; Tarkang & Zotor, 2015). Topics analyzed using the HBM have ranged from body mass index (BMI), to mental illness, and even to health-related Internet use (Ahadzadeh et al., 2015; McArthur et al., 2018; Mo et al., 2016).

The development and use of the HBM in the context of various health-related contexts was made possible mainly due to the generalization made possible by the HBM constructs. For instance, McArthur et al. (2018) adapted the HBM and its constructs into a healthy eating and healthy physical activity habits questionnaire. McArthur et al. aimed to identify the relationship of these variables with BMI, as BMI is generally used to measure adiposity, which is associated with health behaviors. McArthur et al. revealed that all HBM constructs significantly correlated with BMI, implying that students' beliefs about obesity consequences, the severity of these consequences, the difficulty of overcoming obesity, the benefits of adopting healthy behaviors, and the motivation from cues all influenced their BMI.

The HBM was also used in a study on medication adherence of kidney transplant patients (Kung, Yeh, Lai, & Liu, 2017). Kung et al. (2017) sought to understand the influence of personal characteristics and health beliefs of 122 patients from Taipei City with their version of an HBM-adapted questionnaire. Kung et al. found that medication adherence was significantly and negatively correlated with time since transplant. Experience of severe infections and drug-induced symptoms were also found to negatively correlate with medication adherence (Kung et al., 2017). Kung et al. concluded that perceived susceptibility to rejection and perceived benefits of medication adherence were significant factors in predicting treatment adherence within these groups of patients, showing how these adapted HBM constructs could assist in predicting medical adherence in kidney transplant patients.

Goodzari, Heidarnia, Tavafian, and Eslami (2019), who examined the HBM constructs concerning dental hygiene behaviors, found that only one construct, self-efficacy, was significantly related to oral health behaviors in general. However, perceived benefits were found to be related to visiting the dentist every 6 months (Goodarzi, Heidarnia, Tavafian, & Eslami, 2019). All scholars were able to adapt the HBM to their instruments per their variables, displaying the flexibility of the HBM and its constructs. These constructs and the possibility of generalization they have provided are the reasons why it is possible to adopt a conceptual framework based on the HBM for the present study.

The HBM has made its way into modern topics of study such as technology. Naslund et al. (2017) purported that the digital age allowed for easier access to information, which raised patients' awareness regarding health practices and beliefs. The rise of the Internet was pivotal for patients' perceived susceptibility, seriousness, benefits, barriers, and cues to action regarding different types of health risks and health-related issues. Novel use of the HBM to study the effect of health risk and health consciousness perception upon health-related Internet use and the effects of perceived usefulness of the Internet on health information and view towards Internet use for health purposes was also made by Ahadzadeh et al. (2015). The data were analyzed using the HBM, and it was found that the HBM when combined with the technology acceptance model (TAM), was capable of predicting Internet use for health purposes (Ahadzadeh et al., 2015). Using the same theories, HBM and TAM, Cheung et al. (2019) examined the impact of consumers' health beliefs, health information accuracy, and the privacy protection of

wearable healthcare technology on perceived usefulness, as well as the influence of perceived usefulness, consumer innovativeness, and reference groups on consumers' intentions to use wearable healthcare technology. Cheung et al. revealed that health belief, as adapted by the HBM, and health information accuracy were more significant predictors of consumers' intention to use wearable healthcare technology than the other variables. Cheung et al. reinforced the vitality of the HBM as compared to other theories, even in the field of healthcare technology. These researchers further augmented the use of HBM in the modern technological age.

The HBM allows for a psychological framework to be adapted into the health and medical field. The HBM was influenced by the cognitive theory, a major psychological theory of human behavior, which reinforces this adaptation (Skinner et al., 2015). Ahadzadeh et al. (2015) found that, as the HBM is based on psychological factors that were instinctual to humans, it can be used for the analysis of various phenomena. The HBM also proved to be a practical framework for psychological and educational intervention. In their study to examine TB-treatment adherence, Tola et al. (2016) used the HBM to develop an intervention program for TB patients in Addis Ababa, Ethiopia. The intervention involved anxiety and depression counseling and patient education based on the HBM constructs by health professionals (Tola et al., 2016). After seven sessions in 4 months, participants who underwent the intervention appeared more willing to adhere to treatment than those who did not (Tola et al., 2016). Tola et al. displayed the influence of HBM not just in measures, but also in psychological interventions. Although I did not use any form of intervention, it is important to note how the HBM

works with psychological theories and interventions to both explain and predict patient behaviors. The roots of the HBM are based on psychological factors that are instinctual to humans, which makes it possible to understand and examine patients' level of awareness and knowledge of information regarding medically induced radiation exposure.

The HBM is also valued in the field of neurology, a field that is highly complementary to psychology. An essential use of the HBM to develop and propose a model illustrating variables that influence dementia care-seeking among older adults was conducted by Sayegh and Knight (2013). Sayegh and Knight provided a basis for the sociocultural HBM (SHBM) to guide future research and service planning of culture and dementia care-seeking. The SHBM provided an empirically based conceptual framework for examining cross-cultural differences in dementia care-seeking among diverse groups (Sayegh & Knight, 2013). Since then, the SHBM has been used to guide other studies regarding Alzheimer's disease, stroke, dementia, and other neurological diseases (Alqahtani, 2015; Azar et al., 2017). This frequent use further shows the consistent and significant developments made into the HBM. The scholars who used the HBM to examine different health-related phenomena on different samples showed the possibility of applying the HBM on a variety of health-related phenomena. This application included the practices of intervention into these phenomena, which further justifies the use of the HBM. This application can then be used to examine and understand and improve patients' level of awareness and knowledge of information regarding medically induced radiation exposure.

HBM based on ethnicity. Several scholars showed that the HBM could be applied to individuals with different backgrounds to examine a variety of health-related factors. The SHBM, which augmented the HBM with the addition of culturally concepts, was used to compare the reporting behaviors of European Americans and Hispanic Americans informants regarding dementia symptoms (Azar et al., 2017). Azar et al. (2017) revealed that Hispanic informants reported more symptoms than European American informants, and they presented several potential reasons for this phenomenon including the value of family and the religiousness of the Hispanic culture. In addition, Verissimo and Grella (2017) studied ethnically diverse individuals with a substance use disorder and found that Latin Americans, along with African Americans, were more likely to attribute their help-seeking behavior, or lack thereof, to structural barriers such as poverty, lack of resources, and poor English language skills. Mellor et al. (2016) investigated health behaviors and perceptions of Indigenous Australian men who have been known to be less healthy than non-indigenous Australian men. Mellor et al. used the HBM to frame their study. Participants recognized their vulnerability as indigenous men and perceived the seriousness of potential illnesses through their in-depth knowledge of the prevalence of chronic diseases in indigenous Australians (Mellor et al., 2016). The participants also identified some barriers preventing their healthy behaviors, which appeared to supersede the potential benefits of perceived healthy behaviors (Mellor et al., 2016). These scholars highlighted the interplay between ethnicity or culture and the HBM constructs in patients' perceptions and behaviors (Azar et al., 2017; Mellor et al., 2016; Verissimo & Grella, 2017). Patients may attribute their health-related behaviors to

certain characteristics or beliefs of their ethnicity and culture. The three researchers' use of the HBM displayed how this model could provide a holistic view of a health problem from different angles, which may help in finding solutions for the problem.

Other demographic characteristics may also be examined in the context of the HBM. In Johannesburg, South Africa, the prominence of noncommunicable diseases (NCDs) appeared to be the leading cause of disability (Kaba, Khamisa, & Tshuma, 2017). The use of HBM was proposed by Kaba et al. (2017) in explaining the high rate of NCDs due to unhealthy habits and obesity in that location. HBM constructs were adapted into a questionnaire given to 2135 individuals from Diepsloot in Johannesburg (Kaba et al., 2017). Young adults were found to be less concerned about the risks of NCDs than middle-aged and older adults, and they were also less likely to find regular health check-ups as useful and were less intentional about weight management. The theory of invincibility was used to explain this finding, as younger adults tended to think of themselves as invincible (Kaba et al., 2017). Another demographic characteristic, gender, appears to also play a role in HBM studies. Verissimo and Grella (2017) reported that women across all ethnicities were more likely to attribute their alcohol use to barriers like depression and anxiety, and they were more likely to display negative attitudes regarding treatment than men. Luquis and Kensinger (2019) explored whether perceived susceptibility and seriousness of health outcomes influenced access to preventive services among young adults with health insurance and found that perceived susceptibility and seriousness to cancer, diabetes, obesity, and cardiovascular disease were higher in females than in males, and in older than younger participants.

Perceived susceptibility and seriousness of sexually transmitted diseases were higher in younger participants (Luquis & Kensinger, 2019). Health beliefs, as per the HBM, may differ not just in ethnically or culturally diverse populations but in different age groups as well (Kaba et al., 2017; Luquis & Kensinger, 2019; Verissimo & Grella, 2017). Scholars who used the HBM to examine different health-related phenomena on different samples showed the possibility of applying the HBM on a variety of health-related phenomena. This information further justifies the use of the HBM to examine and understand patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina.

HBM in nonclinical studies. The use of the HBM has been established in the clinical field; however, it also has its uses in nonclinical studies. Khani Jeihooni, Hidarnia, Kaveh, Hajizadeh, and Askari (2015) measured the effect of an educational program based on the HBM and social cognitive theory in the prevention of osteoporosis in women. A significant increase in the HBM constructs of self-regulation, social support, nutrition, and walking performance was found after intervention in the experimental group when compared to the control group (Khani Jeihooni et al., 2015). Salari and Filus (2016) incorporated the HBM in their assessment of parental intention to participate in parenting programs. Salari and Filus adapted the constructs of the HBM to their topic, arriving at the variables of perceived benefits of parenting programs, perceived barriers to participating in parenting programs, perceived child problem

susceptibility, perceived seriousness or severity of child problems, and perceived self-efficacy as parents. Salari and Filus revealed how perceived benefits and barriers significantly correlated with participation in parenting programs, while perceived child susceptibility and severity were not. These scholars showed that it was possible to use the HBM and adapt its constructs to nonclinical studies, reinforcing the flexibility of this theory (Khani Jeihooni et al., 2015; Salari & Filus, 2016).

The constructs of the HBM provide an understanding of various barriers and motivators to the performance of behavior in clinical fields and elsewhere. Yoon and Kim (2016) used HBM constructs to examine environmental behavior and attitude towards green advertising concerning people's beliefs. Yoon and Kim purported that the fields of environment and health shared similarities; hence, the HBM should be compatible with both. Yoon and Kim focused on their past experiences, perceptions, and environmental attitudes, and they used modified HBM constructs to fit the environmental field. Yoon and Kim displayed that attitude and intended behaviors were significantly related to perceived severity and susceptibility response efficacy and social norms. With these findings, Yoon and Kim recommended the use of perceived severity and susceptibility, along with other HBM constructs, in green advertising to promote the urgency of environmental actions. Msengi (2019) also incorporated HBM constructs into a waste management intervention program. The program imparted examples of how the benefits of recycling outweighed the barriers. After 6 months, a positive change in participants' waste management was observed in the posttest questionnaire as well as the participants' weight of recyclables (Msengi, 2019). Msengi concluded that the

incorporation of the HBM constructs assisted in motivating the participants into better waste management. Movahhed et al. (2019) found that perceived benefits, severity, and sensitivity predicted waste collection behavior, reinforcing HBM constructs' use in environmental studies. Overall, scholars revealed the used of HBM in showing how perceptions, awareness, knowledge, and beliefs can influence behavior. The HBM constructs can be used in this study, as patients' awareness and knowledge about medical radiation were examined qualitatively.

Literature Review Related to Key Variables and Concepts

General Description and Historical Overview

Historical overview. Since the development of radiation technology in the 1900s, medical radiation, mostly through diagnostic imaging, has been pervasive in the field of health care (Abdallah, 2017). An overview of medical imaging radiation risks caused by various sources of imaging was provided as far back as in the 1950s. Price (1958) classified ionizing radiation as a public health problem and mentioned that it had effects on a large portion of the population. Pinheiro et al. (1970) focused on the knowledge and perception of patients about radiation exposure from medical procedures. Price also examined the reaction and understanding of general populations about radiation exposure risks from conventional sources, such as x-rays. There was a need for the design of social action to have more thoughtful consideration (Price, 1958). In their study, Pinheiro et al. (1970) provided a self-applied questionnaire to patients undergoing medical imaging exams. In an analysis of 300 questionnaires, Pinheiro et al. found that 25% of patients believed that they were exposed to radiation from medical imaging exams. Also,

60% said they rarely or never worried about exposure to radiation while undergoing medical imaging exams (Pinheiro et al., 1970). Pinheiro et al. concluded that patients lacked awareness and underestimated the risks of medical imaging radiation exposure. From the studies of Price and Pinheiro et al., several studies occurred within the field of radiation. However, a gap in research exists about the perceptions and level of knowledge of patients when it comes to radiation risks and effects on personal health.

General studies on medical imaging radiation exposure. It is essential to note the effects of low-dose radiation from medical imaging procedures. Ding and Gao (2017) examined how low levels of exposure resulted in significant health risks to patients, specifically in terms of cardiovascular diseases (CVD). Ding and Gao showed that the current consensus held by national and international radiological protection organizations was, for comparatively low doses, the most appropriate risk model; it stated that the risk of radiation-induced cancer and hereditary disease was assumed to increase linearly with increasing radiation dose, with no threshold—known as the linear no-threshold (LNT) model (Ding & Gao, 2017). The LNT model, however, is not supported by studies on lower doses, as these lower doses did not seem to form a linear pattern with a disease. Ding and Gao found no dose-effect threshold for heart disease, which is troubling as it displays how low doses of radiation already provide risk. Duncan, Lieber, Adachi, and Wahl (2018) also emphasized the increased cancer risk related to the DNA mutations brought about by low doses of radiation. Duncan et al. noted that the LNT was still the safest model to follow in terms of radiation doses. Weber and Zanzonico (2017) examined different studies concerning low dose radiation risks of cancer and revealed

contrasting results, with some scholars purporting various minimum doses and some supporting the LNT with no minimum dose. Weber and Zanzonico concluded that, although the LNT remains the only model currently supported by several observational data, it should not be used solely in due to the uncertainties found in the literature surrounding it. Based on these studies, the issue of low dose radiation remains to be in debate, and no proven model can guide decisions to undergo medical imaging with low doses of radiation. It is vital to study the awareness of patients about such standard medical imaging procedures that may guide their decision-making processes.

It is important to study the awareness of patients about common medical imaging procedures. The experts' perceived radiological risks varied within their circle and from the general public as well. Their awareness of medical x-rays and natural radiation was significantly higher than in the general population (Evans et al., 2015; Szarmach et al., 2015**)**. Evans et al. (2015) explored the public's level of awareness about the risks of ionizing radiation and found that 80% of respondents underestimated the contribution of medical imaging tests to total ionizing radiation exposure.

Furthermore, mass media did not use the same language as technical experts while addressing radiological risks (Perko, 2016**)**. The discrepancy in risk perception and the communication gap between the experts and the general population was concluded as a challenge in the process of mutual understanding between experts and the general population (Perko, 2016). Chandrashekhar, Shaw, and Narula (2015) observed that there was no proper measure of risks from medical radiation exposure on individual patients, although several studies had been carried out on the topic and various guidelines were

available. The lack of awareness about medical imaging radiation risks among patients is an ongoing issue of concern. The present study, by examining patients' level of awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina, will contribute insights on this topic in the literature and thus fill this gap.

Factors Influencing Patients' Radiation Awareness

The conflicting guidelines and opinions on radiation doses presented in the preceding section may be reflected in patients' awareness and perceptions regarding medical radiation. Several factors may influence the perceptions of patients about the effects of radiation exposure. These factors are (a) education, (b) communication, (c) experience, and (d) cultural differences.

Education. Education refers to the formal training or learning that patients underwent that may have increased or affected their knowledge about the different effects of medical radiation. Researchers (Al Ewaidat et al., 2018; Talab, Mahmodi, Aghaei, Jodaki, & Ganji, 2016) examined the relationship between education and the awareness of radiation exposure risks and found that the level of education had a significant effect on the knowledge of radiation among the subjects.

Children are not exempt from the effects of medical radiation. The education of parents plays a part in their awareness about the risk of radiation exposure, among other health issues, on their children (Ahn et al., 2017). Ahn et al. (2017) surveyed parents of childhood cancer survivors (CCS) in Korea regarding past cancer diagnosis and treatment

exposure and found that treatments for CCS may have side effects that parents were not aware of. Ahn et al. found that the majority of the parents were not aware of the cardiotoxic agents and radiation that their child received during treatment, especially in the cases of leukemia and lymphoma. Being exposed to cardiotoxic agents and radiation could have long-term effects and even cause secondary cancer (Ahn et al., 2017). Those parents who understood the risk factors, on the other hand, displayed more concern about these risk factors and increased their follow-up visits to their oncologists (Ahn et al., 2017). Oikarinen et al. (2018) examined parents' experience with the information provided on their child's plain radiographic examination and they found that education for both the staff and parents were necessary to advance pediatric patient information, particularly on medical radiation. Parents' education also played a role in Pahade et al.'s (2018) findings, as they examined parents' and caregivers' preferences in terms of receiving information before an imaging examination. Pahade et al. found that parents with higher educational attainment preferred to receive information through an e-mail or website rather than through the phone or face-to-face. Although convenient, the information provided through online means may not be reliable, which places these parents at a disadvantage (Pahade et al., 2018). These scholars showed the role of education in medical radiation awareness, as a lack of education might lead parents to overlook the adverse effects of the radiation treatments that their children received, while educated parents who prefer to seek information by themselves may be led to unreliable sources online.

Adults need to be equally aware of their health regarding radiation exposure. Al Ewaidat et al. (2018) examined knowledge and awareness of radiation and dosage in CT scans for 600 patients from Jordan. Al Ewaidat et al. found that awareness and knowledge regarding these risks were related to education levels. Patients with higher education levels were more aware and knowledgeable than those with lower education levels (Al Ewaidat et al., 2018). There was a distinction between different populations regarding their health behaviors (Al Ewaidat et al., 2018).

Patients' education may be secondary to other sources such as their providers and referrers. In an analysis between referred and self-presenting patients in Bahrain, Al-Mallah, Vaithinathan, Al-Sehlawi, and Al-Mannai (2017) found no significant difference regarding educational levels as it related to their awareness and knowledge of radiation dosage and exposure. Overall, Al-Mallah et al. found that referred patients appeared to be more aware and knowledgeable than self-presenting patients, regardless of educational attainment. Thus, patients' differing education mattered less than the referral of their doctor or provider (Al-Mallah et al., 2017). Despite being educated about radiation, patients rely on the recommendations and referrals of other people. Patients' education may be influential in their radiation awareness, but it may be subverted by the limited or incorrect knowledge of the referrers, which affects the knowledge of the patients. This insight will help provide a better understanding of the perception of the patients regarding medical radiation risks that I examined in this study.

Medical professionals, aside from being referrers, are among the primary sources for patients to increase their awareness about the risks associated with medical imaging

radiation. Talab et al. (2016) found that higher educational levels caused higher awareness of medical imaging radiation risks, even among radiographers. Based on the data collected from 185 radiographers through three questionnaires, Talab et al. found that there was a significant relationship between education and knowledge of radiographers. Portelli et al. (2015) found that the knowledge of radiation doses among radiographers, as imparted during standard radiological procedures, and the consequent risk to the individual patient was reduced among health professionals. Portelli et al. revealed that some practitioners were not up-to-date in terms of training for the past 10 years. Nurses were also found to be underprepared in radiation protection. Badawy, Mong, Lykhum, and Deb (2016) found that less than half (42%) of the radiation protection questions were answered correctly, and the majority of these nurses received no further training regarding radiation. Badawy et al. concluded that nurses' radiation protection knowledge was limited, and they required more training programs. Patients may not be receiving the proper radiation protection from these healthcare professionals.

The lack of awareness of healthcare professionals may be traced back to their education as medical students and residents. Scali, Nicolaou, Kozoriz, and Chang (2017) found that senior medical students' level of knowledge about ionizing radiation and doses in radiological examinations was inadequate. Ditkofsky et al. (2016) investigated emergency department providers' knowledge of the ionizing radiation risks from commonly performed imaging examinations, and they also examined the comfort level of providers in terms of explaining the dosage and risks of radiation. Ditkofsky et al. found that only 63.5% of the providers were able to correctly rank the tests from lowest to

highest radiation exposure; this should be basic information that providers should know, especially in the emergency department where limited time is provided. Some emergency residents (37.5%) expressed that they were not comfortable discussing radiation risks to patients as well (Ditkofsky et al., 2016). Patients undergoing radiation examinations may be left uninformed about the procedure (Ditkofsky et al., 2016). As future doctors and referrers for radiation imaging, these students and residents should have been exposed to radiology curriculum teaching radiation safety guidelines; however, their knowledge of medical radiation may be insufficient.

Overall, when it comes to the awareness of the risks associated with medical imaging radiation, education plays a role not only for the patients but also for the medical professionals. Medical professional awareness may be affected by many factors, such as education. Furthermore, their awareness depends on the awareness of their sources. Among one of these sources, namely radiographers, education plays a part when it comes to the awareness of the risks associated with medical imaging radiation (Talab et al., 2016). The lack of awareness among senior medical students, future doctors, about medical imaging radiation risks directly affects the level of awareness of patients about these risks. These findings provide a background for understanding the awareness of the primary sources of patients' awareness of medical imaging radiation.

