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Job-Related Attitudes and Burnout Amongst Medical Physicists in the United States

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A Dissertation Study Submitted to Dr. Pallavi Patel College of Health Care Sciences

In Partial Fulfillment for the Requirement for the Degree of

Doctor of Philosophy in Health Science

1 June 2021

Nova Southeastern University
Dr. Pallavi Patel College of Health Care Sciences

We hereby certify that this dissertation, submitted by Deborah Schofield, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirement for the degree of Doctor of Philosophy in Health Science.

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Abstract

In the last forty-five years, burnout has evolved from a psychological fad to a validated syndrome included in both the 10th and 11th editions of the International Classification of Diseases by the World Health Organization. Numerous studies have been conducted to determine the prevalence and toll of burnout within the health care sector including within the field of oncology. However, the impact of this syndrome on medical physicists has been largely unevaluated. This dissertation study aims to fill the gap in the literature by examining job-related attitudes and burnout amongst medical physicists in the United States. The multi-dimensional theory of burnout provided the theoretical underpinnings of this cross-sectional correlational study. The survey instrument utilized in this dissertation study consisted of two questionnaires, the Maslach Burnout Inventory and an organizational survey tool based on version one of the Agency for Healthcare Research and Quality Survey on Patient Safety Culture. The Maslach Burnout Inventory was used to quantify the burnout burden amongst medical physicists in the United States. Additionally, the relationship between the emotional exhaustion domain and work hours, error reports, and organizational and safety features amongst therapeutic medical physicists was also determined.

Keywords: burnout, safety, medical errors, stress, medical physics

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Chapter 1: Introduction

Introduction to the Chapter

Over the last several decades, "burnout" has become part of the common lexicon and is often associated with extreme exhaustion. The World Health Organization included the term in the 10th edition of the International Classification of Diseases (ICD-10) and further expanded the definition in the ICD-11 manual (World Health Organization [WHO], 2019). Burnout syndrome is a work-related condition, typically identified in those employed in the caring professions, that consists of three dimensions: a) emotional exhaustion, b) cynicism/depersonalization, and c) reduced personal performance and achievement (Maslach, 2003a).

The emotional exhaustion component is the most commonly reported and studied aspect of burnout syndrome (Maslach et al., 2001) and can lead to increased rates of absenteeism and decreased job performance and engagement (Maslach & Leiter, 2008). However, the development of cynicism or depersonalization amongst care givers can result in negative consequences, such as inferior quality services for those receiving care, and aids in separating burnout from standard work stress (Maslach, 2003b). A decreased feeling of personal accomplishment can have devastating effects on the caregivers, including depression and/or the precipitation of the caregiver leaving the chosen employment field all together (Maslach, 2003a). While one of the primary goals of a medical physicist is to ensure safety, often with regards to the use of radiation in both therapeutic and diagnostic settings, burnout in this profession has largely been unstudied.

Background to the Problem

Numerous researchers have evaluated burnout in medical workers, including those employed in the oncology field. In one study, nearly 50% of practicing radiation oncologists demonstrated feelings of burnout while almost one-third of respondents also reported having insufficient time for personal endeavors (Pohar et al., 2013). In the United Kingdom, researchers found that 42% of radiation oncology staff, including physicists, suffered from "presenteeism"; a side effect of burnout that entails attending work while feeling unable to fulfill all the duties of the position (Hutton et al., 2014). Further, in a survey of chairs of academic radiation oncology programs, Kusano et al. (2014) reported that 75% and 0% of respondents were found to be suffering from moderate and high levels of burnout, respectively, while 25% of respondents were moderately to extremely likely to step down from their positions within 1–2 years. In comparison, chairs of academic anesthesiology programs have demonstrated the highest level of burnout (Kusano et al., 2014), with 62% and 28 % experiencing moderate levels and high levels of burnout, respectively, and 46% reporting that they were moderately to extremely likely to step down within the next 1–2 years (De Oliveira et al., 2011).