Another educational factor that influences the awareness of medical imaging radiation is related to guidelines. Potential consequences of guideline adherence to patients' radiation exposure risks were noted by Weltermann et al. (2015) and Gupta et al. (2014). Weltermann et al. examined individual patients' histories and the associated

radiation exposures to assess the discrepancies between guideline recommendations for coronary angiographies and clinical practice. Based on the analysis of 441 procedures for patients with coronary artery disease in an academic teaching practice who underwent angiography with or without intervention, Weltermann et al. found that there were potential benefits of guideline adherence to decrease patients' radiation exposure. Gupta et al. provided evidence for how educational materials like guidelines affected the risk of medical radiation. These findings displayed the importance of guidelines and the medical professionals' adherence to them.

Guidelines and protocols may also influence the decision to use medical imaging. Engineer et al. (2018) implemented a patient-care path involving clinical decision support (CDS) based on published evidence to guide emergency clinicians towards appropriate head CT scan use in patients with a mild head injury. Engineer et al. found that implementation of the CDS reduced the use of a CT scan from 62.7% down to 22% of patients with a mild head injury and that there were no missed traumatic brain injuries within the study. Adherence to guidelines decreased the number of unnecessary imaging procedures used by medical professionals, which decreased the radiation exposure risks (Engineer et al., 2018). Portelli et al. (2015) found that a majority (77.3%) of their radiographer participants were unaware of or did not follow guidelines such as these is then another cause for concern. Hanna, Shekhani, Zygmont, Kerchberger, and Johnson (2016) likewise found that practicing emergency radiologists tended to be either too aggressive or less aggressive than recommended societal guidelines. In their study, 59.9% of the cases led to more aggressive imaging, increasing the risks related to

radiation (Hanna et al., 2016). Education regarding guidelines, as well as adherence to these guidelines, is vital to patients' medical radiation risks. Patients may be subjected to too much or too little medical imaging exams without their knowledge, due to nonadherence of radiologists to guidelines.

Not all scholars found the correlation between higher education and higher awareness of medical imaging radiation risks to be positive. This finding was evident through higher educational attainment and education through programs about medical imaging radiation risks. Brun et al. (2018), Evans et al. (2015), and Schnitzler et al. (2017) did not find any significant effect of the general educational attainment of participants on their awareness of radiation exposure risks. Furthermore, in terms of training programs on radiation exposure risks, Brun et al. showed that, although training programs could be provided as part of an effort to increase surgeons' and anesthetists' awareness of radiation exposure risks, it does not guarantee a change in their hazardous occupational practices. Brun et al. noted that short-term changes could not be expected from a single or a small number of training sessions. Hence, there is a need for more strategic training for physicians in terms of radiation safety practices (Brun et al., 2018). Evans et al. also showed that education did not affect the misperceptions they had of actual risks of exposure to ionizing radiation. Although the general educational attainment among the respondents in their study was high, this finding was especially inherent in medical imaging tests. As important as education may be, it does not appear to be a panacea in resolving the issue of medical radiation.

Schnitzler et al. (2017) found that medical jargon used to educate patients prevented them from fully understanding the risks involved in the treatment. Some educational programs may not be as effective in increasing knowledge and awareness regarding radiation exposure risks (Schnitzler et al., 2017). The data for the study by Brun et al. (2018) were collected from 90 preintervention and 35 postintervention questionnaires. In these data, all of the participants had attended training intervention about radiation safety practices (Brun et al., 2018). The data for the study by Evans et al. (2015) were collected through surveys from the general public at six Vermont locations. The data for the study by Schnitzler et al. (2017) were collected from 58 patients and 10 radiation therapists. These scholars countered previously discussed literature regarding the role of healthcare providers' education in radiation awareness. Education in general, while proven vital to radiation awareness in other past studies, may not be as effective as specific types of education that would address healthcare practitioners' awareness of radiation risks and guidelines, as well as how to properly communicate these with patients.

Communication between patient and physician. Scholars have found a relationship between higher awareness of patients about medical imaging radiation exposure risks and communication between the patient and the medical professional about these risks. Communication between patients and other members of their immediate social network was also found to be influential to the perceptions of patients. The importance of communication between patients and other members of their social circle is discussed in this section.

Communication between patients and radiologists is crucial, as their roles consist of service user and service provider. Vijayasarathi and Duszak (2019) provided a review of the personal and clinical benefits of direct communication between radiologists and patients. These benefits included a broadening of radiologists' understanding of the patients' diseases and assistance for patients regarding follow-up recommendations (Vijayasarathi & Duszak, 2019). These recommendations may include taking note of the risks involved in medical radiation. Increased communication between patients and medical professionals result in positive consequences when it comes to decreasing the risks associated with medical imaging radiation (Vijayasarathi & Duszak, 2019). Communication may also decrease the anxiety of patients who are about to undergo medical imaging with radiation. Heyer et al. (2015) found that patients who were not informed about the screening process and the risks involved were more anxious. Patients are willing to learn about the risks associated with medical imaging radiation (Heyer et al., 2015). As service users, patients may be gratified by being told about the service they are about to undergo. In this context, the role of communication in decreasing the risks of medical imaging radiation is significant.

The sources by which patients attain information are more critical to examine than their desire. Furthermore, Marin, Thomas, Mills, Broder, and Boutis (2017) reported that doctors frequently discussed radiation risks with patients, especially for younger patients. Physicians have the desire to discuss this with their patients. However, although patients and doctors share the concern about the need for discussion about radiation exposure risks, there was a lack of a structured method for this communication (Marin et al., 2017).

This is also reflected in the use of complex medical jargon by healthcare providers in explaining medical radiation to patients (Schnitzler et al., 2017; Thornton et al., 2015). Ukkola, Oikarinen, Hnner, Haapea, and Tervonen (2017), who surveyed patients about the information discussed with them regarding the radiological examinations that they underwent, found that 35% of their participants did not receive any information at all, and 65% received some information. The information provided may be inadequate as it mostly focuses only on the indication or course of the examination or radiation use. It may not include information about the dose and the risks related to the examination (Ukkola et al., 2017). Medical professionals must be mindful of how they communicate with patients and ensure that patients understand what they are about to undergo. It is through the medical professional that the patient is capable of getting accurate information on radiation risks.

Reports about medical radiation may also be insufficient for patients. Salerno et al. (2018) administered two surveys, a pre-CT survey and a post-CT survey (after the patients have also received a CT dose report). The participants for this study were 412 patients who underwent a CT at the University Hospital "Paolo Giaccone" in Palermo (Salerno et al., 2018). Salerno et al. found that 66% of the participants reported that they did not understand the numerical CT-dose parameters provided in the report. This factor could also be why the patients also expressed little interest in the knowledge of CT dose parameters. Salerno et al. also purported that patients may fear the examination results. Salerno et al. also displayed a knowledge gap in patients regarding radiation risks. This gap, paired with the lack of interest in gaining knowledge on the matter, calls for more

efforts in communicating the importance of radiation risks to patients (Salerno et al., 2018). Communication between patients and physicians have high tendencies of influencing the perceptions of patients (Heyer et al., 2015; Salerno et al., 2018; Ukkola et al., 2017; Vijayasarathi & Duszak, 2019). However, there is a need to explore further the perceptions of patients about the risks related to radiation exposure. Exploring this topic is needed to provide more insight to design strategies to help policymakers and providers understand how they could provide more awareness to patients. It is also essential to know the present state of the awareness of patients regarding medical imaging procedure radiation risks.

Experience of physicians. Along with education and communication, another factor that affects the awareness of patients about radiation risks from medical imaging procedures is the experience level of the medical professionals. Tong, Wallace, Hartwig, D'Amico, and Huber (2016) examined patients' decision-making process for lung cancer treatment. Radiation therapy is among the options for treatment and requires much thought due to its risks and benefits (Tong et al., 2016). A survey of 225 individuals who were aged 40 and above with a history of smoking revealed how provider volume or the experience of the physician was the second most important factor in patients' decision making, next to treatment type (Tong et al., 2016). The participants preferred a thoracic oncology specialist over physicians with other skill sets (Tong et al., 2016). While investigating interventional cardiology procedures that used large amounts of radiation, Andreou, Pantos, Tzanalaridou, Efstathopoulos, and Katritsis (2016) found that operator experience influenced radiation exposure. More experienced operators used lower doses

than less experienced operators (Andreou et al., 2016). These findings supported the value of physician experience in patients' perceptions and health beliefs or behaviors.

As important as physicians' knowledge is, it appears to be more crucial that they share this knowledge with their patients. Kruger et al. (2014) believed that information about radiation would be useful for making decisions and for discussions between patients and clinicians. Kruger et al. showed that information about radiation exposure would improve the knowledge of clinicians, along with making discussions between patients and clinicians more informed. Kruger et al. showed that it is vital to understand and increase the knowledge of patients regarding the risks associated with medical imaging radiation. This understanding will help to decrease the exposure to the risks associated with medical imaging radiation among patients. Marin et al. (2017) also examined the role of physicians' years of experience with the discussion of radiation risks, and they found no significant difference between years of experience and reported comfort in discussing radiation risks. Comfort in discussing these risks, however, does not directly translate into proper communication with the patient. Overall, past scholars generally showed how healthcare providers' experience might influence radiation risks and patients' awareness regarding these risks. The lack of awareness among medical professionals about medical imaging radiation risks directly affects the level of awareness of patients about these risks. These findings provide a background for understanding the awareness of the primary sources of patients' awareness of medical imaging radiation.

Cultural and racial differences. Cultural differences may act as a source of hindrance in the patients' awareness of medical imaging radiation risk. McNierney-

Moore et al. (2015) compared Hispanic American and European American emergency department populations to determine if cultural differences had any impact on the radiation awareness level of patients. McNierney-Moore et al. concluded that the overall knowledge of the study group about radiation was poor; however, there were no significant differences between the awareness levels of Hispanic American versus European American patients. Lind, Jensen, Perez-Portillo, and Garg (2019) investigated patient perceptions regarding CT and found that patients wanted to know more about the scan. Lind et al. revealed higher scores for African Americans and Asian Americans or Pacific Islanders compared to European Americans for this particular item. One item was not enough to purport a meaningful difference in races, showing how race may not be related to patient's radiation risk awareness (Lind et al., 2019). Based on these studies (Lind et al., 2019; McNierney-Moore et al., 2015), racial and cultural differences do not play a role in the awareness of patients about medical imaging radiation risks. This insight that racial and cultural differences do not play a significant role was considered while studying the perception of patients regarding medical imaging radiation risks.

Awareness of Different Individuals about the Risks of Medical Imaging Procedures

Awareness may change the process of medical imaging. Scholars have explored awareness of different groups of individuals (ie., physicians, resident doctors, interns, radiographers, and nurses) about risks of radiation exposure. For this change to take place, it is important first to assess and then increase the level of knowledge the patients possess about radiation risks from medical imaging procedures. Although it is hard to generate an appropriate metric to measure radiation safety (Elnahal et al., 2016), a set of

protocols of radiation safety have been researched and reviewed in the past years (Ahmed & Taha, 2017). To fulfill these protocols, it is important first to assess and then increase the level of knowledge the patients possess about radiation risks from medical imaging procedures.

Patients' sources of knowledge must be examined, as they will serve as the basis for patient awareness. Jacobs, Amuta, and Jeon (2017) revealed that even in the digital age where information is easily searchable, health care providers are still considered a major source of health information. The benefits of indicated medical imaging outweigh the relatively small excess cancer risk; however, for certain subsets of patients, radiation risk had to be of greater concern to the clinician (Zanzonico, 2016). To provide the information needed to balance the factors of risk and benefits, and to contribute information for the clinician to make decisions while assessing the radiation risk for different subsets of patients, it is important to study the knowledge and views of patients and their awareness about radiation risks from medical imaging procedures. Furthermore, research has been carried out to assess the level of awareness among medical professionals about medical imaging radiation risks.

Awareness of doctors about radiation imaging. Healthcare providers are usually the primary source of knowledge for patients. Hobbs et al. (2018) displayed a lack of awareness of health care providers from different departments of primary care specialties before an intervention regarding radiation exposure and risk. Hobbs et al. revealed significantly low scores regarding radiation knowledge, which then improved after education intervention. Radiologists had higher baseline results than other

specialties but still showed improvement after an intervention (Hobbs et al., 2018). Faggioni, Paolicchi, Bastiani, Guido, and Caramella (2017) also discovered the poor state of radiation awareness among medical students, radiology residents, and radiography students. Analysis of the data collected from 159 responses found that less than half of all participants were able to provide all the correct answers (Faggioni et al., 2017). Further, an inquiry on their perceived knowledge on the subject matter revealed that the participants, particularly medical students, may have overestimated their awareness and knowledge of the subject matter (Faggioni et al., 2017). As confident as they may be in their awareness level, it can be observed that much improvement is still necessary. There is a need for further training and interventions to improve health care providers' and students' awareness and knowledge regarding radiation exposure and risk.

Level of radiation awareness is important for residents, as they are already trained to be referrers for medical imaging. Extremely poor awareness levels among residents, the time in the field of urology, about radiation dose were found in a study conducted by Harris, Loomis, Hopkins, and Bylund (2019). Harris et al. explored radiation safety training, knowledge, behavior, and attitudes of urology residents in the United States. Based on the data collected from 136 residents, Harris et al. found that only 54% of residents were successful in correctly answering questions about directional x-ray travel and exposure and that only 7% knew that the fluoroscopy machine was set to continuous. These represented the lowest scores regarding radiation knowledge in the study (Harris et al., 2019). These low scores are reflected in Scali et al.'s (2017) study on senior medical students and Ditkofsky et al.'s (2016) study on emergency residents, which both

criticized the curriculum for lack of coverage regarding medical radiation. Harris et al. also found that some radiation protection practices were not being followed by these residents, such as wearing lead gloves, lead shields, lead-lined glasses, and dosimeters. This finding was reflected in Portelli et al.'s (2015) study on practicing radiographers. As referrers form the primary source of information for the patients about radiation risks, this lack of awareness among referrers themselves signals a need to explore the issue further.

As referrers use these services often, it is expected that they would be fully aware of radiation doses and risks. The awareness of medical professionals about radiation doses as well as risks from common radiological procedures was poor (Faggioni et al., 2017; Harris et al., 2019; Hobbs et al., 2018). Furthermore, this lack of awareness affected the risk to the individual patient (Faggioni et al., 2017). The lack of awareness among patients, despite their willingness to know about the risks associated with medical imaging radiation, may be due to the lack of knowledge among medical professionals themselves about the risk (Faggioni et al., 2017). Hobbs et al. (2018) purported that this lack of awareness can be addressed by even a modest educational presentation. As primary sources of information for patients regarding healthcare, these medical professionals would need more thorough training to meet patients' needs.

Awareness of radiographers about radiation imaging. It is also important to note other sources of knowledge for the patients regarding the risks associated with medical imaging radiation. Several researchers have explored the level of awareness of radiographers regarding medical imaging radiation exposure risks. For instance,

Furmaniak, Kołodziejska, and Szopiński (2016) examined the knowledge of radiologists, radiology students, dentists, and dentistry students about general radiation knowledge. The mean scores of correct answers amounted to only 64% for dentists and 62% for radiographers, which were found to be inadequate (Furmaniak et al., 2016). Although insignificant, dentist' scores were higher than radiologists (Furmaniak et al., 2016). Paolicchi et al. (2015) likewise found a significant need for improvement in the awareness of radiographers about the risks and protection from radiological exams.

Additionally, Paolicchi et al. (2015) found that only 12.1% of the radiographers took part in regular radiation protection courses. On the contrary, Karim et al. (2016) found that the majority of their radiologist and radiographer participants were aware of the radiation doses of skull x-rays, intravenous urography (IVU), and lumbar spine x-rays. The participants displayed inadequate knowledge about CT radiation doses (Karim et al., 2016). Despite the general positive scores, their inadequacy on CT radiation knowledge is still unacceptable as it is one of the most commonly used exams (Karim et al., 2016). Radiologists act as the service providers for the patients. More training and intervention appear to be necessary for radiologists and radiographers.

Other scholars have found high levels of radiologists' and radiographers' awareness regarding radiation risks. Adambounou et al. (2015) examined the knowledge and the perspective of Togolese radiographers concerning the medical irradiation of pregnant women. Based on a cross-sectional study conducted with 72 radiographers, Adambounou et al. found that a quarter of the radiographers understood MRI as an irradiant examination. However, Sharma, Singh, Goel, and Satani (2016) showed that

knowledge about radiation protection did not necessarily translate into practice. Sharma et al. examined the level of awareness and knowledge, as well as the practices, of radiographers in Agra regarding radiation protection. Sharma et al. showed that all 50 participants were aware of radiation protection practices but rarely used those. Sharma et al. revealed how further intervention is still necessary for these providers as they are considered experts in the field and are held responsible for proper radiation protection practices. The lack of awareness among radiographers about medical imaging radiation risks, as well as their disregard for radiation safety practices, directly affects the level of awareness of patients about these risks, as they are one of the primary sources of education for the patients about the risks associated with medical imaging radiation exposure. These findings provide a background to understanding how radiologists and radiographers, as primary sources of patients' awareness of medical imaging radiation, may need further efforts and interventions to meet patients' needs.

Awareness of dental practitioners about effects of radiation imaging. Medical radiation is not limited to the common procedures done in hospitals but is also present in some dental practices. Dental practitioners are also health care providers, and as such, must also be aware of medical radiation. Aravind et al. (2016) assessed the knowledge levels of dental practitioners about radiation exposure risks. Based on the data collected through 300 general dental practitioners in Kerala, India, Aravind et al. found that the knowledge of dental practitioners, especially those who have been in practice for 5 to 25 years, about radiation was generally acceptable. This knowledge, however, was also not translated into practice, as 90.3% of the participants were found to lack any safety

measure for their patients (Aravind et al., 2016). Furthermore, only 22% of the participants appeared to be aware of their susceptible patients, such as pregnant women and children (Aravind et al., 2016).

Swapna et al. (2017), who examined radiation awareness among third- and fourth-year dental surgery students, revealed an acceptable 70% for correct responses overall. An alarming number (65%) of students, however, reported not being aware of radiation protection guidelines (Swapna et al., 2017). Swapna et al. then rated their KAP level from low to medium and recommended further training for them and an updating of radiation protection guidelines. The practice of dentistry also makes use of medical imaging exams with radiation such as X-rays; hence, the finding that their awareness of and adherence to radiation safety practices were also inadequate is a cause for concern. These findings show how dental patients must be equally vigilant when discussing medical radiation with their dentists.

Awareness of referrers about effects of radiation imaging. The awareness among referrers plays a part in the awareness of patients about the risks of medical imaging radiation exposure risks, as they are not only one of the primary sources of education for the patients about the risks associated with medical imaging radiation exposure, but also the ones responsible for suggesting these exams. Poullis, Mackay, and Ahmed (2015) established the knowledge of physicians about radiation dosages and found that clinicians' knowledge of radiation doses was poor with a mean score of 17%, thereby concluding that clinician awareness about radiation doses of common diagnostic procedures was poor and underestimated the true values. In a similar study, Kruger et al.

(2014) found that clinicians and physicians showed a poor understanding of radiation exposure risks from medical imaging procedures. Kruger et al. also found that clinicians felt that they had limited knowledge about the clinical implications of radiation exposure. The awareness among referrers plays a part in the awareness of patients about the risks of medical imaging radiation exposure, as they are one of the primary sources of education for the patients about the risks associated with medical imaging radiation exposure. The knowledge of the referrers themselves is lacking, which affects the knowledge of the patients they serve. This insight will help better understand the perceptions of the patients regarding medical radiation risks that I examined.

The development of medical imaging over the years would have ideally raised awareness at a similar pace. Schuster et al. (2017) explored the changes in the level of awareness of providers, radiologists, and patients regarding CT scan radiation risks between 2004 and 2015 and suggested that in the year 2015, there was a higher awareness among providers and patients regarding the radiation risks from CT scans compared to the levels of awareness in 2004; however, there was infrequent discussion on the risks and radiation exposure from CT scans, and such discussions took place less often than the frequency emergency providers perceived. Singh et al. (2017) found that there was little or no information that patients received from their referring providers regarding the risks and dose of medical imaging radiations. Although the findings were contrary to those suggested by Schuster et al. in the same period, an important difference between the studies was that the study by Singh et al. was conducted in a single private clinic in Melbourne, Australia. Nevertheless, the findings from various studies on the

awareness of different stakeholders on medical imaging radiation risks present a lack of consensus. The knowledge of the referrers themselves is lacking, which affects the knowledge of the patients they serve.

Awareness of medical students. Medical students, as future doctors, have a responsibility to be equally aware of radiation exposure risks. Scali et al. (2017) showed how medical students in their final year of studying may still have inadequate KAP regarding radiation dosage and risks. Specifically, Scali et al. found that only 12% of the 192 participants routinely discussed radiation risks with their patients. Scali et al. found that less than a quarter of the participants correctly determined that gonads were the most radiation-sensitive tissue and that the majority of the student's overestimated chest x-ray relative dosage. These gaps in knowledge must be filled before the students enter into medical practice, so as not to set up increased and unnecessary radiation risks for patients. Similar results were found in Norway, as medical students in their final year were tested regarding radiation dosage and risks (Kada, 2017). Seventy-five medical students completed questionnaires to test their knowledge of common radiation procedures (Kada, 2017). A low mean score of 3.91 out of 11 was procured, and only 18% of the participants were able to score more than half of the total points (Kada, 2017). Although 83% of the participants reported receiving lectures about radiation, only 39% reported radiation dosage and risks as the topics of these lectures (Kada, 2017). Kada (2017) study also displayed how final year medical students may not be fully prepared for practice considering their low level of awareness and knowledge regarding radiation.

Scholars have suggested that the level of awareness about radiation exposure risks is poor, not only among medical professionals of all specialties but also among medical students (Faggioni et al., 2017; Harris et al., 2019; Hobbs et al., 2018; Scali et al., 2017). Medical students become referrers in the future, and their awareness levels of medical imaging procedure risks play a role in understanding the way information about this topic is provided to medical professionals as students. The level of awareness among patients is thus affected by how medical students receive their knowledge about the risks associated with medical imaging procedures as well as their knowledge and misconceptions about it.

Patients Lack Awareness of Risks Related to Radiation Exposure

Radiation awareness is important, considering the prevalence of medical imaging exams. There is a need to study functional imaging to provide new insights into low-dose radiation cardiovascular risks (Baumann et al., 2016). Routine daily imaging of patients has little clinical use (Kleinpell, Farmer, & Pastores, 2018). It is possible to eliminate unnecessary medical imaging procedures if the patient has an adequate amount of awareness about medical imaging procedures (Kleinpell et al., 2018). To design policies and educational materials that could address this need, it is first important to know the current level of awareness among patients about the risks of radiation from medical imaging procedure.

The risks from radiation can be divided into two categories concerning the presence of a threshold: deterministic risks and stochastic risks (Zener, Johnson, Wiseman, Pandey, & Mujoomdar, 2018). Deterministic effects occur beyond a certain

threshold, often set at 10 Sv, after which the effects increase linearly (Dobrescu & Rădulescu, 2015). These deterministic effects may manifest in the form of skin burns, eye cataracts, and reduced life duration (Zhekova-Maradzhieva et al., 2017). Stochastic effects, on the contrary, have no threshold, and its probability increases in a linear relationship with the absorbed dose (Dobrescu & Rădulescu, 2015). These stochastic effects include radiation carcinogenesis, leukemia, and other types of cancers (Zhekova-Maradzhieva et al., 2017). Dobrescu and Rădulescu (2015) noted, however, that it is often difficult to distinguish between two effects. Zener et al. (2018) further discussed the possibility of including radiation risks in the consent discussion for interventional radiology procedures. To do this, it is important to have an understanding of what is the current state of awareness among patients about radiation from medical imaging procedures. Uncovering the current state of patient awareness also assists in formulating proper guidelines for disclosing information. The use of ionizing radiation during an imaging procedure must be disclosed to all patients by the ordering provider at the time of ordering (Lumbreras et al., 2017). Lumbreras et al. (2017) suggested recommendations to avoid testing that involved radiation in patients with inappropriate indications. Despite numerous guidelines and research papers, there is no good measure of the risks of radiation associated with current-day imaging for an individual patient (Chandrashekhar et al., 2015). There is a need to explore further the awareness level of patients on radiation exposure risks and the overall view of patients on medical imaging procedures and the radiation caused by this procedure.

A knowledge gap about radiation exposure from CT scans among patients as well as medical staff was mentioned by Guena et al. (2017). Guena et al. summarized the ways suggested to close this gap (Guena et al., 2017). Following up on this study (Guena et al., 2017), it becomes important to study the awareness of patients about radiation from medical imaging procedures to contribute to filling this gap. The level of awareness of patients about the radiation risks associated with the dose of medical imaging procedures was the subject of studies conducted by Bohl et al. (2016), Guena et al. (2017), and Singh et al. (2017). These scholars (Bohl et al., 2016; Guena et al., 2017; Singh et al., 2017) underline the significant aspects of medical imaging radiation risks awareness among patients and the need to explore it further to provide knowledge to patients regarding implications of medically induced radiation exposure.

Patients' decisions about medical imaging involving radiation may rely on their level of awareness regarding its risks. The level of awareness about medical imaging radiation risks among patients is not satisfactory, and there was a need to increase this awareness by providing information about the topic (Singh et al., 2017). In the study conducted by Singh et al. (2017), only 54.6% of the patients said they were concerned about radiation before their scan. Although most patients remembered that their health care had provided discussions informing them about the reasons for imaging, discussion about radiation-associated risk was not provided (Singh et al., 2017). Singh et al. studied the level of awareness among local patients about radiation dose as well as the associated risks that are caused by radiological procedures, and they found that the majority of patients incorrectly identified x-ray as having a higher radiation dose than a CT scan.

Most patients underestimated the radiation dose of a CT scan in the study by Bohl et al. (2011). Patients also incorrectly associated the MRI with at least some radiation exposure risks (Bohl et al., 2011). As the CT is one of the most common imaging tools used, these findings revealed how little people know about it. Patients who underestimate the radiation dose of CT exams, along with other medical imaging with radiation, may end up overusing it.

Several other researchers have emphasized how patients were oblivious to the risks involved in medical imaging with radiation, causing them to underestimate it. Lambertova et al. (2019) found that patients were more fearful of the results of a CT examination rather than the risks involved and that nearly half of their 315 participants were unaware of radiation risks in general. Lambertova et al. concluded that, as a whole, the information provided to patients regarding CT examination was lacking. Ghimire, Koirala, and Singh (2018) found that only 30.1% of the patients were aware of radiation exposure risks. Similar evidence was echoed in a study conducted by Steele, Jones, Clarke, Giordano, and Shoemaker (2016), who based their finding on an e-mail survey in which 5,462 patients participated. The questionnaire focused on measuring awareness among oncology patients on the risks and use of ionizing radiation in the context of imaging examinations for diagnosis (Steele et al., 2016). Steele et al. suggested that most caregivers and patients did not have a basic understanding of ionizing radiation used in the context of diagnostic imaging in oncology. Steele et al. noted the need to increase the education of caregivers and patients to improve the decision-making process among

patients. Patients appeared to be unaware of the general risks related to medical imaging with radiation.

Researchers also focused on the perceptions of patients to understand the information they would like to receive regarding imaging radiation risks. In their study, Ukkola et al. (2015) interviewed 147 patients between the ages of 18 and 85 following different radiological examinations. The questionnaire included both qualitative and quantitative questions (Ukkola et al., 2015). The results, reflecting the overall lack of awareness among participants from various studies in the existing literature, suggested that an overwhelming majority of patients (95%) wanted more information about the risk and dose of radiological examinations (Ukkola et al., 2015). This was especially true for African Americans and Asian American or Pacific Islanders based on Lind et al.'s (2019) findings. Thornton et al. (2015), whose participants were mostly European American, found that these patients desired information regarding medical radiation, such as which exams used ionizing radiation, the doses of each exam, and the risks involved in each exam, among others. Participants stated, however, that the providers often did not discuss these with them, and that they had trouble finding reliable sources for these types of information (Thornton et al., 2015). Although patients may be willing to learn more about radiation, they may not have the resources to do so. The lack of awareness among patients about medical imaging radiation risks has implications for their health. These findings provide a background to understanding the lack awareness of patients of medical imaging radiation.

Implications of the Lack of Awareness about Medical Radiation Imaging

Low levels of radiation risk awareness may translate into an overdose of medical radiation. Routine daily imaging of patients has little clinical use (Kleinpell et al., 2018). It is possible to eliminate unnecessary medical imaging procedures if the patient has an adequate amount of awareness about medical imaging procedures (Kleinpell et al., 2018). The lack of awareness among patients about medical imaging radiation risks has implications on their health, as they may not be able to make the best choices regarding radiation testing or treatment because of it. Patients are not informed by the providers about the risk of medical imaging radiation (Alhasan, Abdelrahman, Alewaidat, & Khader, 2015; Heyer et al., 2015; Ukkola et al., 2017**)**. The level of awareness of patients is affected by this lack of information.

It is also important to understand how often and why providers discuss radiation risks to their patients. Newman (2016) examined the reasons behind the lack of information provided by radiographers regarding CT-scan risks and found that only 63.16% of the participants disclosed the cancer-inducing risks of their CT scans "sometimes," and that none of them "always" disclosed this information. The factors behind their decisions to inform patients were a patient inquiry, perceived additional risk, and patient anxiety (Newman, 2016). Newman concluded that radiographers' passive approach in informing patients about CT risks might be detrimental to proper patient care. Guena et al. (2017) identified healthcare providers' lack of time as a factor in whether or not they discuss radiation risks with patients. This is especially true in the emergency department, where diagnosis and treatment have to be expedited (Ditkofsky et

al., 2016). Healthcare providers are known to have busy schedules, treating multiple patients and sometimes dealing with emergencies; hence their valuation of time may lead them to skip what they deem to be unnecessary steps (Guena et al., 2017). Healthcare providers might undervalue the discussion of radiation risks with patients.

Several factors affect the level of awareness among patients about medical imaging radiation exposure. The lack of information the patients were provided by their care providers about the risks associated with medical imaging radiation, along with how the patients' level of awareness about medical imaging radiation risks, is affected not only by their characteristics, such as education (Ahn et al., 2017; Al Ewaidat et al., 2018) but also by the knowledge and misconceptions of their providers (Guena et al., 2017). It is important to explore the complexities of sources these insights suggest about the influences that affect the awareness of patients about medical imaging radiation exposure.

Research Gap

As this literature review shows, there is a lack of communication between medical professionals and patients regarding the risks associated with medical imaging procedures (Alhasan et al., 2015; Heyer et al., 2015; Ukkola et al., 2017). The lack of communication between health professionals and patients results in the lack of awareness about medical imaging radiation risks among patients; further, it also increases the exposure of the patients to the risks of radiation associated with medical imaging procedures (Bohl et al., 2016; Guena et al., 2017; Singh et al., 2017). These deficiencies display the need for more studies, such as the present one, to understand the knowledge and perceptions of radiation risks by patients.

Many medical professionals were not aware of the adequate doses required for certain medical imaging procedures (Faggioni et al., 2017; Harris et al., 2019; Hobbs et al., 2018; Poullis et al., 2015). These medical professionals remain to be patients' primary source of information regarding medical imaging radiation (Talab et al., 2016). Due to the lack of awareness among medical professionals about the risks associated with medical imaging radiation, which affects the perception of the patients, along with the insight that low levels of radiation exposure from medical imaging procedures also affect the health of the patient, it is important to study the awareness of patients about such common medical imaging procedures.

Patients' awareness regarding medical radiation risks is a concern. The need to know the current state of awareness among patients about radiation from medical imaging procedures was noted by Zener et al. (2018). The purpose of the present study is to provide an understanding of the awareness levels of patients about the implications of the various medical imaging procedures. The information obtained in this study will help in the understanding of the current state of awareness among patients about radiation from medical imaging procedures.

As medical imaging with radiation may be necessary for some patients, it must be done discerningly and within the protocol. Despite numerous guidelines, there is no good measure of the risks of radiation associated with current-day imaging for an individual patient (Chandrashekhar et al., 2015). There is a need to further explore the awareness levels of patients on radiation exposure risks and the overall view of patients on medical imaging procedures and the radiation caused by these procedures. A knowledge gap

about radiation exposure from CT scans among the patients, as well as the medical staff, was also mentioned by Guena et al. (2017). Guena et al. summarized their suggestions to close this gap. It becomes important to study the awareness of patients about radiation from medical imaging procedures to contribute to filling this gap. The benefits of indicated medical imaging outweigh the relatively small excess cancer risk; however, for certain subsets of patients, radiation risk had to be of greater concern to the clinician (Zanzonico, 2016). To provide the information needed to balance the factors of risks and benefits, and also to contribute information for the clinician to make decisions while assessing the radiation risk for different subsets of patients, it is important to study the knowledge and views of patients and their awareness about radiation risks from medical imaging procedures.

Awareness may change the process of medical imaging. A set of protocols of radiation safety have been researched and reviewed in the past few years (Ahmed & Taha, 2017). To fulfill these protocols, it is important first to assess and then increase the level of knowledge that the patients possess about radiation risks from medical imaging procedures. The information that the present study will provide, and its implications, are aimed at the goal of filling the preceding gaps.

Summary and Conclusion

In this review, the awareness of radiation exposure risks from medical imaging procedures among different demographics was reviewed, along with the conceptual framework of the present study. The conceptual model for the study was the HBM. The basic concept of the HBM is the observation that health behavior is determined by

personal beliefs and perceptions about the disease as well as the available strategies to lessen its occurrence (Tarkang & Zotor, 2015). This made the HBM appropriate for the present study, as I explored the patients' awareness and knowledge of information regarding medically induced radiation exposure.

In the second section of this chapter, a general and historical overview of radiation and imaging was discussed. The level of awareness about medical imaging radiation risks among the general population was found to be poor. Hence, there is a need to explore awareness among patients about the effects of medical radiation imaging. In the third section of the literature review, the factors influencing the awareness of patients about radiation were discussed. The main factors were (a) education, (b) communication, (c) experience, and (d) cultural differences. The educational attainment of the patient as well as the attending physician and the potential referrers was the basis for the perceptions or knowledge of the patients about medical radiation. The discussion between patients and physicians about radiation also increased the awareness and knowledge of patients about medical radiation. Moreover, having an experienced physician or referrer may have positive influences on the perceptions and awareness of patients about medical radiation. Finally, the cultural difference has been a strong factor that may hinder the development of patients' awareness of medical imaging radiation risk.

In the succeeding sections, the focus of the discussion was on the level of awareness of different individuals in relation to the patient. The knowledge of medical professionals, who are one of the primary sources through whom patients attain their

knowledge about the risks associated with medical imaging radiation, provides information about the constructs related to patients' awareness of medical imaging radiation risks.

The insights about the awareness of medical professionals provide a way of understanding and analyzing the perception of the patients who either had undergone or were currently undergoing medical radiation exams that the present study will examine. The insights found from the present study will contribute more information about how the awareness of patients about medical imaging radiation risks is affected by the awareness of medical professionals. To understand the significance of this potential insight, it is important to first examine the current literature on the awareness of medical professionals about the risks associated with medical imaging radiation.

Many medical professionals were not aware of the adequate doses required for certain medical imaging procedures (Faggioni et al., 2017; Harris et al., 2019; Hobbs et al., 2018; Poullis et al., 2015). The lack of awareness among patients about medical imaging radiation risks has implications for their health. These findings provide a background to understanding the lack of awareness that patients have of medical imaging radiation. The final section of this chapter was focused on the gaps in the previous literature based on the literature about radiation risks from medical imaging procedures. Adequate information of the level of awareness among patients about the radiation risks from medical imaging procedures was necessary to do the following: properly include radiation risks in the consent discussion for interventional radiology procedures, to get a good measure of the risks of radiation associated with current-day imaging for an

individual patient, to fill the knowledge gap about radiation exposure from medical imaging among the patients, to balance the factors of risk and benefits as well as to contribute information for the clinician to make decisions while assessing the radiation risks for different subsets of patients, to design policies and educational materials that could address the need to educate patients and eliminate unnecessary medical imaging procedures, to make patients aware of these risks without needing to depend on the referrers, to construct a philosophy of radiation safety, and to implement the changes that result from higher awareness of patients about radiation risks from medical imaging procedures.

The contents of the next chapter include information about the methodological plan for the study. Given the problem and the identified gap in the literature, a qualitative case study was used to address the problem and the research gap about the level of awareness among patients about the radiation risks from medical imaging procedures. The next chapter will also provide descriptions of the role of the researcher; the participant selection process; instrumentation; procedures for recruitment, participation, data collection, and data analysis plan; and issues of trustworthiness.

Chapter 3: Research Method

Introduction

The purpose of this qualitative, case study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure based on the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina. A qualitative research design was used to conduct this study. In this chapter, the details regarding the methodology and research design are provided. The major sections of this chapter are (a) research design and rationale, (b) role of I, (c) methodology, (d) data analysis plan, (e) issues of trustworthiness, and (f) ethical procedures. This chapter will conclude with a summary of the research method used for this study.

Research Design and Rationale

There is little information known regarding patients' perceptions and knowledge regarding medical imaging radiation exposure, the associated terminologies used in the medical radiation field, accessibility to information regarding general and personal radiation information, and where this information is available. I explored patients' awareness and knowledge of information regarding medically induced radiation exposure based on the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in the Central North Carolina region of the United States. To address the problem and accomplish the purpose of this study, the following research questions were used:

RQ1: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive their susceptibility to medical radiation procedures?

RQ2: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the seriousness associated with medical radiation exposure?

RQ3: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the benefits of taking action associated with medical radiation exposure?

RQ4: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the barriers to taking action related to medical radiation exposure?

RQ5: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the cues to action associated with medical radiation exposure?

Research Design and Rationale

The research design that was chosen for this study was a qualitative case study. A qualitative methodology was appropriate for this study because it focuses on individuals' perceptions or experiences within the context of certain phenomenon related to culture, history, socioeconomic status, and community or organizational dynamics (Leedy & Ormrod, 2010; Merriam & Tisdell, 2015). For the current study, the phenomenon of interest was patients' knowledge regarding the implications for medically induced

radiation exposure. Unlike quantitative studies, qualitative studies permit the exploration or investigation of a particular phenomenon in depth within its uncontrolled environment (Merriam & Tisdell, 2015). Moreover, qualitative research offers its readers the advantage of gathering and presenting rich data, especially when data gathering is performed through interviews (Merriam & Tisdell, 2015).

A case study was the appropriate research design because it focuses on an in-depth exploration of the perceptions of participants using structured interviews. This description is similar to Yin's (2011) description of case study appropriateness. Researchers described the different purposes of other qualitative research designs (e.g., phenomenology, grounded theory, and narrative research; Achora & Matua, 2016; Lewis, 2015; Teherani, Martimianakis, Stenfors-Hayes, Wadhwa, & Varpio, 2015). However, the purposes for these designs were not aligned with the problem, purpose, and research questions for this study. A case study was the appropriate approach for this study because its purpose and research question format are focused on studying perceptions. Yin (2011) proposed four criteria in choosing a case study approach: (a) the study aims to answer "why" and "how" questions, (b) the researcher does not need to manipulate the behavior, decision, and attitude of the members of the groups being studied, (c) the researcher will explore contextual conditions as important aspects of the phenomenon under study, and (d) the phenomenon and context have unclear boundaries. Given these criteria, a case study was chosen as the most appropriate research design to be used.

Role of the Researcher

The role of the researcher in this exploratory qualitative inquiry was to be the central research instrument for data gathering and analysis by being the interviewer and analyst (see Råheim et al., 2016). As an instrument of data gathering, I conducted interviews with participants who had undergone or who were undergoing medical radiation exams. I made interpretations and analyzed the perceptions of these patients based on the different data sources to explore the phenomenon focused on in this study. To avoid any potential bias in being the interviewer, I used a semistructured interview guide. There were subquestions designed to help prompt more answers if the participants do not give adequate details. Moreover, before data collection, I identified their point of view and possible biases concerning the studied phenomenon.

To ensure that I remained unbiased during data gathering and analysis, I used bracketing with the concept of intellectual honesty to maintain the authenticity of the research. Bracketing was necessary to maintain the focus of the research and not interject personal opinions on the research process, especially the data collection and analysis portions of the process (Dempsey, Dowling, Larkin, & Murphy, 2016; Sorsa, Kiikkala, & Åstedt-Kurki, 2015). Moreover, with the interview guide, I was able to facilitate semistructured interviews and be flexible with the interview process while staying on track with the purpose of the study. Intellectual honesty, which requires that I avoid allowing personal beliefs to interfere with data collection and analysis, was the goal (see Keller et al., 2017). Information should not be purposefully omitted or altered; member checking helps to certify all data (Gunawan, 2015). This member checking was done by

sharing transcripts and initial interpretations with participants to ask for their feedback regarding the accuracy of transcription and interpretation.

Methodology

The target population in the study included patients who underwent or were currently undergoing medical radiation exams (e.g., CT scans, x-ray) in radiologic clinics and hospitals in central North Carolina. Individuals having the experiences needed to provide relevant information to address the problem and purpose of the study were included in the target population. The participants needed to have undergone medical radiation within the last 12 months to help ensure accurate recall.

Participant Selection Logic

The participants were recruited from Central North Carolina. Choosing this area limits the findings to this population. Providing complete documentation of the processes used in this study will make it easy for future researchers to conduct the same study with a different population or in a different area. There were several inclusion criteria for participation in this study. First, patients had to have undergone medical radiation exams (e.g., CT scans, x-rays) at least once to make sure that the participant was knowledgeable about the studied phenomenon. Second, patients had to have had the treatment within the past 12 months or were currently undergoing radiation treatment cycles. These criteria ensured the patient did not have a difficult time recalling the treatment experience. Finally, patients had to be at least 18-years-old because this is the minimum age that individuals can consent to participate in a study without the need to inform their parents (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012). Patients below 18-years-

old also cannot undergo medical imaging with radiation without parental consent; therefore, healthcare providers would need to discuss it with the parent instead of the patient. Those who were excluded from participation were those who fell within at least one of the following groups: (a) patients with difficulty in talking clearly, (b) patients who were 70-years-old or older, and (c) women who were pregnant at the time of the study. All of the participants in the sample fit the criteria above; hence, none were excluded from the study. The participants were screened for eligibility by asking interested participants for their contact information to discuss the inclusion and exclusion criteria before scheduling an interview. The screening questions are listed in Appendix B. Participation consideration required each recruit to answer this screening questionnaire.