Apart from physicians, another key but under-researched group of health professionals are medical physicists. Medical physicists are professionals who apply the principles of physics to medicine. Diagnostic medical physicists, for example, oversee the quality assurance and implementation of medical imaging devices including, but not limited to, a) computed tomography (CT), b) mammography, c) x-ray, and d) magnetic resonance imaging (MRI) machines. Therapeutic medical physicists are employed to provide safe, quality care to patients receiving radiation therapy treatments, typically in response to a cancer diagnosis. Due to the nature of the work, these medical professionals can be subjected to high levels of both acute and

chronic stress (Johnson et al., 2019). A study using a National Aeronautics and Space Administration Task Load Index showed that therapeutic medical physicists have the highest workloads and the highest scores for mental demand and effort amongst all professionals (including physicians) working in radiation oncology (Mazur et al., 2012). Working in a caregiving occupation with high workloads and stress levels may make therapeutic medical physicists particularly susceptible to burnout. With the hallmarks of burnout being absenteeism, depersonalization, and decreased engagement in work, there is considerable risk associated with unrecognized burnout in these medical professionals tasked with ensuring that high levels of radiation are safely delivered to patients or ensuring that the imaging devices are performing at optimal levels for the appropriate and timely diagnosis of diseases.

Relevance

There are significant negative consequences for both those suffering from burnout as well as the patients who receive care from the burned-out professionals. West et al. (2006) reported a destructive cycle between burnout and medical errors with a 1-point increase in emotional exhaustion and cynicism/depersonalization on the Maslach Burnout Inventory scale, resulting in a 7% and 10% respective increase in the odds of a reported error in the ensuing three months. Another study with American surgeons found that, after controlling for other factors, burnout and depression were strongly associated with perceived errors while practice settings, the number of hours worked, and even the number of nights on call each week were not associated with perceived errors (Shanafelt et al., 2010). In addition to errors, the quality of care patients believe they receive has also been shown to be related to the burnout burden. After adjusting for patient age, severity of illness, race, and gender, satisfaction with the nursing care received was negatively correlated with the emotional exhaustion score of the providers (Vahey et al., 2004).

Errors made by the therapeutic medical physicist can have devastating consequences. Scott Jerome Parks, a 41-year-old New York man undergoing treatment for head and neck cancer, suffered a horrific death following a massive radiation overdose when a rushed medical physicist failed to conduct a quality assurance test prior to his treatment (Bogdanich, 2010). While errors made by most medical professionals affect a single patient, some errors made by medical physicists can affect many patients. At Moffitt Cancer Center in Tampa, Florida, and CoxHealth in Springfield, Missouri, a miscalibration by separate physicists resulted in a 50% radiation overdose in approximately 140 patients between the two facilities combined (Bogdanich & Ruiz, 2010). In 2019, a Canadian facility had to halt one of their programs after discovering that an error made by a physicist during commissioning resulted in the inappropriate targeting of radiation treatments in 25 cervical cancer patients (McQuigge, 2019). Failures in conducting routine testing of diagnostic equipment has also resulted in systematic errors affecting numerous patients. A high-profile example of this was when more than 200 patients were exposed to eight times the normal radiation dose levels during CT perfusion exams over an 18-month period at Cedars Sinai Hospital in Los Angeles (Zarembo, 2009). While the cause was linked to an error during the protocol creation by a hospital employee, the failure to perform routine quality assurance of all active protocols allowed this issue to continue until abnormal hair loss was reported by a patient.

Statement of the Problem

As mentioned, high levels of burnout have been reported amongst personnel involved in the medical/healing professions, including those working in radiation oncology. While multiple studies have evaluated burnout syndrome in physicians, residents, nurses, and radiation therapists, medical physicists have largely been ignored, a gap that has been previously identified

(Halkett et al., 2017). Further, several studies have indicated a link between errors made by practicing medical professionals and burnout. Given that a single error made by a medical physicist can propagate and affect multiple patients (Stern Rubin, 1978; Bogdanich & Ruiz, 2010; McQuigge, 2019), it is important to understand both the prevalence of burnout and the relationship between burnout and safety in this profession.

Elements

Theory

The multi-dimensional theory provided the foundation of this dissertation research. The psychological test selected for the dissertation study, the Maslach Burnout Inventory, was built on the acceptance of the multi-dimensional theory and provides a means to evaluate the three constructs of burnout – emotional exhaustion, depersonalization, and decreased personal achievement. Further, this theory provides for the appearance of a spectrum of burnout burdens that aide in explaining why a single remedy to the syndrome is unlikely.

Research Questions

The prevalence of burnout amongst medical physicists in the United States was unknown. There had also been no research to evaluate the relationship between burnout and other important factors such as organizational features or medical errors amongst therapeutic medical physicists. This dissertation research aimed to answer the following questions:

1. What is the prevalence of burnout amongst medical physicists in the United States?
2. Are there significant differences in the prevalence of burnout amongst medical physicists as a function of sub-specialty (i.e., diagnostic and therapeutic medical physicists)?

3. Are there significant differences in the prevalence of burnout amongst medical physicists as a function of clinic type (i.e., academic or non-academic facility)?
4. What is the relationship between emotional exhaustion and key organizational features amongst therapeutic medical physicists?
5. What is the relationship between emotional exhaustion, average hours worked weekly, department safety grade, and error reports submitted over the prior 12 months amongst therapeutic medical physicists?

Hypotheses

There is consistent evidence that medical workers suffer from high rates of burnout. With studies indicating that medical physicists routinely experience high levels of stress (Johnson et al., 2019), these medical professionals may be highly susceptible to experiencing burnout. Prior to conducting the dissertation study, this researcher hypothesized that:

1. More than 40% of medical physicists participating in this research would be experiencing a burnout burden in at least one of the domains.
2. A higher burnout burden would be identified in therapeutic medical physicists as compared to medical physicists practicing in other sub-specialties.
3. Medical physicists employed in a non-academic institution would have a higher burnout burden than those employed in an academic facility.
4. There would be a negative relationship between emotional exhaustion and key organizational features amongst therapeutic medical physicists.
5. In the therapeutic medical physicist cohort, there would be a negative relationship between emotional exhaustion, the number of events reported in the prior 12 months,

and the safety grade of the department. However, a positive correlation would exist between emotional exhaustion and the average number of work hours each week.

Definition of Terms

American Association of Physicists in Medicine (AAPM). The preeminent professional organization of medical physicists in the United States. The organization supports multiple peer-reviewed journals and publishes highly regarded scientific reports.

Burnout. A work-related condition comprised of the following dimensions: a) emotional exhaustion, b) cynicism or depersonalization, and c) reduced personal performance and achievement (WHO, 2019).

Cynicism and depersonalization. Cynicism and depersonalization are regarded as one of the hallmarks of burnout that results in the withdrawal from one's job and a lack of concern or negative opinions towards those seeking care from the caregiver (Leiter & Maslach, 2016). While some distancing may be necessary in caregiving professions, burnout results in an extreme form wherein those needing care can be dehumanized and caregiver responses can become callous (Maslach et al., 2001).

Diagnostic medical physicist. A physicist with specialty training in the safety and efficacy of diagnostic imaging.

Emotional exhaustion. Of the three dimensions of burnout, emotional exhaustion is the best known and most associated with the syndrome. Emotional exhaustion is a result of overload, chronic exposure to a high workload with low time and/or resources, that results in emotional depletion and a lack of energy to face another day of work (Maslach, 2003a).

Maslach Burnout Inventory-Human Services Survey. The Maslach-Burnout Index (MBI) is a validated survey tool designed to assess burnout in study participants.

Incident. Any event that, "under slightly different circumstances, could have been an accident" (Barach & Small, 2000).

Medical error. The Institute of Medicine (2000) defined medical errors as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim."

Near-miss. A near-miss may also be called a close-call. The Agency for Healthcare Research and Quality (2019) defines a near-miss as "an unsafe situation that is indistinguishable from a preventable adverse event except for the outcome." In other words, it is an error that was avoided either through an intervention or pure luck.

Personal accomplishment. Personal accomplishment can be defined as feelings of adequacy and competence (Kumar, 2007). The loss of these feelings is identified as the third facet of burnout.

Radiation oncology. A medical specialty wherein radiation is used in the treatment of a disease. The disease most typically treated in this profession is cancer.

Radiation oncologist. A medical doctor with specialty training in radiation oncology.

Therapeutic medical physicist. A physicist with specialty training tasked with ensuring the safe delivery of high radiation doses to patients.

Description of Variables

Independent Variables

An organizational features instrument was utilized to assess multiple aspects of the respondents' work environment. The instrument included questions around five themes: a) teamwork and staffing, b) feedback, c) responsibility, d) patient safety perceptions, and e) open communication and punitive concerns (Kusano, 2015).