The sample sizes for qualitative studies have ranged from five to 20 participants to be sufficient enough to achieve data saturation. Beck (2009) noted that the sample size should range from six to 25. Yin (2013) also claimed that increasing the sample size for case studies does not necessarily make for a more reliable and valid data set. Yin (2011) claimed that recruiting at least six individuals who had the relevant characteristics of the study is enough to achieve data saturation for some case studies. For this purpose, at most, 20 participants who fall within the boundaries of the inclusion and exclusion criteria for the study was the sample size chosen to conduct the current study properly.

Participant selection was made through purposive sampling. Etikan (2016) claimed that participants who are selected purposively are often more willing to participate and are more likely to contribute to the richness of the data for a given study.

Moreover, purposive sampling is a sampling technique commonly used for qualitative studies that focus on the inclusion and exclusion criteria for its sample (Etikan, 2016). Based on the research questions of this study, homogeneous purposive sampling was performed because the questions required the gathering of in-depth information from a group of the sample (Etikan, 2016). The homogeneous sample's common characteristics were based on the inclusion and exclusion criteria.

Potential participants were gained by distributing flyers in local hospitals and clinics to facilitate purposive sampling. Before conducting any form of recruitment, the approval of Walden University's Institutional Review Board (IRB) was obtained to allow recruitment from clinics and hospitals within the Central North Carolina area. Upon obtaining permission from the IRB, permission from the head of these local hospitals and clinics was also secured to confirm that they would allow flyer distribution within their facility. On the flyer, the purpose of the study was briefly described together with the inclusion and exclusion criteria provided. If the number of participants was still incomplete after 14 days from the beginning of the recruitment process, snowball sampling was also performed. Palinkas et al. (2015) claimed that using snowball sampling together with purposive sampling would help make recruitment more efficient. Existing participants were asked to recommend people they knew as potential participants of the study to conduct snowball sampling. In this manner, the network of participants would grow to achieve sufficient data saturation.

Those who wished to participate contacted me through the contact details provided on the flyers. Interested participants were contacted through phone calls to

inform them that they were formally invited to participate in the study. They were asked a series of screening questions to check for their eligibility to participate (Appendix B). Those who passed the eligibility screening were asked to provide their e-mail addresses. The participants received an invitation e-mail together with a copy of the informed consent form, which had information on the rights and responsibilities of the participants. The participants were to sign the consent form if they agreed with the information contained in the form. After receiving the signed informed consent form, the interested participants were contacted through phone calls to review the inclusion and exclusion criteria and to ask about their availability for partaking in the interview for the study. The schedule for the interview was then finalized.

Instrumentation

The main instrument used for this study was a semistructured interview guide. Using semistructured interviews allowed for flexibility in the manner of interviewing, which meant that as the interviewer, I was able to ask follow-up questions provided that they aligned with and were relevant to the questions in the interview guide (see Merriam & Tisdell, 2015). Through this data collection method, I was able to gather accurate and in-depth data from participants. Moreover, using interviews for data collection, I collected useful information that described the actions and perceptions of participants in a contextual environment (see Merriam & Tisdell, 2015).

Face-to-face interviews could have affected the results of the study, especially if the presence of the interviewer discomforted the participants. To address this problem, I made the atmosphere of the interview calming and comfortable. Also, I avoided

intimidating the participants with any overly formal interview questions by keeping the tone friendly and conversational.

I used the interview guide as the basis for the questions that were asked. The contents of the interview guide included questions that directly addressed the research questions. The semistructured interview guide (see Appendix A) was based on information gathered from the literature. The interview guide questions were reviewed for purposes of technical validation with the help of field expertise. I asked the expert for technical validation regarding how the interview questions were written, worded, and framed. I also made sure that the questions were written in the correct structure and with proper wording.

Data Collection

There was one data source for the study: semistructured interviews. The data were gathered from the interviews of 20 previously screened participants. I conducted interviews for data collection at a predetermined time and place. The chosen location for the interviews was an area at a public library or another public place with private room access that provided a quiet, comfortable, and neutral place to conduct the interviews.

Semistructured Interviews

Before beginning the interview, I greeted the participant, reviewed the informed consent form, and had the form signed by the participant. The participants were allowed to ask questions before signing the informed consent form. There was a brief discussion of the flow of the interview session. I also presented examples of the questions that I would ask them to give them an idea of what to expect.

Each interview was audio-recorded, which was made known to the participants through the informed consent form. Each of the research questions had at least one corresponding interview question in the interview guide (see Appendix A). The corresponding interview questions were used to address and answer the different research questions.

The interview guide directed the interview; the guide contained individual and topic-based questions to address the research questions of the study. Using this flexible framework enabled me to explore the topic at hand by asking the same questions in whatever order seemed appropriate for each participant. Each interview was expected to last for about 30 minutes. This timeframe varied slightly depending on the flow of the conversation between the interviewer and each participant.

To end each interview session, I informed the participant that there were no more questions. I then asked the participant if he or she had any questions for clarification or any suggestions. This questioning provided a time for participants to discuss the questions and any concerns they may have had. For instance, when a participant realized that he or she may have been exposed to a large amount of radiation and became concerned, I referred him or her to a specialist. This specialist could run tests to determine any implications of radiation exposure for the patient. Once there were no longer any questions, I formally ended the interview by thanking the participant and reminding him or her of the process of member checking. I also reminded the participant that member checking would happen in the next 7 days.

Data Analysis Plan

Data were analyzed using Yin's (2011) five-phased cycle for analyzing case studies. However, before actual analysis through the five phases, data were first organized and prepared for analysis.

Data Preparation

Transcripts were generated for each interview. I transcribed all the interviews. In each transcript, each participant was assigned a unique code or pseudonym to protect his or her identity. To ensure the credibility of the transcript, I also performed member checking. In this process, I allowed the participants to review their transcripts for accuracy. The intended meanings of the statements were also relayed to the participants through member checking (see Gunawan, 2015) so that participants could validate or correct the initial interpretations. The participants had the opportunity to clarify and discuss any mismatch between their understanding and the intended meaning. Finally, I asked the participants if there was any clarification that was needed.

If a participant was not available to review his or her transcript within 1 week from the interview date, then his or her transcript was deemed accurate with no need for revision. This review was made available to all participants, but it was not a prerequisite for being included in the data analysis. All nonreviewed transcripts were considered correct and accurate.

Five-Phased Case Study Analysis

Transcripts were loaded into the NVivo software to begin the data analysis through Yin's (2011) five-phased analysis for case studies. The five phases of analysis

were (a) compiling, (b) disassembling, (c) reassembling (and arraying), (d) interpreting, and (e) concluding. Analysis began by compiling and sorting (to put in order) the transcripts generated from the interviews. The second phase, which was disassembling, required breaking down the data into smaller, more easily coded fragments. Disassembling included the assignment of new labels or codes to the smaller fragments.

Disassembling was repeated many times as part of a trial-and-error process for testing codes (Yin, 2011). The third phase, which was reassembling, involved using substantive themes (or even codes or clusters of codes) to reorganize the disassembled fragments into different groupings and sequences (Yin, 2011). During this phase, I used the HBM as a guide in the assembling and disassembling of data. I used this model when coming up with an assembled set of fragments of information that were aligned with the concepts of the health belief framework. I reassembled and disassembled phases in an alternating manner (Yin, 2011). The fourth phase involved using the reassembled material to create a new narrative; hence, interpretation occurred in this phase. I related the discussion or narrative to the HBM. After coming up with interpretations, conclusions were derived in the fifth phase (Yin. 2011).

Issues of Trustworthiness

Credibility

In line with the credibility of the data collected, member checking (Gunawan, 2015) was performed for verification of the accuracy of transcripts as reviewed by the participants. I also shared interpretations and conclusions with participants to gather their feedback and impressions throughout data collection and analysis. Ensuring that the

transcripts were accurate, based on the review from the participants, was especially important. The findings of this study were validated with the participants.

Transferability

Transferability entails the ability to transfer the study findings to another population different from the one used by the researcher of the original study (Noble & Smith, 2015). Transferability was achieved by providing in-depth and detailed descriptions of the phenomena under investigation to allow readers to have a proper understanding of the study. A study that has transferability is one that allows comparison. This comparison helps to determine if the findings are transferrable to other studies (Noble & Smith, 2015). I collected and presented detailed descriptive data along with the direct answers from participants. All data collected were kept in their original form to prevent distortion.

Dependability

Dependability was also an objective of the data collection and analysis for this study. For dependability, the research methods, contexts, and participant information were given in detail. This will assist future researchers in repeating the work and assessing the extent to which appropriate research practices were followed.

Ethical Procedures

To obtain approval for the qualitative case study, I submitted an ethics application to Walden University. The approval from the university's IRB required the explanation of the research objective, questions, and process as well as consent from the participants. Upon obtaining the required approval, I conducted the interviews.

Confidentiality must be addressed when human participants are part of the research process. Participants' anonymity was ensured with the deletion of any personally identifiable information and by using pseudonyms in place of any identifying information that was deleted. In all cases, data were reported either in the aggregate or using these pseudonyms. This information regarding confidentiality was included in the informed consent form.

Participation in the study was entirely voluntary, and participants were provided with informed consent material before beginning the interview process. This information was also included in the informed consent form. There were no added benefits or consequences incurred for participating in the study. Even if participants had already consented to participate, they still had the option to discontinue their participation in the study at any time without incurring any consequences on their part.

All data related to the study, including electronic files, the recorded interviews, and the interview transcripts, were all kept inside my home in a water and fire-proof safe in my private office. All electronic files were password-protected on my personal computer. The physical data forms, such as data sheets and printed transcripts, were kept in secured storage space, to which only I have access. Only myself, my dissertation chair, and my dissertation committee members were able to review the interview data. The files will be kept in a private safe in my home office for 5 years after the study concludes, and then the files will be destroyed. The data will be destroyed by burning and shredding physical documentation and by permanently deleting any data existing on any computer devices.

Summary

A qualitative case study approach was used to address the purpose of this study. This approach was the most appropriate research design because it aligned with the purpose and research question requirements of the study (Yin, 2011). Data were gathered through semistructured interviews conducted with a total of 20 participants. The interview participants were patients who either underwent at least one procedure that used medical radiation within the past 12 months or who were currently undergoing radiation treatment. Data were analyzed using Yin's (2011) prescribed a five-phased analysis for case studies. Member checking (Gunawan, 2015) was performed for the credibility of the data.

Chapter 4 includes the results of the study.

Chapter 4: Results

Introduction

Chapter 4 of this qualitative case study contains the results from having analyzed the 20 participant interviews. The purpose of this study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina. I employed Yin's (2011) five-phased analysis for case studies to analyze the 20 interview transcripts. I used NVivo12 by QSR to systematically code and tabulate the themes of the study. The following research questions were used to guide this study:

RQ1: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive their susceptibility to medical radiation procedures?

RQ2: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the seriousness associated with medical radiation exposure?

RQ3: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the benefits of taking action associated with medical radiation exposure?

RQ4: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the barriers to taking action related to medical radiation exposure?

RQ5: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the cues to action associated with medical radiation exposure?

This chapter contains a review of many result areas that were vital to obtaining quality results. There is a discussion of the data collection setting, the participants' demographics, a brief explanation of the data collection performed, and an explanation of the data analysis applied. This discussion continues with a review of steps performed to ensure the trustworthiness of the study. This discussion is an extensive presentation of themes found and verbatim responses from participants; I include a summary of the results to conclude the chapter.

Setting

I asked the participants to choose their most convenient time and place for the interviews. The chosen locations were a public library and other public areas that had access to a private room. Private rooms were secured to achieve a quiet and comfortable environment during the interview. The environment of the interviews was crucial, as I hoped to make the participants feel safe and relaxed during the interview sessions. This strategy was used to encourage their full participation and address the questions as honestly and thoroughly as possible.

Demographics

Interviewees totaled 20 participants. Recruited participants were from the Central North Carolina are who met criteria. First, the patients must have undergone medical radiation exams (e.g., CT scans, x-ray) at least once to ensure that the participant was

knowledgeable about the studied phenomenon. Second, patients had to have had medical radiation treatment within the past 12 months or were currently undergoing radiation treatment. These criteria were to ensure that the patient will not have a difficult time recalling the treatment experience. Finally, patients had to be at least 18-years-old. Table 1 contains the numbers assigned to each participant and lists the type of medical radiation exam they had.

Table 1

Participant Information

Participant Number	Type of Medical Radiation Exposed to
Participant 1	CT scan, MRI, and x-ray
Participant 2	CT scan
Participant 3	CT scan, MRI, and x-ray
Participant 4	CT scan and x-ray
Participant 5	X-ray
Participant 6	CT scan and x-ray
Participant 7	CT scan, MRI, and x-ray
Participant 8	CT scan, MRI, and x-ray
Participant 9	CT scan and MRI
Participant 10	CT scan, MRI, and x-ray
Participant 11	CT scan, MRI, and x-ray
Participant 12	CT scan and MRI
Participant 13	MRI
Participant 14	CT scan and x-ray
Participant 15	CT scan, MRI, and x-ray
Participant 16	CT scan, MRI, and x-ray
Participant 17	CT scan, MRI, and x-ray
Participant 18	CT scan, MRI, and x-ray
Participant 19	CT scan, MRI, and x-ray
Participant 20	CT scan, MRI, and x-ray

Data Collection

I conducted semistructured interviews with 20 participants. These participants were selected purposefully, and participation selection stopped as I reached data saturation. Before the formal interviews commenced, I oriented the participants to the purpose and parameters of the study, and then I informed them of their rights as volunteer participants. I also presented informed consent forms to the participants. I assured the participants that codes would be assigned to them to ensure their privacy and that exposing their identity would not happen in any way. Participants felt at ease with the setting, and then interviews were conducted smoothly. Interviews were audio-recorded, and each interview lasted about 30 minutes. Ultimately, all discussions went as scheduled. I did not encounter any issues during the interview sessions.

Data Analysis

I used Yin's (2011) five-phased cycle for analyzing case studies. The five phases consisted of the following: (a) compiling, (b) disassembling, (c) reassembling (and arraying), (d) interpreting, and (e) concluding. The generation of 23 themes occurred in the current study, all addressing the five research questions outlined previously.

I started the data analysis by managing and organizing all interview transcripts; during this step, I read and reread all 20 interview transcripts. The second phase required me to disassemble and breakdown the interview content into smaller and more targeted codes. The codes I created were closely related to the research questions of the study; simple descriptions were also provided to guide me in coding the interviews. As each

interview was analyzed, I revised the codes according to the meanings shared by the participants.

In the third phase of data analysis, I continued to reassemble the codes from the previous stage. This reassembling was done to ensure that all codes were relevant to the subject of the study. Upon confirming the significance of the codes, I assigned the final names to the themes. The fourth step involved the creation of meanings and interpretations of the final themes. I employed the NVivo12 by QSR software to systematically code the initial themes and finalize them based on the number of times that the participants mentioned them. The software was critical in methodologically determining essential themes and finding other discrepant cases within the analyzed data. The final step of this analysis, the conclusion of data, is discussed in the next sections of the study.

Tagged themes that had the greatest number of references were the major themes of the study and the most significant findings per research question. Themes with fewer references were considered as the minor themes of the study or the other vital perceptions and experiences shared by the participants. Only the themes with more than 20% of the participants' references are thoroughly discussed. Themes providing less than 20% of the participants' responses were deemed as the discrepant or nonconfirming cases. These discrepant cases have been presented in their respective tables and may need further research to solidify the trustworthiness of any findings related to them.

Evidence of Trustworthiness

I followed Lincoln and Guba's (1985) suggested techniques to increase the trustworthiness of the data. The following techniques outlined by Lincoln and Gupta were used: (a) credibility, (b) dependability, (c) transferability, and (d) confirmability. Polit and Beck (2013) described credibility as the researcher's "confidence in the truth of the data and interpretations of them" (p. 492). I selected and analyzed the most significant findings from the participants' interviews that supported the generated themes.

Another strategy employed was to perform member checks (Gunawan, 2015) on the participants to ensure that their responses were accurate and truthful. Lincoln and Guba's (1985) second technique was to address the dependability of the data. According to Polit and Beck (2013), data must withstand the ever-changing conditions of study and practice. To address this concern, I discussed the processes employed to complete the study. Also, I created a journal to keep track of their actions and decisions throughout the research study.

The third technique used was the transferability of the study, which was described by Polit and Beck (2013) as the "extent to which transferring the findings to other settings or groups" (p. 493). I worked to discuss all findings with thorough descriptions. This technique could assist future researchers in understanding the formed themes and why they were deemed relevant to a greater audience.

Last, I established the confirmability of data. This confirmability was described as the degree to which the data weres actual representations of the participants' perceptions and experiences and not from the researcher's thoughts and imagination (see

Polit & Beck, 2013, p. 492). I then regularly reviewed the themes within the interview transcripts to match the extracted meanings.

Results

Perceptions on Susceptibility to Medical Radiation Procedures

In the first research question, I explored the susceptibility of the participants in medical radiation procedures. Based on the analysis results, the participants had different perceptions of their vulnerability to medical radiation procedures. Seven of the participants indicated that there would be increased harmful effects for those exposed continuously. Another seven participants added how there should be limited risk exposure with the help of having obtained more knowledge and skills to protect themselves. Other minor themes emerged from the data analysis. These minor themes, which had fewer references, were (a) having no fear or concerns on radiation exposure and (b) lacking knowledge on radiation exposure limitations. Table 2 contains the themes that addressed the first research question of the study.

Table 2

Themes Addressing Research Question 1

Major/ Minor Themes	Other Themes or Discrepant Cases	Number of References	Percentage of References
Having increased harmful effects for those constantly exposed		7	35%
Having limited harmful effects with the proper knowledge and skills to protect themselves from medical radiation exposure		7	35%
Having no fear or concerns about radiation exposure		4	20%
	Lacking knowledge of radiation exposure limitations	2	10%

Minor Theme 1: Increased harmful effects for those exposed continuously.

The first minor theme under the first research question discussed the probability of increased harmful effects for those who are regularly exposed to medical radiation, as shared by seven of the 20 participants (35%). Participant 3 discussed how more exposed individuals, especially those who work in the field of radiology, are faced with more risks. This participant commented, "Because you have seven different kinds of background radiation in the atmosphere and so you can have that daily, but the people that work in it are exposed to more being in the field."

Participant 4 emphasized the belief that increased radiation is harmful to patients and individuals. Participant 4 stated that "I believe it can just because it is radiation and

too much of it can harm you." Participant 5 added how long periods of exposure could also lead to long-term and more harmful effects on individuals. The participant highlighted,

> Long term, large scale, it could be radiation poisoning, which I know about. It can lead to cancer. It can lead to basically dumbing down all your cells, and making it easier for you to be more susceptible to cancer. I know that.

Additionally, Participant 8 stated that medical radiation could bring harmful effects to a person's body and can be dangerous with increased exposure. Participant 8 said, "I certainly do. I think because it is foreign to our bodies to be able to process. So yeah, I do think it can be dangerous." Participant 9 echoed the previous participants, saying, "I mean, I am assuming that it would if you have it often, but I mean if you are doing it for a medical reason, then I do not think that is the case."

Participant 15 commented that the effects vary on the individual's condition and case, stating that the effects vary "I think probably under certain circumstances." Finally, Participant 18 believed that patients and individuals must be aware of the effects of medical radiation exposure to their bodies. The participant highlighted how individuals must be proactive and should choose not to expose themselves unless significantly called for or needed, saying:

> I do personally; I do not think that you should be having it a lot unless it is necessary. Many people have them done yearly or whatever it can help, but I feel like it is also not the best for you. I feel like it can contribute to cancer and all that stuff. Like I don't I mean even outside walking outside you're going to get

> radiation, but I feel like you shouldn't be adding to it unless it's necessary. I mean the radiation in and of itself is not good for your body, but I feel like it can cause more harm than good.

Minor Theme 2: Proper knowledge to protect from medical radiation exposure. The second minor theme of the study included the six participants' belief that harmful effects can be limited with the individuals' proper knowledge and skills to protect themselves from exposure. Another seven participants highlighted how their susceptibility to the adverse effects of exposure to medical radiation could be reduced. They could accomplish this with the proper knowledge and skills to keep themselves safe and protected. Participant 1 stated that understanding of how to defend against medical radiation exposure and its effects is the number one solution to the issue. Participant 1 indicated that training has continuously helped them limit exposure to medical radiation, saying:

> Not if it's done correctly. Because being trained in it, I know that you shield, distance, time. That's all related to the amount of radiation that is given to you at a certain time. You shouldn't get unnecessary exams. You should be informed about what the doctors are looking for and why they want the exam.

Participant 2 added how susceptibility is limited, given a lack of exposure to medical radiation. For this participant, the risks were controllable, given the lack of exposure. However, the participant was also concerned about patients' wellness and added that they would inform them as needed:

> It's very limited. None. That's redundant because I answered that. As I said, I'm not exposed to it. And I do read, I'm very detailed when I read things as far as the insurance company, looking at details, looking at the documentation. So, I don't feel like it's the risk there for me. If it were for the patients, I would let them know.