Dependent Variables

The MBI was utilized to provide an assessment of the respondents' level of burnout burden by providing scores in each of the three dimensions of the syndrome – emotional exhaustion, cynicism/depersonalization, and decreased personal achievement.

Rationale

While modern medicine has provided amazing cures, safety in the medical field still lags far behind other high-reliability institutions and organizations. Medical errors have been cited as one of the leading causes of mortality with estimates of 44,000–98,000 deaths (Institute of Medicine, 2000) to over 250,000 deaths annually in the United States (Makary & Daniel, 2016). If such data is accurate, medical errors are one of the top causes of death in this country. Multiple studies have also demonstrated a relationship between medical errors and burnout, driving the need to determine burnout prevalence and its driving factors (Shanafelt et al., 2010; Tsiga et al., 2017; Tawfik et al., 2018).

One study, in which therapeutic medical physicists were included in the sample, found that 38% of staff were suffering from emotional exhaustion while 42% were suffering from presentism – the act of attending work without the emotional ability to fully perform the duties of the job (Hutton et al., 2014). In addition to responding to issues that arise throughout the day, medical physicists are often tasked with performing routine quality assurance after-hours, which extends their workday and decreases their autonomy and work-life balance. As the primary group responsible for ensuring the safety of both staff and patients, it is critical to understand the prevalence of burnout in medical physicists and the relationship between the syndrome and other contextual features such as organizational structure, work hours, and errors.

Assumptions

The organizational portion of the survey had participants rate their current employer and colleagues. Since this may be a sensitive topic, participants were assured anonymity and confidentiality to promote honesty in the responses. One of the primary assumptions of this dissertation research was that participants answered the survey honestly. Participants may have been unaware that they were suffering from the syndrome or may have been in denial due to the potential negative connotations associated with burnout. While honesty was assumed, utilizing the MBI further helped to minimize bias. In one study, the MBI and a single-item self-defined burnout question were administered to over 1000 participants, including 444 primary care physicians and 606 staff members. The single-item self-defined burnout question was found to underestimate burnout with a correlation between 0.48 and 0.63 ($p < 0.001$) between the two measures and the two groups, respectively (Knox et al., 2018).

The survey for the dissertation study was administered via a web application. Given that medical physicists work with multiple complex computer systems, it was assumed that all potential participants had access to the internet and would not be intimidated by a web-based survey platform. This was considered a reasonable assumption since multiple prior web-based surveys of the AAPM membership resulted in over 1,000 participants per study.

Summary of the Chapter

Burnout is a recognized, work-related syndrome that can have devastating consequences on both the burned out professional as well as the recipient of the services. While burnout was once considered to be primarily linked to workload alone, the multi-dimensional theory suggests that it is more likely linked to a mismatch between the job expectations/environment and the employee. Further, the syndrome can appear as any one of the permutations of the three

dimensions of the syndrome – emotional exhaustion, cynicism, and decreased personal accomplishment. Many studies have evaluated burnout in medical professionals. Despite medical physicists being responsible for the safe use of therapeutic or diagnostic equipment while maintaining high workloads and mental demands, these medical professionals have largely been overlooked in burnout research. Further, the relationship between burnout, organizational features, and errors amongst therapeutic medical physicists was unknown.

Chapter 2: Review of the Literature

Introduction to the Chapter

Since the introduction of burnout, numerous studies have been conducted to evaluate the impact of burnout on individuals employed in the caring professions. The phenomenon has been linked not only to a direct negative impact on the lives of the burned-out medical professional, but also to those to whom care is provided through a decreased quality of service and increased incidence of errors. In this chapter, the historical overview of burnout research will be discussed. The development of the MBI, the most widely used instrument to measure burnout, and the multi-dimensional theory upon which the MBI is based will be reviewed. The relevant research of burnout in radiology and radiation oncology will also be examined.

Historical Overview

Herbert Freudenberger (1974) is credited with the first use of the term “burnout” to describe the effects he observed, namely the emotional depletion and loss of motivation and commitment, with the volunteer staff at a free clinic for drug addicts and the homeless in New York City. The term ‘burnout” had been previously used to describe the destructive end effect of chronic drug use and was borrowed from the drug scene by Freudenberger (Schaufeli et al., 2009). As someone who had experienced burnout, his ensuing research focused on prevention and treatment rather than the underlying theory of the syndrome (Schaufeli, 2017).