Participant 6's mother's knowledge allowed him or her to understand the seriousness of the issue. This participant explained how his or her mother had always talked about the risks of medical radiation exposure, which made the participant cautious and alerted regarding potential exposure. Participant 6 provided several examples, saying:

> I feel like just from being very young, you're always told that radiation is very bad for you, and they have all those warnings and everything. And then, my mom being in the field has affected the way I view it. So, I'm very cautious whenever I go into, even the dentist. When they ask to take x-rays, I usually decline unless it's been like 4 years and I need to get it done. But other than that, I'm very aware of going into an x-ray or any radiation.

Participant 13 said, "Not if it's performed correctly." Participant 14 added that the risks are not alarming if the exposure is not constant or if it is limited. Participant 14 stated, "I would say, as long as you're not subject to it for a long period, I guess just for whatever the purpose is." Participant 17 argued that the risks should not be an issue if the exposure is controlled or limited. Participant 17 stated the following:

> It doesn't matter to me because we weren't exposed to it enough for it to be an issue. We worked in the lead-lined room for CT, that sort of stuff. So, we didn't have to worry about it outside of where the machine was, and we didn't go in when the machine was running. So, like here, we have our radiation department downstairs. We don't worry about that because all of that's enclosed. So, I would say, no, it doesn't pose a threat. It could if it was not properly contained, I'm sure. But we don't have to worry about it here.

Minor Theme 3: Having no fear or concerns about radiation exposure. The third minor theme of the study was the finding that four participants did not express their fear over the risks of being exposed to medical radiation. Four participants indicated that radiation is always present and is unavoidable. Participant 7 stated that "From the information, I've been given, no… As I said, it's a less significant amount of radiation than just walking around on the Earth all the time." Participant 16 also shared how people overreact with the issue of medical radiation exposure. The participant indicated that

> Because people make too much out of it. They think they get one x-ray, and you know, "Oh, my God, I've got, but they don't realize they're laying out it the sun, or they're flying from here to you, where they still get radiation.

Seven of the participants believed that more exposure leads to more damaging and harmful effects. Participants indicated how individuals who are unable to avoid exposure must be more mindful and careful about their health. Some examples of the illnesses they believed would develop included cancer and other critical illnesses.

Another seven participants added how proper knowledge and awareness could be the key to protecting themselves from the damaging effects of radiation exposure. Four participants believed that individuals must not be alarmed about the impact of medical radiation exposure. A discrepant case that generated was the lack of knowledge on radiation exposure limitations, which was stated by two participants. There is a need for more in-depth research to explore it further and increase the trustworthiness of this finding.

Perceptions of the Seriousness Associated with Medical Radiation Exposure

The second research question of the study contained the discussion of the participants' perceptions of the seriousness associated with medical radiation exposure. The majority, or 60%, of the participants were aware that being exposed to medical radiation could to lead to more serious medical concerns if not managed or controlled (e.g., cancer, cell destruction). Three other minor themes emerged as well; these themes had fewer references than the first major theme. The other interviewed participants also reported the following beliefs: (a) having no fear or concerns on medical radiation exposure effects (lack of exposure), (b) looking at the risks versus benefits for the patient or individual, and (c) lacking knowledge and understanding of the medical exposure risks. Table 3 displays the themes in response to the second research question of the study.

Table 3

Themes Addressing Research Question 2

Major/ Minor Themes	Other Themes or Discrepant Cases	Number of References	Percentage of References
Tending to lead to more serious medical concerns if not managed or controlled (cancer, cell destruction, etc.)		12	60%
Having no fear or concerns on medical radiation exposure effects (lack of exposure)		5	25%
	Lacking knowledge and understanding of the medical exposure risks	3	15%
	Looking at the risks versus benefits for the patient or individual	2	10%

Major Theme 1: Serious medical concerns if not managed or controlled. The first major theme of the study was that the participants' belief that there was a tendency for the exposure to lead to more serious medical concerns if not managed or controlled. Twelve participants, or 60% of the participants, discussed how too much exposure to radiation might develop other, more severe health concerns for the individuals or patients. Participant 1 explained how too much radiation might produce adverse effects on the body of the individuals, saying,

> Too much radiation, that's if you receive a certain amount of radiation within a certain time, you could develop cataracts. That's known. Other stuff, it's just a lottery. It's just; however, much radiation you get could or could not produce certain effects in your body.

Participant 5 echoed Participant 1's statement. Participant 5 stated, "Those are very serious, but I don't think if it's not like you're coming in here every day and getting an x-ray every day, that's going to make a big difference in your health." Additionally, Participant 6 discussed how cancer is a concern for most individuals, especially those with a background or history of cancer in their families: "Cancer, which is very serious. I've had cancer in my family, so avoiding any potential to get that from an outside source is very serious." Similarly, Participant 7 added that "Radiation causes cancer and cell destruction, so I don't think it's super serious, but there's always a chance."

Participant 8 noted the direct relationship of cancer to the amount of exposure to medical radiation. Participant 8 stated that "I would probably say maybe cancer, and the risk depending on how often you were around it, 25%." Participant 9 shared another similar concern and stated, "Well, I mean, from what I've been told you can get cancer from being around too much radiation, so that would be the only thing I would be concerned about." Participant 11 had a slightly different perception but also emphasized the factor of the amount of exposure leading to the development of some sicknesses. The participant said the following:

> I think it all depends on how much you get. I know radiation can cause some sickness. Again, I probably should know more than I do, but I don't know what

> radiation can do to you. What significant amounts or even small amounts of radiation can do to you? I know if you're pregnant I want to do anything I can to protect the baby, and because I don't know how it all works, I want to do whatever to protect that.

Participant 14 emphasized the probability of developing cancer: “I would say probably cancer…Very serious.” Participant 15 then affirmed the previous participants’ beliefs, stating: “I think too much radiation can cause damage to your body, cancer maybe.”

Minor Theme 1: Having no fear about medical radiation exposure effects. The first minor theme of the study was the theme of having no fear or concerns on medical radiation exposure effects; this was mainly due to the lack of the participants' exposure. Five of the participants shared that they were not personally alarmed due to their lack of exposure as compared to other patients or individuals. Participant 2 commented, "I'm not exposed to it." Also, Participant 10 explained, "To me, personally? I don't think it's any radiation risk to me at all, because I'm not around it enough to be concerned."

For the majority of the participants, there was a tendency to lead to more serious medical concerns if the exposure was not managed or controlled. The examples given were the development of cancer and even cell destruction. Meanwhile, five participants did not believe that they should be alarmed or concerned given their lack of exposure to medical radiation. Identified were two discrepant cases under the second research question. The discrepant cases were (a) lacking knowledge and understanding of the medical exposure risks and (b) looking at the risks versus benefits for the patient or

individual. Performing more research or exploration to confirm or refute the cases must be done.

Perceptions of the Benefits of Taking Action and Medical Radiation Exposure

In the third research question of the study, I focused on the perceived benefits of the participants in taking action associated with medical radiation exposure. For the majority of the participants, 16 of the 20 participants (80%), the critical advantage of taking action related to medical radiation exposure was the opportunity to protect oneself from potentially harmful effects of medical radiation exposure. The analysis uncovered two other minor themes. These minor themes were (a) lacking an overall knowledge of medical radiation exposure and (b) having no fear or concerns on medical radiation exposure effects (lack of exposure). Table 4 contains the breakdown of the themes addressing the third research question of the study.

Table 4

Themes Addressing Research Question 3

Major/ Minor Themes	Other Themes or Discrepant Cases	Number of References	Percentage of References
Being more proactive to protect oneself from potentially harmful effects of medical radiation exposure		16	80%
	Lacking an overall understanding of medical radiation exposure	3	15%
	Having no fear or concerns on medical radiation exposure effects (lack of exposure)	2	10%

Major Theme 2: Proactive to protect from medical radiation exposure. The second major theme of the study was the benefit of being more proactive, allowing individuals or patients to protect themselves from the possible harmful effects of medical radiation exposure. The study participants believed that taking action may lead to a healthier and safer future for individuals or patients.

Participant 1 commented on the importance of taking action to prevent medical radiation exposure, saying to "Lead a healthier lifestyle." Participant 2 also shared their perception and noted that "I mean I would want to know if I'm exposed to something that's going to harm me today, tomorrow or future." Similarly, Participant 3 highlighted

the need to be an active defender of the own body and stated, “Because you need to be an advocate of your own body and make sure that you know what is being done and what could be done unnecessarily.”

Participant 4 stated, “I don't know. I don't know. Well, I don't know that I could, depending on what the issue is and if that's going to help to make me better diagnosing it.” Participant 5 emphasized why patients and individuals must be aware of the effects of medical radiation exposure, as this may indeed be damaging to their health. Participant 5 explained,

> Because it could be detrimental to health. So, you should be informed of what the actual risks are, and whether or not you want to risk that. But I mean if it's not long term there are not that many risks. But you should know in general anyway. Just not being interested.

Participant 7 stated that “Yes, I think it is important to. Everybody should always know the risk of what they're getting into.” For Participant 10, being proactive and acting against medical radiation exposure is even more significant, especially if a person is regularly exposed to it. Participant 10 stated that “I think it's important because those that are concerned and those that are working with it every day need to know if they've been exposed too much to it.”

Participant 14 argued that each person must be well-informed and knowledgeable about the things or factors that may negatively affect their bodies. Participant 14 stated, “Like before; you need to know what's being done to your body. You need to know what kind of chemicals you're being exposed to.” Participant 16 shared the value of keeping

the patients informed as well, suggesting, "To give knowledge to the patient so they will not be afraid." Participant 18 expressed the need to be proactive in taking action to have the proper knowledge of the risks and outcomes of their exposure. Participant 18 stated,

> Being proactive about knowing your risks before you go in and kind of educating yourself and making sure that you know all possible outcomes, and it's even necessary for you yourself, and if like I said if they are not using what they should be using or if you are familiar with the process how should you see someone doing it wrong I would definitely speak up, and you know.

Participant 20 indicated that "I'd probably take the initiative to do more research on my own, yeah."

The majority of the participants articulated that individuals must be more proactive to protect themselves from the potentially harmful effects of medical radiation exposure. These participants had developed a clearer understanding of the importance of knowledge and awareness on the damaging effects of medical radiation exposure.

I uncovered two discrepant cases in the data analysis. These discrepant cases were (a) lacking an overall understanding of medical radiation exposure and (b) having no fear or concerns on medical radiation exposure effects (lack of exposure). Similar to other cases, more research is recommended to solidify the trustworthiness of these results.

Perceptions of the Barriers to Taking Action to Medical Radiation Exposure

In the fourth research question of the study, I explored the perceptions of the participants on the barriers to taking action related to medical radiation exposure. For the

majority of the participants (65%), there were no barriers to taking concrete actions to fight or limit medical radiation exposure. Six other minor themes emerged regarding the other perceived barriers for the participants, but these minor themes had few references. The small number of references from the participants may require further research to increase the trustworthiness of these minor themes. Table 5 contains the themes in response to the fourth research question of the study.

Table 5

Themes Addressing Research Question 4

Major/ Minor Themes	Other Themes or Discrepant Cases	Number of References	Percentage of References
No barriers perceived		13	65%
Lacking accurate information and knowledge about medical radiation exposure		4	20%
	Considering the age of the person, individual, or patient	2	10%
	Lacking one's interest and willingness to learn about medical radiation exposure	1	5%
	Requiring patients to undergo medical examinations	1	5%
	Needing to access the results of the medical devices concerned	1	5%
	Having a fear of taking action and learning more about medical radiation exposure	1	5%

Major Theme 3: No barriers perceived. For 13 of the 20 participants, there were no perceived barriers if and when they decided to take action in association with medical radiation exposure. Participants 2, 10, 11, 14, 15, 17, 19, and 20 answered "no" when asked about the factors that may hinder them from taking action. Participant 4 shared that with proper research and education, barriers would not exist. Participant 4 stated, "I don't think there are any barriers if you want to research it." Participant 9 had the same perception as Participant 4, saying "No. No. Not at all. I mean, you've got access to the internet and, of course, people that I work with that would be beneficial in getting that information."

Participant 16 focused on the value of information and education for eliminating the barriers as individuals take action related to medical radiation exposure:

> No. I like to read. I like knowledge. It shouldn't be a barrier to it. The knowledge is out there. As long as it's the correct knowledge or you're talking to a person or a... Let's say you've gone through a class or you're on the [inaudible 00:06:14]. Where is this from? Is it reliable information?

Minor Theme 1: Lacking accurate information about medical radiation exposure. The first minor theme that followed from this research question was the lack of accurate information and knowledge about medical radiation exposure as one of the chief barriers, as shared by four participants. Four participants discussed how the lack of familiarity with medical radiation exposure affected the willingness and urgency of the individuals to take actions that would address the possible effects of the exposure.

Participant 1 commented on the presence of misconceptions and misrepresentations about the subject. Participant 1 stated, “I think there's a lot of misinformation out there, so be sure what you're reading and what you're subjecting yourself to, you've done the proper research of it.” Participant 12 addressed the need for more credible research studies discussing facts about medical radiation exposure, stating the following:

> I think it would be the type of research. How can you become knowledgeable with the long-lasting or long-term effects of that and everything, but the internet is not always correct? I don't think its false information. I think its broad information that tends to make your mind wander, and then you start to diagnose yourself. When I go in, and I read, I try to be very open-minded and say, "Okay, this is how this is," but that's not everybody. Now somebody could read it and say, "Oh my goodness. I have cancer because I just had an MRI, or a CT scan, or an x-ray yesterday, and I've had it every six months.

For the majority of the participants, there were no barriers present. This feeling was as long as the individuals were willing and open to exerting time and effort to increase their knowledge of the effects and impact of medical radiation exposure. One minor theme that followed was the belief that there was a lack of accurate information and knowledge about the issue of medical radiation exposure.

Under the fourth research question, five discrepant cases emerged. These discrepant cases were (a) considering the age of the patient, (b) lacking interest and willingness to learn about radiation exposure, (c) requiring patients to undergo medical

examinations, (d) needing to access the results of the medical devices concerned, and (e) having the fear of taking action and learning more about medical radiation exposure. The broad perceptions of the participants were deemed as discrepant cases given the number of times they were referenced during the study. Therefore, more research is suggested to explore the circumstances as mentioned above.

Perceptions of the Cues to Action Associated with Medical Radiation Exposure

In the fifth research question of the study, I centered on the participants' cues to action associated with medical radiation exposure. Eight participants, 40% of the participants, noted that having the proper information and resources available to educate themselves would allow them to take action with medical radiation exposure. Four other minor themes emerged as well. These minor themes were (a) being more careful with their bodies to avoid examinations with medical radiation exposure, (b) hearing reports about individuals getting ill from medical radiation exposure, (c) having a key individual taking the initiative to learn more about with medical radiation exposure, and (d) lacking knowledge about medical radiation exposure in general. Table 6 contains the breakdown of the themes addressing the final research question.

Table 6

Themes Addressing Research Question 5

Major/ Minor Themes	Other Themes or Discrepant Cases	Number of References	Percentage of References
Having the proper information and resources to educate oneself and take action with medical radiation exposure		8	40%
Being more careful with their bodies to avoid examinations with medical radiation exposure		7	35%
Hearing reports about individuals getting ill from medical radiation exposure		6	30%
	Having a key individual taking the initiative to learn more about medical radiation exposure	2	10%
	Lacking knowledge about medical radiation exposure in general	1	5%

Minor Theme 1: Having the proper information to take action with medical radiation exposure. The first minor theme that emerged from the analysis of the interviews was the finding that proper information and resources to become educated and take action could permit the participants to address the issues surrounding medical radiation exposure. Participant 1 suggested visiting trusted facilities to ensure that the

providers were well-equipped at protecting and safeguarding the wellness of their patients.

Participant 1 said, “Make sure you go to a licensed and registered facility so that they are, that the people doing the exams do have the qualifications to do those exams that you're going to be getting.” Participant 3 echoed Participant 1’s perception and highlighted the importance of education in encouraging individuals and patients to take concrete and practical actions, saying:

> Find the best possible staff members, the best possible location to have them done, the most up-and-coming facility that had the newest equipment, better training. It would depend on the research to see if anything is a cause and effect from having it done later because things are still evolving all the time, but just being aware. You could write into your legislature and ask for more rules and regulations for the radiation protection in the state.

Participant 6 discussed how education could be the key indicator. Individuals and patients could start looking into the issue and search for the best ways to limit and protect themselves from medical radiation exposure. The participant added how education is the key solution and answer to the misrepresentations around the issue. Participant 6 stated,

> I guess, just like you said, researching it before you go into it. I don't know. As I said, I'm super cautious about, whenever I go to the dentist because every single time, they tell me you need to get an x-ray done on my teeth. So, I think, just being aware of how much radiation is in everything, that that's about the only way I would prevent it. Just- So, you mean educating yourself.

Participant 9 explained how education could help a broader audience become more aware of the possible danger and alarming effects of medical radiation exposure. Proper information about the risks should prompt concerned individuals to act upon the issue. Participant 9 shared the following,

> As I said, I guess just get educated. Maybe talk to some people that have had testing before to see what maybe they've been experienced. Honestly, I don't know. When you have a test, I guess you're expecting that the person ordering it is doing it in your best interest and there's a good reason to have it. So, I'm hoping that whatever is being done that I'm going to be informed at the time that what my risks could be.

For Participant 16, patients must possess sound judgment and must always be attentive to use the knowledge about potential risks to their health and take action accordingly. Participant 16 discussed how education would push the patients or individuals to know more about the issue and take action as deemed needed. Participant 16 stated the following:

> Common sense. That's it. It's just common sense. Talk to the doctor or the radiologists or a physicist. Well, if I've had, let's say, I've had MR, and they want to do another MR, and they want to do another MR, and this is in six weeks. And I'm going to say, "Whoa. I want to know. I got to find out how much radiation I'm getting. Not MR, but CT. And I'm doing one here, here, here, here. But in some cases, if you're a trauma patient or a cancer patient, in real bad shape. You don't have a choice. Sometimes the good outweighs the bad, that's the way I see it.

Minor Theme 2: Being more careful to avoid examinations with medical radiation exposure. Another minor theme that emerged was the cue of being more careful and cautious to avoid examinations with medical radiation exposure. Participant 10 commented, "First of all, not try to get injured in no way to have a radiological exam. Stay up here on the third floor, don't go around Amy too much." Another cue to action shared was the desire to protect their bodies and live a healthier lifestyle, with Participant 10 stating, "Probably being healthier, eating healthier, doing what my nutritionist says to do. Doing the colonoscopies and endoscopies more often. Just following doctor's orders versus pushing it along and saying, 'Oh, it will get better.' Then you crash and burn." Participant 19 shared that people would be more cautious and careful going forward. An example Participant 19 shared was

> I would weigh the benefits versus the risks, like if it were necessary. Like a broken bone, it would depend, you know. So, I agree with the procedures, but I would have trust in my doctors. But if it became something I was doing often enough, I would probably have to question it.

Minor Theme 3: Hearing reports about individuals getting ill from medical radiation exposure. The second minor theme of the study was seeing and hearing reports concerning individuals experiencing complications and falling ill due to medical radiation exposure. Participant 2 stated that a signal for them would be when they witnessed peers or coworkers becoming sick or affected due to their exposure. Participant 2 commented, "If it was brought to me that someone needed to find out more and I am working in radiology, I would get that information. If my coworkers had started getting sick, I would

know that something is wrong." Participant 7 stated, "If I got cancer," then they would start taking concrete steps to address the radiation issues. Participant 8 provided an example, indicating the presence of consistent physical consequences as one signal or cue to action. Participant 8 shared the following:

> Probably seeing a consistent consequence. I think I'd probably say. Let us say hypothetically, these ten women have gone to get mammograms, and all ten have come back say a year later with cancer. At that point, that would be a red flag for me. Even though I know that it may not be connected.

I established three minor themes and two other discrepant cases under the final research question of this study. For eight participants, the cue to action would have the proper information and resources to educate themselves with medical radiation exposure. Another theme was the realization of the need to be more careful with their bodies to avoid examinations with medical radiation exposure. The last minor theme was hearing reports about individuals getting ill from medical radiation exposure. Further investigation established two discrepant themes. These discrepant cases were (a) having a key individual taking the initiative to learn more about medical radiation exposure and (b) lacking knowledge about medical radiation exposure in general.

Summary

This chapter of the study contained the presentation of the results from the analysis of the 20 participant interview transcripts. The purpose of this qualitative case study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had

undergone or were currently undergoing medical radiation exams in Central North Carolina. Following Yin's (2011) five-phased analysis for a case study, 23 themes were generated to address the five research questions of the study. Overall, the uncovering of three major themes and eight minor themes occurred. Discrepant themes or cases (12 in total) were also established from the analysis but may need more research to solidify the trustworthiness of that data. Interpretation and discussion of these major and minor themes occur in Chapter 5, alongside some of the pertinent literature related to the subject recommendations, implications for change, and conclusions will be presented as well.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this qualitative case study was to explore patients' awareness and knowledge of information regarding medically induced radiation exposure from the perceptions of patients who either had undergone or were currently undergoing medical radiation exams in Central North Carolina. Medical imaging with radiation has become popular due to its utility in diagnosis and prevention. Despite this utility, there are other implications of medical radiation to the health of patients that may engender more harm than good (Awosan et al., 2016). Examinations such as X-rays and CT scans may cause an overdose of radiation exposure when frequently done. Sherer et al. (2018) noted how the human average medical radiation exposure per year could reach as high as 6.3 mSv, which markedly exceeds the threshold of 3 mSv limit per year. This piece of information may not be familiar to patients, which puts them at risk.

There is little information regarding patients' current knowledge regarding medical imaging radiation exposure. I conducted a qualitative case study to explore and understand how patients perceived medical radiation and its risks to address this problem. The HBM was used as the framework for this study, as its constructs allowed for a holistic view of how patients' knowledge and perspectives influenced their health-related decisions (Hochbaum, 1958). The five constructs were (a) perceived susceptibility, (b) perceived seriousness, (c) perceived benefits of taking action, (d) barriers to taking action, and (e) cues to action (Hochbaum, 1958). Interviewing patients who either had

undergone or were currently undergoing medical radiation exams allowed me to have a grasp of their perspectives on medical radiation with these five constructs.

I found that most participants were aware of the harmful effects of medical radiation and its seriousness if not managed or controlled. The majority of this study's participants also believed in the benefits of being more proactive in protecting themselves from potentially harmful effects of medical radiation exposure and perceived no barriers to taking action. Several cues to action were also provided by the participants, including having the proper information and resources to educate oneself, being more careful with their bodies to avoid examinations with radiation, and hearing reports about individuals getting ill from medical radiation exposure. Although a minority of the participants revealed no fears or concerns about radiation exposure and lacking accurate information and knowledge about it, they constituted only a small percentage of the sample.

Overall, I found a general awareness of the dangers of medical radiation exposure and how to increase this level of awareness. However, caution must be given as there is still a small number of patients who were not aware of these dangers, and it must be noted that no details or numbers were reported by the participants regarding how much radiation they considered to be harmful.

Interpretation of the Findings

The research questions were patterned after the constructs of the HBM, and consequently, as were the findings. I revealed three major themes and eight minor themes across all the research questions. Twelve discrepant themes or cases were also found; however, as these only appeared in the data in isolation, they may need more

research to solidify their trustworthiness; hence, there were not considered as key findings for this study. The major and minor themes are discussed in this section in relation to existing literature.

Perceptions on Susceptibility to Medical Radiation Procedures

Findings from the first research questions produced three minor themes describing how patients perceived their susceptibility to medical radiation exposure. An equal number of seven (35%) participants each comprised the responses for the first two themes. The third minor theme was derived from only four (20%) participants. A final discrepant theme emerged from two (10%) participants; however, as previously stated, this will not be discussed in detail as it requires further research. These numbers displayed some divergence when it comes to patients' perceived susceptibility to medical radiation.

Minor Theme 1. Emphasis on this first minor theme was placed on the harmful effects of radiation for those who are constantly exposed to it. Participants expressed the "long term" and "large scale" harmful effects of artificial radiation, which, according to them, may lead to diseases such as cataracts, radiation poisoning, and cancer. These participants noted how medical imaging was helpful, but still harmful, and should only be done if necessary.

The ideas discussed by the patients have been confirmed by past studies showing how medical radiation may lead to a range of diseases. This is mostly due to the damage caused by radiation to human DNA (Desouky et al., 2015; Dobrescu & Rădulescu, 2015; Sherer et al., 2018). In addition to the diseases mentioned by the present study's

participants, radiation exposure may also lead to cardiovascular problems and skin erythema (Awosan et al., 2016; Ding & Gao, 2017). Previous scholars presented the linear no-threshold model, which describes a linear and proportional relationship between radiation dose and risk of diseases (Ding & Gao, 2017; Dobrescu & Rădulescu, 2015). In a study of cancer survivors' worry about medical imaging, Hay, Baser, Westerman, and Ford (2018) found that most of their 452 participants worried about their susceptibility when undergoing medical imaging with radiation. Hay et al. purported that these survivors, having experienced cancer before, may be more vigilant regarding the cancer-inducing risks of medical radiation. This is in line with the present study's participants' belief that more exposure to medical radiation translated to higher risks of cancer.

Minor Theme 2. The second minor theme displayed how participants in the present study believed that the harmful effects of medical radiation might be minimized by having the proper knowledge and skills to protect themselves. Similar to participants in the first theme, these participants also expressed that medical radiation brings harmful effects when overexposed. The discrepancy lay in their belief that they were not susceptible to these harmful effects, as they held proper knowledge and skills to protect themselves. They emphasized that patients should know exactly why they were being referred to a medical examination with radiation and that they should be cautious and decline these examinations if they are unnecessary. Engineer et al. (2018) stated that guidelines existed that prescribed less unnecessary imaging procedures. If these guidelines were followed, patients would indeed have reduced radiation risks (Engineer et al., 2018). Further supporting this theme, Al Ewaidat et al. (2018) displayed the

relationship between patient education and awareness of radiation risks. These two studies echoed the findings of this study that increased knowledge assists in reducing the perceived radiation risks from medical imaging, revealing the importance of education and acquiring knowledge and skills to protect oneself.

Although the content of participants' perceptions in the two minor themes above was confirmed by existing literature, the level of awareness regarding these perceptions was not supported by past studies. In the present study, the majority of the participants (70%) expressed at least some knowledge regarding the risks of medical radiation exposure. In previous studies, approximately half of the participants involved were unaware of medical radiation risks (Ghimire et al., 2018; Lambertova et al., 2019; Schuster et al., 2017; Singh et al., 2016). Faggioni et al. (2017) and Guena et al. (2017) revealed how even medical professionals lacked knowledge and awareness regarding proper radiation doses and radiation risks. Medical professionals such as doctors, radiologists, and radiographers were considered patients' primary source of information regarding medical radiation (Singh et al., 2016; Talab et al., 2016). Their lack of knowledge and awareness then translated into patients' lack of awareness despite their willingness to know more about radiation risks (Faggioni et al., 2017). Schuster et al. (2017) revealed that knowledge regarding CT radiation dose and risks have slightly improved since the year 2004 but is still lacking as only a minority of patients, emergency providers, and radiologists correctly estimated the radiation dose and risk of CT scans as compared to X-rays. These past studies involved quantitative data that may be more reflective of the current state of public awareness regarding medical radiation

risks; however, in this present qualitative study, the participants revealed that patients might at least be partially aware of the dangers of medical radiation, enough to raise caution in undergoing unnecessary examinations.

Minor Theme 3. Although this third minor theme comprised of notably fewer participant responses than the first two, it is still worth noting that four (20%) participants in this present study expressed no fear or concerns regarding medical radiation exposure risks. These four participants asserted that radiation is always present, even in nonmedical instances such as staying out in the sun. Furthermore, a participant expressed doubts about radiation risks, stating that people were overreacting about the issue. These findings are troubling considering how radiation, regardless of the dose, increases the risk of cancer (Desouky et al., 2015). Previous scholars, however, confirmed these findings. The majority (80%) of patients in Evans et al.'s (2015) study underestimated the radiation risks from medical imaging examinations. Medical professionals who are presumed to be knowledgeable in the field, may also underestimate radiation risks and not apply their knowledge to their practices (Aravind et al., 2016; Brun et al., 2018; Sharma et al., 2016). These findings, along with this third minor theme in the present study, displayed how patients' current knowledge and awareness about the susceptibility to radiation risks may not be enough to cause them to feel susceptible and influence their decisions.

Perceptions of the Seriousness Associated with Medical Radiation Procedures

One major theme and one minor theme were derived regarding the perceived seriousness of the medical radiation effects. Twelve (60%) of the participants were aware of the seriousness of the medical concerns related to medical radiation exposure if

not managed or controlled, while five (25%) once again expressed having no fear or concerns on medical radiation exposure effects. These findings somewhat reflect the findings of the first three themes discussed above, with minor discrepancies. They reveal how patients may mostly be aware of the seriousness of medical radiation risks, but the divergent ones who expressed otherwise cannot be ignored.

Major Theme 1. As the first major theme of the study, I found that patients are generally aware of the seriousness of medical radiation risks if not managed or controlled. The majority of the participants displayed knowledge regarding the risk of cancer, cell destruction, and other diseases such as cataracts from too much radiation exposure. This is supported by the literature, which lists these diseases, among others, as serious consequences of radiation exposure (Desouky et al., 2015; Ding & Gao, 2017; Dobrescu & Rădulescu, 2015; Sherer et al., 2018). The present study's participant who had a family history of cancer stated that radiation risk was a more serious concern for them. This reflected Hay et al.'s (2018) findings that the experience of cancer strengthens the worries associated with radiation risks.

The percentage of participants in the present study who expressed their concerns regarding the seriousness of medical radiation risks were more reflective of the findings from Singh et al.'s (2017) study, which reported 130 out of 238 (54.6%) participants who expressed concerns about medical radiation. Similarly, in Manning et al.'s (2019) study of 841 patients, thoughts and concerns about radiation risks occurred in 55.9% of patients before their X-ray and 46.1% of patients before their CT scan. The number of participants in this theme was lower than the combined numbers of the first two themes

discussed earlier. Patients may be generally aware of their susceptibility when undergoing medical imaging with radiation, but that some may not perceive it as serious enough.

Minor Theme 1. Some participants may not perceive medical radiation risks as serious at all. The number of participants who showed no fear or concerns about the seriousness of medical radiation risks also somewhat reflects the number who showed no fear or concerns about their susceptibility to it, making it a minor theme with only five (25%) participants in this study. Their lack of fear or concern mostly proceeded from believing that they were not exposed to radiation. Scholars displayed how radiation is already present in natural sources, and this background radiation may be low, but still contributes to the accumulated annual dose recommended for humans (Desouky et al., 2015; Dobrescu & Rădulescu, 2015). With the additional radiation from medical imaging examinations that can reach up to 6.3 mSv per year, patients may receive excessive radiation that can cause harm (Sherer et al., 2018). Radiation may have stochastic or long-term effects even with low doses (Desouky et al., 2015; Zener et al., 2018). This present study's finding that some people tend to underestimate the seriousness of medical radiation may warrant some attention.

This study was not the first to report some form of underestimation regarding the seriousness of medical radiation. In Zener et al.'s (2018) study, although patients desired to know about the radiation risk of cancer, only 45% of their participants considered the cancer risk as serious. Thornton et al.'s (2015) participants were likewise aware of the risk of cancer, along with other long-term risks brought about by medical radiation, but

also disregarded these as they felt that medical imaging was more beneficial than harmful for their health. These findings, along with this present study's findings, indicate a need for stronger advocacies regarding the seriousness of radiation risks.

Perceptions of the Benefits of Taking Action with Medical Radiation Exposure

Whether or not patients perceived medical radiation risks as harmful and serious, a majority of the participants in this study agreed that there are benefits to taking action related to medical radiation exposure. The majority of the participants believed that taking action allowed them to protect themselves from potentially harmful health risks. The single theme associated with this construct encompassed the greatest number of participants in this study. This displays promising results as this would entail patients' proactivity regardless of their beliefs regarding medical radiation risks.

Major Theme 2. When asked about the benefits of taking action related to medical radiation, only a single major theme emerged from the data. Sixteen (80%) of the participants expressed that being more proactive allowed them to live healthier and safer lives. They noted how a person must be aware of his or her own body and the procedures that it undertakes. Participants emphasized the value of being fully informed about medical procedures, and even taking initiative to keep themselves informed. This finding was confirmed by Ukkola et al.'s (2015) study, in which 95% of their 147 participants expressed the desire for more information about the risk and dose of medical imaging with radiation. Heyer et al. (2015) also revealed that patients who were not informed about the medical imaging processes they were about to undergo were more anxious than those who were informed. In Thornton et al.'s (2015) study, however, some

participants stated that discussions about radiation-related cancer were "outrageous, useless, and frightening" (p. 5). This perspective, albeit not the majority one, revealed how some patients might not perceive proactivity as beneficial when it comes to medical radiation, as it may instead cause increased anxiety (Thornton et al., 2015). This may also explain the small number of participants in the present study who did not perceive any benefits of taking action. Although this major theme showed promising results, caution must still be given for the small number of participants who did not advocate proactively seeking information regarding medical radiation.

Perceptions of the Barriers to Taking Action to Medical Radiation Exposure

The fourth research question of this present study yielded one major and one minor theme. The majority of the participants believed that there were no barriers to taking action related to medical radiation. A smaller number of participants reported otherwise, stating that they lacked accurate information and knowledge about medical radiation exposure, which then prevented them from taking action. These two themes displayed a divided perspective regarding the barriers to taking action.

Major Theme 3. When asked about barriers to taking action related to medical radiation, 13 (65%) participants in this study responded that they did not perceive any. They alluded to the Internet as being an accessible source of information for research regarding radiation. Ahadzadeh et al. (2015) likewise found that patients in Malaysia who were concerned about health risks, in general, tended to use the Internet to gain information about their health risks. This was also echoed by some of Thornton et al.'s (2015) participants, who relied on self-directed internet searches regarding medical

imaging with radiation. Other scholars did not support this finding though, as both Singh et al. (2016) and Talab et al. (2016) noted how medical professionals remained to be patients' primary source of information. Referrers, radiologists, and radiographers are often asked about the necessity of medical imaging radiation and reassurance that the process will be performed with fidelity (Frush & Perez, 2017). In Ukkola et al.'s (2015) study, the majority of the patients still preferred to receive radiation-related information from their referring practitioner or the hospital rather than the internet. Ria et al. (2017) also revealed that patients preferred to have the radiation dose and risk information readily available in their medical reports. Lastly, Jacobs et al. (2017) noted how the use of the Internet was limited to certain groups influenced by age, education, socioeconomic status, health condition, family history of cancer, health perception, and Internet skill. The use of the Internet, while valuable, may not be enough to consider having any barriers to taking action related to medical radiation.

One participant in this present study also suggested other reading materials and classes as reliable sources of information. These sources may be limited to certain groups as well. Additionally, receiving additional knowledge may not have much value if not practiced. Brun et al. (2018) found that training programs for medical practitioners regarding radiation risks did not translate into their practices, as they continued their hazardous practices afterward. Overall, these findings disconfirm this present study's finding that there are no perceived barriers to taking action related to medical radiation.

Minor Theme 1. A surprisingly low number, four (20%) participants, reported having barriers to taking action related to medical radiation. They emphasized the lack of

information and knowledge available to them as a barrier. They also noted that not all information may be correct and that some may also be misinterpreted. This minor theme was more in line with the existing literature. Several scholars revealed how patients had difficulty obtaining resources for information regarding medical radiation or found this information to be inadequate (Evans et al., 2015; Schnitzler et al., 2017; Singh et al., 2016; Ukkola et al., 2017). Media representations of medical radiation risks may be exaggerated, focusing only on the risks and not the benefits (Frush & Perez, 2017). Salerno et al. (2018) also found that the patients who did not understand the written radiation information provided for them lost interest in the matter. These findings, along with this present study's minor theme, displayed how information regarding medical radiation may not be readily available or may be misinterpreted if not discussed properly with the patient.

Perceptions of the Cues to Action Associated with Medical Radiation Exposure

As the benefits and barriers to taking action related to medical radiation were discussed by this study's participants, several cues to action also emerged. The following themes described what triggering events would prompt them into taking action regarding medical radiation. Three minor themes emerged, which were having the proper information and resources to become educated regarding medical radiation exposure, being more careful with their bodies to avoid medical examinations with radiation, and hearing reports about individuals getting ill from medical radiation exposure.

Minor Theme 1. The value of information regarding medical radiation has been emphasized in the previous themes of this present study. Eight (40%) of the participants

identified it as a cue to taking action. Participants discussed education and going to the best possible facilities as vital in allowing them to take proper action against radiation exposure. Education may influence awareness of radiation risks, which may affect their health decisions (Al Ewaidat et al., 2018; Talab et al., 2016). Not all scholars agreed with this finding, however, as some found no significant relationship between education and radiation awareness (Al-Mallah et al., 2017; Brun et al., 2018; Evans et al., 2015; Schnitzler et al., 2017). What these findings, together with the present study's theme, entail is that education may not necessarily mean general education or educational attainment, but specifically education regarding radiation risks, and how to properly interpret and avoid them.

As reported by this study's participants, going to the best possible facilities and receiving the best care would also allow them to take action and avoid radiation overdose. This involves not just receiving correct information from experts, but also receiving proper services. Scholars confirmed this finding, emphasizing medical professionals who specialized in their fields and strictly followed guidelines (Andreou et al., 2016; Engineer et al., 2018; Tong et al., 2016). Ria et al. (2017) and Thornton et al. (2015) also noted how patient care involved the responsibility of medical professionals to discuss and inform the patients regarding medical radiation risks. These findings then revealed the importance of finding the best possible facilities that would provide not just the best services but also the most information regarding medical radiation, as stated by this present study's participants.

Minor Theme 2. As medical imaging with radiation may sometimes be necessary for some cases, seven (35%) participants in this study believed that simply staying healthy and being cautious would allow them to avoid medical radiation risks. Previous scholars have shown that some medical radiation conducted in the past may have been unnecessary (Engineer et al., 2018; Kleinpell et al., 2018). One participant mentioned some examinations without radiation that could be done routinely such as endoscopy and colonoscopy, instead of routinely having those that emitted radiation. Similarly, in Moreno et al.'s (2019) study, patients who promoted colorectal cancer screening preferred tests that did not involve radiation such as optical colonoscopy. When provided with options, patients would generally be careful enough to choose one with the least radiation risk (Moreno et al., 2019).

The majority of foot and ankle patients in Manning et al.'s (2019) study preferred medical imaging with radiation as they believed these tests to be more definitive. These contrasting findings raise caution regarding patients' preference of medical imaging tests, as not all patients may be careful with medical radiation. Adambounou et al. (2015) also noted the common misconception that the MRI produced harmful ionizing radiation when it did not. The overuse of CT scans might be avoided by using the less harmful MRI. Kleinpell et al. (2018) stated that routine daily imaging with radiation had little utility. These findings confirmed the present study's finding that patients could stay healthy and monitor their health without the use of medical radiation.

Minor Theme 3. The last minor theme for this study revealed the final cue to action, which was hearing reports about the negative effects of medical radiation on

another individuals' health. Six (30%) of the participants reported the impact of witnessing their peers, coworkers, or other people getting ill after medical examinations with radiation on their decisions. This finding was confirmed by Thornton et al. (2015), who emphasized the sensationalism of radiation risks causing people to be reluctant to undergo these examinations. In Singh et al.'s (2016) study, 9.9% of their 242 participants also reported relying on their friends and families for information or opinions regarding medical radiation. Although this was a small number, just as this present study had, it still shows the importance of other individuals' influence on the patients' decisions.

Overall, the themes presented in this chapter revealed some consistencies and some inconsistencies with existing literature. According to the findings, patients were generally aware of their susceptibility to medical radiation risks, and the seriousness of these risks. The participants also reported the benefits of taking action regarding medical radiation, which entailed being more proactive in staying well-informed about their bodies and the procedures they undergo. The majority of the participants reported having no barriers to taking action, while a few did report the lack of available and correct information as a barrier. Participants also identified having the proper information and resources to educate themselves, being more careful with their bodies to avoid unnecessary examinations with radiation, and hearing about other individuals getting ill from medical radiation exposure as cues to action regarding medical radiation. These qualitative findings generally revealed acceptable knowledge and awareness regarding medical radiation exposure risks, but with notable divergent insights showing a lack of awareness and concern of the dangers behind these radiation risks.

Limitations of the Study

As a qualitative case study, this study may have some limitations. The data were gathered from human participants and analyzed by me, both of whom may hold some personal biases that may have influenced the findings (see Roulston & Shelton, 2015). I acknowledged these potential biases and reminded participants to answer the questions as accurately as possible while being cautious myself during analysis. The findings of this study are also limited to one group of people, and they may not be generalizable to other groups. The findings were also derived from opinions of the participants, and as such cannot be considered as facts.

Recommendations

Considering the limitations of this study, it is recommended that future researchers use more quantitative methods to confirm the results of this study. Quantitative evidence on the themes found in this study would further solidify them. Future researchers could examine how much the findings in this study affected patients' decisions to undergo medical examinations with radiation by using surveys on large samples. The discrepant cases presented in Chapter 4 also warrant further investigation, even though they were mentioned in isolation. Qualitative scholars could investigate them in more depth. Quantitative studies could also be applied to check if they are significant enough to warrant more attention. A study similar to this, but in a different setting, could confirm, disconfirm, or add to the findings as well.

Implications

Positive Social Change

Implications on social change by the findings of this study can be observed in several levels. These levels include individuals, organizational, and societal or policy and methodological. The qualitative findings of this study may promote better understanding and awareness of patients' perceptions regarding medical radiation exposure risks for the three levels of individual, organizational and societal or policy. Additional implications may also be made for replication of this study.

Individual. In the first level, the findings of this study allowed patients who had undergone or were undergoing medical examinations with radiation to share their insights regarding radiation risks. Individuals who are about to undergo similar examinations may gain insights from these findings and increase their awareness regarding medical radiation. The findings of this study may assist individuals in discerning whether the benefits of medical examinations with radiation outweigh the risks. The emphasis of the participants in this study on proactivity on taking action regarding medical radiation also implies that individuals should exert effort in keeping themselves informed about the procedures that they undergo.

Organizational. In the second level, I found several implications for organizations such as health care providers. The finding that patients were generally aware of their susceptibility to radiation, but may not have perceived to them as serious enough, implies that further discussions about the seriousness of the risks are required.

Medical professionals need to fully disclose the gravity of the risks brought about by even a small dose of radiation.

The minor finding that some patients considered the lack of accurate information about medical radiation as a barrier should also be heeded by health care organizations. Organizations such as hospitals and other medical facilities should exert more effort in providing accurate information to their patients. Some patients may not have access to the Internet, and the Internet may not be the most reliable of resources. Referrers should also be cautious in selecting examinations and explaining how important it is to the patient, as the participants in this study expressed how medical examinations with radiation should only be done if necessary,

Societal/Policy. For the last level, further quantitative investigations on large samples are necessary to establish patterns that would guide societal- and policy-related implications, such as the need for stricter guidelines on medical examinations with radiation. The present qualitative findings were obtained from only 20 participants; hence, they may not be representative of society as a whole. The themes in the present study may act as fundamental basis as they illustrated patients' cues to action such as weighing the risks and benefits of medical radiation, and reliance on proper information sources such as physicians, radiologists, radiographers, and other medical staff. As such, quantitative evidence to support these would imply the need for guidelines regarding standards on which cases required examinations with radiation and which ones could do without them, as well as on medical professionals thoroughly discussing the risks of

medical radiation to patients before the procedure. Quantitative scholars should then quantify the frequency of these beliefs to form societal or policy implications.

Methodological. The qualitative nature of this study provided deeper insights into the perceptions of patients regarding medical radiation. The use of semistructured interviews allowed for a degree of flexibility of data. The use of the HBM as theoretical framework also allowed the data to cover several angles on patients' perceptions regarding medical radiation. The findings of this study could be used by future scholars in different settings, or with quantitative methods. Future researchers using quantitative methods may build on the themes presented in this study to establish stronger empirical evidence and generate further implications regarding the influence of health beliefs on patients' decisions to undergo medical imaging with radiation. The present study's methodology could also be replicated in other settings or larger samples to increase the generalizability of the findings.

Conclusion

This qualitative case study provided in-depth insights from patients regarding their perceptions of medical radiation. The dangers of radiation from certain medical examinations have been reported in past studies (Awosan et al., 2016; Sherer et al., 2018). It was, therefore, important to determine what influenced patients to agree to undergo these examinations. I found that most patients were generally aware of the negative effects of medical radiation, but some may not consider them serious enough. I also revealed how being proactive in protecting oneself from radiation effects, as well as staying healthy, were perceived benefits to taking action regarding medical radiation.

The majority of the participants in this study also reported perceiving no barriers to taking action; however, a notable number also reported a lack of accurate information and knowledge available as a barrier. Several cues to action were also provided by the participants, including having the proper information and resources to educate themselves, being more careful with their bodies to avoid examinations with radiation, and hearing reports about individuals getting ill from medical radiation exposure. With these findings, patients, medical professionals, health care organizations, and other stakeholders may glean the importance of discussing these radiation risks with patients and emphasizing the seriousness of these risks.

References

Abdallah, Y. Y. (2017). History of medical imaging. *Archives of Medicine and Health Sciences, 5*(2), 275-278. doi:10.4103/amhs.amhs_97_17

Achora, S., & Matua, G. A. (2016). Essential methodological considerations when using grounded theory. *Nurse Researcher, 23*(6), 31-36. doi:10.7748/nr. 2016.e1409

Adambounou, K., Achy, O., Fiagan, Y., Adigo, A., Mondé, K., Gbande, P., … Adjenou, K. (2015). Knowledge and attitude of Togolese radiographers on medical irradiation of pregnant women. *Journal of Nuclear Medicine & Radiation Therapy*, *7,* s7. doi:10.4172/2155-9619.s7-003

Adler, A. M., & Carlton, R. R. (2019). *Introduction to radiologic & imaging sciences & patient care*. St. Louis, MO: Elsevier.

Ahadzadeh, A. S., Pahlevan Sharif, S., Ong, F. S., & Khong, K. W. (2015). Integrating health belief model and technology acceptance model: An investigation of health-related internet use. *Journal of Medical Internet Research*, *17*(2), e45. doi:10.2196/jmir.3564

Ahmed, T. A. N., & Taha, S. (2017). Radiation exposure, the forgotten enemy: Toward implementation of national safety program. *The Egyptian Heart Journal, 69*(1), 55-62. doi:10.1016/j.ehj.2016.10.001

Ahn, E., Park, H. J., Baek, H. J., Hwang, P. H., Lee, Y. H., Park, B.-K., … Park, K. D. (2017). Awareness about past diagnosis and treatment history: Nationwide survey of childhood cancer survivors and their parents. *Japanese Journal of Clinical Oncology, 47*(10), 962-968. doi:10.1093/jjco/hyx102

Al Ewaidat, H., Zheng, X., Khader, Y., Spuur, K., Abdelrahman, M., Alhasan, M. K. M., & Al-Hourani, Z. A. (2018). Knowledge and awareness of CT radiation dose and risk among patients. *Journal of Diagnostic Medical Sonography, 34*(5), 347-355. doi:10.1177/8756479318776214

Al-Mallah, A., Vaithinathan, A. G., Al-Sehlawi, M., & Al-Mannai, M. (2017). Awareness and knowledge of ionizing radiation risks between prescribed and self-presenting patients for common diagnostic radiological procedures in Bahrain. *Oman Medical Journal, 32*(5), 371-377. doi:10.5001/omj.2017.72

Alhasan, M., Abdelrahman, M., Alewaidat, H., & Khader, Y. (2015). Medical radiation knowledge among patients in local hospitals. *Journal of Medical Imaging and Radiation Sciences, 46*(1), 45-49. doi: 10.1016/j.jmir.2014.09.002

Alqahtani, M. M. (2015). Understanding the sociocultural health belief model influencing health behaviors among Saudi stroke survivors. *Neuroscience and Medicine, 6*(4), 149-159. doi:10.4236/nm.2015.64023

Andreou, K., Pantos, I., Tzanalaridou, E., Efstathopoulos, E., & Katritsis, D. (2016). Patient radiation exposure and influencing factors at interventional cardiology procedures. *Physica Medica, 32*(3), 234. doi:10.1016/j.ejmp.2016.07.485

Aravind, B. S., Tatu Joy, E., Kiran, M. S., Sherubin, J. E., Sajesh, S., & Manchil, P. R. D. (2016). Attitude and awareness of general dental practitioners toward radiation hazards and safety. *Journal of Pharmacy & BioAllied Sciences, 8*(Suppl 1), S53-S58. doi:10.4103/0975-7406.191969

Awosan, K., Ibrahim, M., Saidu, S., Ma'aji, S., Danfulani, M., Yunusa, E., . . . Ige, T. (2016). Knowledge of radiation hazards, radiation protection practices and clinical profile of health workers in a teaching hospital in Northern Nigeria. *Journal of Clinical And Diagnostic Research, 10*(8), 7-12. doi:10.7860/jcdr/2016/20398.8394

Azar, M., Zhu, C., DeFeis, B., Gu, Y., Ornstein, K., Lawless, S., & Cosentino, S. (2017). Increased reporting accuracy of Alzheimer's disease symptoms in Caribbean Hispanic informants. *Alzheimer Disease and Associated Disorders, 31*(4), 328-334. doi:10.1097/WAD.0000000000000199

Azman, R. R., Shah, M. N. M., & Ng, K. H. (2019). Radiation safety in emergency medicine: Balancing the benefits and risks. *Korean Journal of Radiology, 20*(3), 399-404. doi:10.3348/kjr.2018.0416

Badawy, M. K., Mong, K. S., Lykhun, U. P., & Deb, P. (2016). An assessment of nursing staffs' knowledge of radiation protection and practice. *Journal of Radiological Protection, 36*(1), 178-183. doi:10.1088/0952-4746/36/1/178

Baumann, M., Krause, M., Overgaard, J., Debus, J., Bentzen, S. M., Daartz, J., … Bortfeld, T. (2016). Radiation oncology in the era of precision medicine. *Nature Reviews Cancer, 16*(4), 234-249. doi:10.1038/nrc.2016.18

Beck, C. T. (2009). Viewing the rich, diverse landscape of qualitative research. *Perioperative Nursing Clinics*, *4*(3), 217-229. doi:10.1016/j.cpen.2009.05.006

Bohl, D. D., Hijji, F. Y., Massel, D. H., Mayo, B. C., Long, W. W., Modi, K. D., . . . Singh, K. (2016). Patient knowledge regarding radiation exposure from spinal imaging. *The Spine Journal, 17*(3), 305-312. doi:10.1016/j.spinee.2016.09.017

Brun, A., Mor, R. A., Bourrelly, M., Dalivoust, G., Gazazian, G., Boufercha, R., … Sari-Minodier, I. (2018). Radiation protection for surgeons and anesthetists: Practices and knowledge before and after training. *Journal of Radiological Protection, 38*(1), 175-188. doi:10.1088/1361-6498/aa9dbd

Chandrashekhar, Y., Shaw, L. J., & Narula, J. (2015). Diagnostic imaging, radiation exposure, and carcinogenic risk. *JACC: Cardiovascular Imaging*, *8*(8), 885-887. doi:10.1016/j.jcmg.2015.05.004

Cheung, M. L., Chau, K. Y., Lam, M. H. S., Tse, G., Ho, K. Y., Flint, S. W., ... Lee, K. Y. (2019). Examining consumers' adoption of wearable healthcare technology: The role of health attributes. *International Journal of Environmental Research and Public Health*, *16*(13). Retrieved from https://www.mdpi.com/1660-4601/16/13/2257/htm

Creswell, J. W. (2009). *Research design: Qualitative, quantitative and mix methods approaches*. Los Angeles, CA: Sage Publications.

Demeter, S., Applegate, K. E., & Perez, M. (2016). Internet-based ICRP resource for healthcare providers on the risks and benefits of medical imaging that uses ionizing radiation. *Annals of the ICRP, 45*(1_suppl), 148-155. doi:10.1177/0146645316637786

Dempsey, L., Dowling, M., Larkin, P., & Murphy, K. (2016). Sensitive interviewing in qualitative research. *Research in Nursing & Health, 39*(6), 480-490. doi:10.1002/nur.21743

Desouky, O., Ding, N., & Zhou, G. (2015). Targeted and non-targeted effects of ionizing radiation. *Journal of Radiation Research and Applied Sciences, 8*(2), 247-254. doi:10.1016/j.jrras.2015.03.003

Ding, C., & Gao, L. (2017). Low dose radiation exposure and cardiovascular diseases: A review. *International Journal of Cardiovascular Practice, 2*(4), 76-79. doi:10.21859/ijcp-030103

Ditkofsky, N., Shekhani, H. N., Cloutier, M., Chen, Z. N., Zhang, C., & Hanna, T. N. (2016). Ionizing radiation knowledge among emergency department providers. *Journal of the American College of Radiology, 13*(9), 1044-1049.e1. doi:10.1016/j.jacr.2016.03.011

Dobrescu, L., & Rădulescu, G. (2015). Radiation dose risk and diagnostic benefit in imaging investigations. *American Journal of Bioscience and Bioengineering, 3*(3), 22-26. doi:10.11648/j.bio.s.2015030301.14

Doses in Our Daily Lives. (2017, October). Retrieved June 6, 2019, from https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html

Duncan, J. R., Lieber, M. R., Adachi, N., & Wahl, R. L. (2018). Radiation dose does matter: Mechanistic insights into DNA damage and repair support the linear no-threshold model of low-dose radiation health risks. *Journal of Nuclear Medicine*, *59*(7), 1014-1016. doi:10.2967/jnumed.118.210252

Elnahal, S. M., Blackford, A., Smith, K., Souranis, A. N., Briner, V., McNutt, T. R., … Terezakis, S. A. (2016). Identifying predictive factors for incident reports in patients receiving radiation therapy. *International Journal of Radiation Oncology*Biology*Physics, 94*(5), 993-999. doi:10.1016/j.ijrobp.2015.11.041

Engineer, R. S., Podolsky, S. R., Fertel, B. S., Grover, P., Jimenez, H., Simon, E. L., & Smalley, C. M. (2018). A pilot study to reduce computed tomography utilization for pediatric mild head injury in the emergency department using a clinical decision support tool and a structured parent discussion tool. *Pediatric Emergency Care, 1.* doi:10.1097/pec.0000000000001501

Etikan, I. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1-4. doi:10.11648/j.ajtas.20160501.11

Evans, K. M., Bodmer, J., Edwards, B., Levins, J., O'Meara, A., Ruhotina, M., … Carney, J. K. (2015). An exploratory analysis of public awareness and perception of ionizing radiation and guide to public health practice in Vermont. *Journal of Environmental and Public Health, 2015*, 1-6. doi:10.1155/2015/476495

Faggioni, L., Paolicchi, F., Bastiani, L., Guido, D., & Caramella, D. (2017). Awareness of radiation protection and dose levels of imaging procedures among medical students, radiography students, and radiology residents at an academic hospital: Results of a comprehensive survey. *European Journal of Radiology, 86,* 135-142. doi:10.1016/j.ejrad.2016.10.033

Frush, Donald P., & Perez, Maria Del Rosario. (2017). *Children, medical radiation and the environment: An important dialogue*. United States. doi:10.1016/J.ENVRES.2017.04.002.

Furmaniak, K. Z., Kołodziejska, M. A., & Szopiński, K. T. (2016). Radiation awareness among dentists, radiographers and students. *Dentomaxillofacial Radiology, 45*(8), 20160097. doi:10.1259/dmfr.20160097

Gargani, L., & Picano, E. (2015). The risk of cumulative radiation exposure in chest imaging and the advantage of bedside ultrasound. *Critical Ultrasound Journal, 7*(1). doi:10.1186/s13089-015-0020-x

Gerend, M. A., & Shepherd, J. E. (2012). Predicting human papillomavirus vaccine uptake in young adult women: Comparing the health belief model and theory of planned behavior. *Annals of Behavioral Medicine*, *44*(2), 171-180. doi:10.1007/s12160-012-9366-5

Ghimire, P., Koirala, D., & Singh, B. P. (2018). An assessment of patient's awareness of radiation exposure to common diagnostic imaging procedures in low socioeconomic regions of Nepal. *Nepalese Journal of Radiology, 7*(1-2), 9-12. doi:10.3126/njr. v7i1-2.19348

Glanz, K., Rimer, B. K., & Viswanath, K. (Eds.). (2015). *Health behavior: Theory, research, and practice* (5th ed.). San Francisco, CA: Jossey-Bass.

Goodarzi, A., Heidarnia, A., Tavafian, S. S., & Eslami, M. (2019). Predicting oral health behaviors among Iranian students by using health belief model. *Journal of Education and Health Promotion, 8*(10). doi:10.4103/jehp.jehp_10_18

Groenewold, G., de Bruijn, B., & Bilsborrow, R. (2012). Psychosocial factors of migration: Adaptation and application of the health belief model. *International Migration*, *50*(6), 211-231. doi:10.1111/j.1468-2435.2012. 00781.x

Guena, M. N., Nguemeleu, D. N., Ndah, T. N., & Moifo, B. (2017). An assessment of both patients and medical staff awareness of the risks of ionizing radiation from CT scan in Cameroon. *Open Journal of Radiology, 7*(3), 199-208. doi:10.4236/ojrad.2017.73022

Gunawan, J. (2015). Ensuring trustworthiness in qualitative research. *Belitung Nursing Journal, 1*(1), 10-11. doi:10.33546/bnj.4

Gupta, A., Ip, I. K., Raja, A. S., Andruchow, J. E., Sodickson, A., & Khorasani, R. (2014). Effect of clinical decision support on documented guideline adherence for head CT in emergency department patients with mild traumatic brain injury. *Journal of the American Medical Informatics Association*, *21*(e2), e347-e351. doi:10.1136/amiajnl-2013-002536

Hanna, T. N., Shekhani, H., Zygmont, M. E., Kerchberger, J. M., & Johnson, J. O. (2016). Incidental findings in emergency imaging: frequency, recommendations, and compliance with consensus guidelines. *Emergency Radiology*, *23*(2), 169-174. doi:10.1007/s10140-016-1378-1

Harris, A. M., Loomis, J., Hopkins, M., & Bylund, J. (2019). Assessment of radiation safety knowledge among urology residents in the United States. *Journal of Endourology, 33*(6), 492-497. doi:10.1089/end.2019.0133

Hay, J. L., Baser, R. E., Westerman, J. S., & Ford, J. S. (2018). Prevalence and Correlates of Worry About Medical Imaging Radiation Among United States Cancer Survivors. *International journal of behavioral medicine*, *25*(5), 569–578. doi:10.1007/s12529-018-9730-3

Heyer, C. M., Thüring, J., Lemburg, S. P., Kreddig, N., Hasenbring, M., Dohna, M., & Nicolas, V. (2015). Anxiety of patients undergoing CT imaging—An underestimated problem? *Academic Radiology, 22*(1), 105-112. doi:10.1016/j.acra.2014.07.014

Hill, K. D., & Einstein, A. J. (2015). New approaches to reduce radiation exposure. *Trends in Cardiovascular Medicine, 26*(1), 55-65. doi:10.1016/j.tcm.2015.04.005

Hochbaum, G. M. (1958). *Public participation in medical screening programs; A socio-psychological study*. Washington, DC: United States Government Printing Office.

Hobbs, J. B., Goldstein, N., Lind, K. E., Elder, D., Dodd, G. D., & Borgstede, J. P. (2018). Physician knowledge of radiation exposure and risk in medical imaging. *Journal of the American College of Radiology, 15*(1), 34-43. doi:10.1016/j.jacr.2017.08.034

Jacobs, W., Amuta, A. O., & Jeon, K. C. (2017). Health information seeking in the digital age: An analysis of health information seeking behavior among US adults. *Cogent Social Sciences, 3*(1), 1-11. doi:10.1080/23311886.2017.1302785

Janz, N. K., & Becker, M. H. (1984). The health belief model: A decade later. *Health Education & Behavior*, *11*(1), 1-47. doi:10.1177/109019818401100101

Kaba, Z., Khamisa, N., & Tshuma, N. (2017). Age-group differences in risk perceptions of non-communicable diseases among adults in Diepsloot township, Johannesburg, South Africa: A cross-sectional study based on the health belief model. *South African Medical Journal, 107*(9), 797-804. doi:10.7196/samj.2017.v107i9.12168

Kada, S. (2017). Awareness and knowledge of radiation dose and associated risks among final year medical students in Norway. *Insights into Imaging, 8*(6), 599-605. doi:10.1007/s13244-017-0569-y

Karim, M. K., Hashim, S., Bradley, D. A., Bahruddin, N. A., Ang, W. C., & Salehhon, N. (2016). Assessment of knowledge and awareness among radiology personnel regarding current computed tomography technology and radiation dose. *Journal of Physics: Conference Series, 694*(1), 012031. doi:10.1088/1742-6596/694/1/012031

Keller, E. J., Crowley-Matoka, M., Collins, J. D., Chrisman, H. B., Milad, M. P., & Vogelzang, R. L. (2017). Fostering better policy adoption and inter-disciplinary communication in healthcare: A qualitative analysis of practicing physicians' common interests. *PLOS ONE, 12*(2), e0172865. doi:10.1371/journal.pone.0172865

Khani Jeihooni, A., Hidarnia, A., Kaveh, M. H., Hajizadeh, E., & Askari, A. (2015). The effect of an educational program based on health belief model and social cognitive theory in prevention of osteoporosis in women. *Journal of Health Psychology, 22*(5), np1-np11. doi:10.1177/1359105315603696

Kleinpell, R. M., Farmer, J. C., & Pastores, S. M. (2018). Reducing unnecessary testing in the intensive care unit by choosing wisely. *Acute and Critical Care, 33*(1), 1-6. doi:10.4266/acc.2018.00052

Kruger, J. F., Chen, A. H., Rybkin, A., Leeds, K., Frosch, D. L., & Goldman, E. L. (2014). Clinician perspectives on considering radiation exposure to patients when ordering imaging tests: A qualitative study. *BMJ Quality & Safety*, *23*(11), 893. doi:10.1136/bmjqs-2013-002773

Kung, P.-C., Yeh, M. C., Lai, M.-K., & Liu, H. (2017). Renal transplant recipients. *Journal of Nursing Research, 1.* doi:10.1097/jnr.0000000000000181

Lam, D. L., Larson, D. B., Eisenberg, J. D., Forman, H. P., & Lee, C. I. (2015). Communicating potential radiation-induced cancer risks from medical imaging directly to patients. *American Journal of Roentgenology*, *205*(5), 962-970. doi:10.2214/ajr.15.15057

Lambertova, A., Harsa, P., Lambert, L., Kuchynka, P., Burgetova, A., & Briza, J. (2019). Patient awareness, perception and attitude to contrast-enhanced CT examination: Implications for communication and compliance with patients' preferences. *Advances in Clinical and Experimental Medicine, 28*(7). doi:10.17219/acem/94146

Leedy, P. D., & Ormrod, J. E. (2010). *Practical research: Planning and design*. Upper Saddle River, NJ: Pearsons.

Lewis, S. (2015). Qualitative inquiry and research design: Choosing among five approaches. *Health Promotion Practice, 16*(4), 473-475. doi:10.1177/1524839915580941

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Lind, K. E., Jensen, A. M., Perez-Portillo, A., & Garg, K. (2019). Patient perceptions of CT imaging in a diverse patient sample. *Journal of the American College of Radiology.* doi:10.1016/j.jacr.2018.12.027

Llewellyn, C., Ayers, S., McManus, C., Newman, S., Petrie, K. J., Revenson, T. A., & Weinman, J. (2019). *Cambridge handbook of psychology, health and medicine* (3rd ed.). Cambridge, MA: Cambridge University Press.

Lumbreras, B., Vilar, J., González-Álvarez, I., Guilabert, M., Pastor-Valero, M., Parker, L. A., . . . Hernández-Aguado, I. (2017). Avoiding fears and promoting shared decision-making: How should physicians inform patients about radiation exposure from imaging tests? *PLOS ONE, 12*(7), e0180592. doi:10.1371/journal.pone.0180592

Luquis, R. R., & Kensinger, W. S. (2019). Applying the health belief model to assess prevention services among young adults. *International Journal of Health Promotion and Education*, *57*(1), 37-47. doi:10.1080/14635240.2018.1549958

Mahbobi, M., Sayadi, A. R., Shabani, Z., & Asadpour, M. (2015). The effect of an educational intervention based on health belief model on the standard precautions among medical students of Rafsanjan University of Medical Sciences. *Research*

in Medical Education, *7*(1), 63-72. Retrieved from http://rme.gums.ac.ir/article-1-156-en.html

Marin, J. R., Thomas, K. E., Mills, A. M., Broder, J. S., & Boutis, K. (2017). Practices and attitudes towards radiation risk disclosure for computed tomography: Survey of emergency medicine residency program directors. *Emergency Radiology, 24*(5), 479-486. doi:10.1007/s10140-017-1493-7

Matsuhashi, S., & Ishioka, N. S. (2018). Medical utilization of radiation. In H. Kudo (Ed.), *Radiation applications: Vol. 7. An advanced course in nuclear engineering* (pp. 293-335). doi:10.1007/978-981-10-7350-2_17

McArthur, L. H., Riggs, A., Uribe, F., & Spaulding, T. J. (2018). Health belief model offers opportunities for designing weight management interventions for college students. *Journal of Nutrition Education and Behavior, 50*(5), 485-493. doi:10.1016/j.jneb.2017.09.010

McNierney-Moore, A., Smith, C., Guardiola, J., Xu, K. T., & Richman, P. B. (2015). Patient understanding of radiation risk from medical computed tomography—A comparison of Hispanic vs. non-Hispanic emergency department populations. *PeerJ*, *3*, e937. doi:10.7717/peerj.937

Mellor, D., McCabe, M., Ricciardelli, L., Mussap, A., & Tyler, M. (2016). Toward an understanding of the poor health status of indigenous Australian men. *Qualitative Health Research, 26*(14), 1949–1960. doi:10.1177/1049732315609898

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th ed.). San Francisco, CA: John Wiley & Sons.

Mo, P. K., Chong, E. S., Mak, W. W., Wong, S. Y., & Lau, J. T. (2016). Physical activity in people with mental illness in Hong Kong: Application of the health belief model. *Journal of Sport and Exercise Psychology*, *38*(2), 203-208. doi:10.1123/jsep.2015-0061

Moreno, C. C., Jarrett, T., Vey, B. L., Mittal, P. K., Krupinski, E. A., & Roberts, D. L. (2019). Patient Knowledge Regarding Colorectal Cancer Risk, Opinion of Screening, and Preferences for a Screening Test. *Current Problems in Diagnostic Radiology*, *48*(1), 50-52. https://doi.org/10.1067/j.cpradiol.2017.12.011

Movahhed, E., Ameri, M., Agh Atabay, R., Alizadeh, S., Jadgal, K. M., Zarepour, M., & Hashemian, S. N. (2019). Predictive factors related to the waste collection behavior in Kerman City based on the Health Belief Model. *Tolooebehdasht*, *17*(5), 10-22. doi:10.18502/tbj. v17i5.310

Msengi, I. G. (2019). Development and evaluation of innovative recycling intervention program using the health belief model (HBM). *Open Journal of Preventive Medicine*, *9*(04), 29. Retrieved from https://www.scirp.org/html/1-1340642_92965.htm

Naslund, J. A., Aschbrenner, K. A., Kim, S. J., McHugo, G. J., Unützer, J., Bartels, S. J., & Marsch, L. A. (2017). Health behavior models for informing digital technology interventions for individuals with mental illness. *Psychiatric Rehabilitation Journal, 40*(3), 325–335. doi:10.1037/prj0000246

Newman, S. (2016). Informing patients about the cancer induction risk of undergoing computed tomography imaging: The radiographers' perspective. *Journal of*

Medical Imaging and Radiation Sciences, 47(4), 337–348. doi:10.1016/j.jmir.2016.07.008

Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence Based Nursing, 18*(2), 34–35. doi:10.1136/eb-2015-102054

Nyberg, L., Lövdén, M., Riklund, K., Lindenberger, U., & Bäckman, L. (2012). Memory aging and brain maintenance. *Trends in Cognitive Sciences*, *16*(5), 292-305. doi:10.1016/j.tics.2012.04.005

Oikarinen, H. T., Perttu, A. M., Mahajan, H. M., Ukkola, L. H., Tervonen, O. A., Jussila, A.-L. I., & Henner, A. O. (2018). Parents' received and expected information about their child's radiation exposure during radiographic examinations. *Pediatric Radiology.* doi:10.1007/s00247-018-4300-z

Pahade, J. K., Trout, A. T., Zhang, B., Bhambhvani, P., Muse, V. V., Delaney, L. R., … Goske, M. J. (2018). What patients want to know about imaging examinations: A multi-institutional U.S. survey in adult and pediatric teaching hospitals on patient preferences for receiving information before radiologic examinations. *Radiology, 287(2), 554–562.* doi: 10.1148/radiol.2017170592

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*, *42*(5), 533-544. doi:10.1007/s10488-013-0528-y

Paolicchi, F., Miniati, F., Bastiani, L., Faggioni, L., Ciaramella, A., Creonti, I., … Caramella, D. (2015). Assessment of radiation protection awareness and knowledge about radiological examination doses among Italian radiographers. *Insights Into Imaging*, *7*(2), 233-242. doi:10.1007/s13244-015-0445-6

Polit, D. F., & Beck, C. T. (2013). *Essentials of nursing research: Appraising evidence for nursing practice*. Philadelphia, PA: Lippincott Williams & Wilkins.

Perko, T. (2016). Risk communication in the case of the Fukushima accident: Impact of communication and lessons to be learned. *Integrated Environmental Assessment and Management, 12*(4), 683-686. doi:10.1002/ieam.1832

Pinheiro, J., Ribeiro, L. P. V., Rodrigues, S., Abrantes, A. F., Silva, C. A., & Almeida, R. P. P. A. (1970). Patient´s knowledge about radiation and radiological protection. *European Society of Radiology*, *B-0579*, 1-12. doi:10.1594/ecr2012/B-0579

Portelli, J. L., Mcnulty, J. P., Bezzina, P., & Rainford, L. (2015). Pediatric imaging radiation dose awareness and use of referral guidelines amongst radiology practitioners and radiographers. *Insights into Imaging, 7*(1), 145-153. doi:10.1007/s13244-015-0449-2

Poullis, C., Mackay, A., & Ahmed, M. (2015). When ignorance is not bliss - A study of poor awareness of radiation exposure. *Journal of Clinical Urology, 8*(6), 369-373. doi:10.1177/2051415813518918

Price, D. E. (1958). Radiation as a public health problem. *Public Health Reports (1896-1970)*, *73*(3), 197-202. doi:10.2307/4590082

Råheim, M., Magnussen, L. H., Sekse, R. J., Lunde, Å, Jacobsen, T., & Blystad, A. (2016). Researcher–researched relationship in qualitative research: Shifts in positions and researcher vulnerability. *International Journal of Qualitative Studies on Health and Well-being, 11*(1), 30996. doi:10.3402/qhw. v11.30996

Rai, R., Kumar, S., Batumalai, V., Elwadia, D., Ohanessian, L., Juresic, E., . . . Liney, G. P. (2017). The integration of MRI in radiation therapy: Collaboration of radiographers and radiation therapists. *Journal of Medical Radiation Sciences, 64*(1), 61-68. doi:10.1002/jmrs.225

Ria, F., Bergantin A., Vai, A., Bonfanti, P., Martinotti, A. S., Redaelli, I., . . . Samei, E. (2017). Awareness of medical radiation exposure among patients: A patient survey as a first step for effective communication of ionizing radiation risks. *Physica Medica, 43*, 57-62. doi:10.1016/j.ejmp.2017.10.014

Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social learning theory and the health belief model. *Health Education Quarterly*, *15*(2), 175–183. doi:10.1177/109019818801500203

Roulston, K., & Shelton, S. A. (2015). Reconceptualizing bias in teaching qualitative research methods. *Qualitative Inquiry, 21*(4), 332–342. doi:10.1177/1077800414563803

Sahiner, B., Pezeshk, A., Hadjiiski, L. M., Wang, X., Drukker, K., Cha, K. H., . . . Giger, M. L. (2018). Deep learning in medical imaging and radiation therapy. *Medical Physics, 46*(1), e1-e36. doi:10.1002/mp.13264

Salari, R., & Filus, A. (2017). Using the Health Belief Model to explain mothers' and fathers' intention to participate in universal parenting programs. *Prevention Science, 18*(1), 83-94.

Salerno, S., Nardi, C., Tudisca, C., Matranga, D., Vernuccio, F., Di Piazza, A., … Colagrande, S. (2018). Complete written/oral information about dose exposure in CT: Is it really useful to guarantee the patients' awareness about radiation risks? *La Radiologia Medica, 123*(10), 788-798. doi:10.1007/s11547-018-0909-0

Sayegh, P., & Knight, B. G. (2013). Cross-cultural differences in dementia: The sociocultural health belief model. *International Psychogeriatrics*, *25*(4), 517-530. doi:10.1017/S104161021200213X

Scali, E., Nicolaou, S., Kozoriz, M., & Chang, S. (2017). Senior medical students' awareness of radiation risks from common diagnostic imaging examinations. *Canadian Medical Education Journal, 8*(4), e31-e41. Retrieved from http://www.cmej.ca

Schnitzler, L., Smith, S. K., Shepherd, H. L., Shaw, J., Dong, S., Carpenter, D. M., … Dhillon, H. M. (2017). Communication during radiation therapy education sessions: The role of medical jargon and emotional support in clarifying patient confusion. *Patient Education and Counseling, 100*(1), 112–120. doi:10.1016/j.pec.2016.08.006

Schuster, A., Forman, H., Strassle, P., Meyer, L., Connelly, S., & Lee, C. (2017). Awareness of radiation risks from CT scans among patients and providers and

obstacles for informed decision-making. *Emergency Radiology*. doi:10.1007/s10140-017-1557-8

Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research, 3*(7), 749-752. Retrieved from http://www.allresearchjournal.com/archives/2017/vol3issue7/PartK/3-7-69-542.pdf

Sharma, M., Singh, A., Goel, S., & Satani, S. (2016). An evaluation of knowledge and practice towards radiation protection among radiographers of Agra city. *Scholars Journal of Applied Medical Sciences, 4*(6), 2207-2210. doi:10.21276/sjams.2016.4.6.70

Sheng, A. Y., Breaud, A. H., Schneider, J. I., Kadom, N., Mitchell, P. M., & Linden, J. A. (2016). Interactive learning module improves resident knowledge of risks of ionizing radiation exposure from medical imaging. *Current Problems in Diagnostic Radiology, 45*(4), 258-264. doi:10.1067/j.cpradiol.2015.11.002

Sherer, M. S., Visconti, P. J., Ritenour, E., & Haynes, K. W. (2018). *Radiation protection: In medical radiography* (8th ed.). St Louis, MO: Elsevier.

Shobeiri, F., Javad, M. T., Parsa, P., & Roshanaei, G. (2016). Effects of group training based on the health belief model on knowledge and behavior regarding the pap smear test in Iranian women: A quasi-experimental study. *Asian Pacific Journal of Cancer Prevention, 17*(6), 2871-2876. doi:10.apjcp.2016.17.6.2871

Singh, N., Mohacsy, A., Connell, D. A., & Schneider, M. E. (2017). A snapshot of patients' awareness of radiation dose and risks associated with medical imaging

examinations at an Australian radiology clinic. *Radiography, 23*(2), 94–102. doi:10.1016/j.radi.2016.10.011

Skinner, C. S., Tiro, J., & Champion, V. L. (2015). The health belief model. In *Health behavior: theory, research, and practice* (pp. 75-94). San Francisco, CA: Jossey-Bass.

Sorsa, M. A., Kiikkala, I., & Åstedt-Kurki, P. (2015). Bracketing as a skill in conducting unstructured qualitative interviews. *Nurse Researcher, 22*(4), 8-12. doi:10.7748/nr.22.4.8. e1317

Steele, J., Jones, A., Clarke, R., Giordano, S., & Shoemaker, S. (2016). Oncology patient perceptions of the use of ionizing radiation in diagnostic imaging. *Journal of the American College of Radiology*, *13*(7), 768-774.e2. doi:10.1016/j.jacr.2016.02.019

Swapna, L., Koppolu, P., Takarji, B., Al-Maweri, S., Velpula, N., Chappidi, V., & Ch, L. (2017). Knowledge on radiation protection & practice among dental students. *British Journal of Medicine and Medical Research, 19*(7), 1-7. doi:10.9734/bjmmr/2017/30761

Szarmach, A., Pickunowicz, M., Swieton, D., Muc, A., Mockallo, G., Dzierzanowski, J., & Szurowska, E. (2015). Radiation safety awareness among medical staff. *Polish Journal of Radiology, 80*, 57-61. doi:10.12659/pjr.892758

Talab, A. D., Mahmodi, F., Aghaei, H., Jodaki, L., & Ganji, D. (2016). Evaluation the effect of individual and demographic factors on awareness, attitude and performance of radiographers regarding principles of radiation protection. *Al*

Ameen Journal of Medical Sciences, 9(2), 90-95. Retrieved from http://ajms.alameenmedical.org/ArticlePDFs/5 AJMS V9.N2.2016 p 90-95.pdf

Tarkang, E. E., & Zotor, F. B. (2015). Application of the health belief model (HBM) in HIV prevention: A literature review. *Central African Journal of Public Health, 1*(1), 1-8. doi:10.11648/j.cajph.20150101.11

Teherani, A., Martimianakis, T., Stenfors-Hayes, T., Wadhwa, A., & Varpio, L. (2015). Choosing a qualitative research approach. *Journal of Graduate Medical Education, 7*(4), 669–670. doi:10.4300/jgme-d-15-00414.1

Thornton, R. H., Dauer, L. T., Shuk, E., Bylund, C. L., Banerjee, S. C., Maloney, E., . . . Hay, J. (2015). Patient perspectives and preferences for communication of medical imaging risks in a cancer care setting. *Radiology, 275*(2), 545-552. doi:10.1148/radiol.15132905

Tola, H. H., Shojaeizadeh, D., Tol, A., Garmaroudi, G., Yekaninejad, M. S., Kebede, A., … Klinkenberg, E. (2016). Psychological and educational intervention to improve tuberculosis treatment adherence in Ethiopia based on health belief model: A cluster randomized control trial. *PLOS ONE, 11*(5), e0155147. doi:10.1371/journal.pone.0155147

Tong, B. C., Wallace, S., Hartwig, M. G., D'Amico, T. A., & Huber, J. C. (2016). Patient preferences in treatment choices for early-stage lung cancer. *The Annals of Thoracic Surgery, 102*(6), 1837–1844. doi:10.1016/j.athoracsur.2016.06.031

Ukkola, L., Oikarinen, H., Henner, A., Haapea, M., & Tervonen, O. (2017). Patient information regarding medical radiation exposure is inadequate: Patients'

experience in a university hospital. *Radiography, 23*(4), e114–e119. doi:10.1016/j.radi.2017.04.001

Ukkola, L., Oikarinen, H., Henner, A., Honkanen, H., Haapea, M., & Tervonen, O. (2015). Information about radiation dose and risks in connection with radiological examinations: What patients would like to know. *European Radiology, 26*(2), 436-443. doi:10.1007/s00330-015-3838-5

Veiga, L. H. S., Holmberg, E., Anderson, H., Pottern, L., Sadetzki, S., Adams, M. J., … Lubin, J. H. (2016). Thyroid cancer after childhood exposure to external radiation: An updated pooled analysis of 12 studies. *Radiation Research, 185*(5), 473–484. doi:10.1667/rr14213.1

Verissimo, A. D. O., & Grella, C. E. (2017). Influence of gender and race/ethnicity on perceived barriers to help-seeking for alcohol or drug problems. *Journal of Substance Abuse Treatment, 75,* 54–61. doi:10.1016/j.jsat.2016.12.013

Vijayasarathi, A., & Duszak, R. (2019). How radiologists can benefit from direct communication with patients. *Current Problems in Diagnostic Radiology.* doi:10.1067/j.cpradiol.2019.03.002

Weber, W., & Zanzonico, P. (2017). The controversial linear no-threshold model. *Journal of Nuclear Medicine*, *58*(1), 7-8. doi:10.2967/jnumed.116.182667

Weltermann, B. M., Rock, T., Brix, G., Schegerer, A., Berndt, P., Viehmann, A., … Gesenhues, S. (2015). Multiple procedures and cumulative individual radiation exposure in interventional cardiology: A long-term retrospective study. *European Radiology*, *25*(9), 2567–2574. doi:10.1007/s00330-015-3672-9

Yin, R. (2011). *Qualitative research from start to finish*. New York, NY: Guilford Press.

Yin, R. K. (2014). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publication.

Yoon, H. J., & Kim, Y. J. (2016). Understanding green advertising attitude and behavioral intention: An application of the health belief model. *Journal of Promotion Management, 22*(1), 49–70. doi:10.1080/10496491.2015.1107006

Zanzonico, P. B. (2016). The neglected side of the coin. *Health Physics, 110*(3), 301-304. doi:10.1097/hp.0000000000000416

Zener, R., Johnson, P., Wiseman, D., Pandey, S., & Mujoomdar, A. (2018). Informed consent for radiation in interventional radiology procedures. *Canadian Association of Radiologists Journal, 69*(1), 30–37. doi:10.1016/j.carj.2017.07.002

Zhekova-Maradzhieva, Z., Velchovska, B., Uzunov, A., Ivanova, E., Petrova, D., Yordanova, M., & Valchev, G. (2017). The effect of X-ray radiation on the human body–pros and cons. Radiation protection in medical imaging and radiotherapy. *Scripta Scientifica Salutis Publicae*, *2*, 161-165. doi:10.14748/sssp.v2i0.4037

Appendix A: Interview Guide

RQ1: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive their susceptibility to medical radiation procedures?

1. What do you know about medical radiation?
2. When was the first time you underwent a radiation treatment?
    a. Radiation treatment or testing is a medical procedure that uses radiation. For this study, the focus is on radiation tests. These may involve radiation use for imaging, such as CT scan, MRI, or x-ray. What among these radiation tests are you aware of?
    b. What kind of medical radiation have you been exposed to in the past?
    c. For what purpose?
    d. How long was the entire treatment process?

RQ2: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the seriousness associated with medical radiation exposure?

1. What do you know about CT scan, MRI, or x-ray procedures?
    a. Can you please explain what you know about these types of procedures?
    b. How did you learn about this information?
    c. Do you trust the person or source where you got the information from? Why?

d. Do you think radiation exposure poses serious risks to you and the people around you (perceived susceptibility)? Why or why not?
e. What do you think are the effects or risks that radiation exposure poses on your health? How serious do you think these risks are? Please explain (perceived seriousness).
f. Is there anything you can do to minimize the risks? What are the things you can do to minimize these risks (perceived benefits of taking action)?
g. What will make you take action and mitigate the risks (cues to action)?
h. Are these action points for mitigating risks easy for you to implement? If so, how will you implement? If not, what are the barriers to these action points (barriers to taking action)?

RQ3: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the benefits of taking action associated with medical radiation exposure?

1. Do you think you know enough about the benefits and risks of having a CT scan, MRI, or x-ray to your body? Why?
2. Do you think having correct information about the risks associated with medical radiation tests is important (perceived seriousness)? Why?
3. What can you do to improve your knowledge about the risks associated with medical radiation tests (perceived benefits of taking action)?

RQ4: How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina currently perceive the barriers to taking action related to medical radiation exposure?

1. Are there any difficulties to the improvement of knowledge and awareness about the risks associated with medical radiation tests (problems that may prevent taking action)?
2. What do you think are the causes of these barriers?

RQ5. How do patients who either have undergone or are currently undergoing medical radiation exams in central North Carolina perceive the cues to action associated with medical radiation exposure?

1. What do you consider to be an indication that you should take action to prevent possible risks of medical radiation exposure?
2. How can you determine these signs?
3. What do you do about these signs?

Appendix B: Participant Screening Checklist

1. When is your birthday? (mm/dd/yyyy)

__ __ / __ __ / __ __ __ __

2. Have you undergone any of the following exams?

_____ x-ray

_____ MRI

_____ CT Scan

_____ Other forms of radiation exam: _____

2. When was the most recent time you had one of these exams?

_____ months ago

3. What exam was this? _____

4. What hospital or clinic did you go to for the exam? _____

5. Do you have a fear of conversing with a person you have just been acquainted with?

_____ Yes

_____ No

6. Are you pregnant or at a sensitive/vulnerable physical or psychological state?

_____ Yes

_____ No