Nearly simultaneously, Christina Maslach (2017) and her colleagues were working to study emotion and how individuals understand and process their feelings. The concept and necessity of “detached concern”, the limitation of emotional involvement in order to proceed with logical cognition in the midst of crisis, was being explored. However, an elevated level of emotional exhaustion and negative perceptions towards the clients was noted amongst human

service workers in California. Interestingly, these negative emotions were a known and recognized phenomenon amongst the workers who had also coined the term “burnout” to describe a constellation of symptoms (Maslach, 1976). Ultimately, the phenomenon of burnout was not sought by Maslach but was rather stumbled upon during research that would later be understood to be related.

While Freudenberger and Maslach published their introductory literature in the 1970’s describing burnout (and coining the term), it certainly was not a new phenomenon. The symptoms were known to practitioners and had even been previously described in both case studies and fictionalized stories. In *A Burnt-Out Case*, a novel by Graham Greene (1961), a world-renowned architect leaves everything behind to search for himself. He eventually lands in a leper colony in the Congo where he is defined as the cerebral version of a “burnt-out case” – the term used to define a leper whose body is rife with disease. An early and oft cited case study is that of psychiatric nurse Miss Jones, who experienced all the now identified dimensions of burnout while working on a ward with other burned-out staff (Schwartz & Will, 1953). The study follows the negative spiral that ensues as Miss Jones goes from being an optimist determined to deliver the best care despite bad circumstances, to experiencing feelings of emotional exhaustion, depersonalization with respect to her patients and colleagues, and loss of personal accomplishment as a result. Through intervention, Miss Jones is able to eventually regain control of her feelings while remaining in her job and again delivering quality care.

Though the earlier hints of the syndrome were present, the question is why burnout truly burgeoned and gained a foothold in the mainstream during the 1970’s. It has been theorized that the societal changes that occurred in the 1970’s, such as the increase in mobility and the ensuing loss of community and roots, along with an increase in the individuals’ alignment of self-worth

with their job or profession, created the perfect storm for the emergence and prominence of the syndrome (Farber, 1982). It has been further suggested that over the past several decades there has been a simultaneous shift amongst employers, with decreasing loyalty to employees and increasing demands to improve financial returns for stockholders, which likely contributed to the increase of burnout (Maslach & Leiter, 1997).

It is also interesting to note that the initial phases of burnout "research" were carried out by practitioners who were directly afflicted by or observing the effects of the disorder. Thus, many of the early articles were pragmatic and anecdotal as opposed to rigorous research. Academics initially rejected the concept of burnout as a fad and journals often rejected early articles on the topic. A manuscript on the MBI was "returned by some journal editors with a short note that it had not even been read because we do not publish 'pop' psychology" (Maslach & Schaufeli, 2017, p. 5).

Maslach Burnout Inventory

As mentioned, given that Freudenberger experienced burnout himself, he focused his investigational efforts primarily on burnout prevention and intervention. Christina Maslach, on the other hand, focused much of her initial research efforts on burnout theory and the creation of an instrument to identify and characterize it. Utilizing information collected from years of qualitative research, including personal interviews, Maslach and her colleagues developed the MBI, an instrument to objectively measure burnout in those employed in the caring professions. The preliminary version of the survey contained 47 items with two scores per item to account for the frequency and strength of the statement. After utilizing the survey on over 600 respondents, four factors were found to account for more than 75% of the observed variance (Maslach & Jackson, 1981). Maslach and Jackson (1981) used factors analysis, a technique to reduce the

number of variables, and reduced the MBI from 47 to 25 items covering the four identified factors of: a) emotional exhaustion (9 items), b) personal achievement (8 items), c) depersonalization (5 items), and d) involvement (3 items). The 25 items included those with the following criteria: "a factor loading greater than 0.40 on only one of the four factors, a large range of subject response, a relatively low percentage of subjects checking the 'never' response, and a high item-total correlation" (Maslach & Jackson, 1981, p. 101). A number of tests were conducted initially to validate the results including, for example, a cross-correlation of answers from respondents' spouses versus the scores from the MBI.

Three factors (emotional exhaustion, depersonalization, and decreased personal achievement) had an eigenvalue greater than one and were kept, while the three items associated with involvement were eliminated (Maslach & Jackson, 1981). The MBI in its current form consists of 22 items and utilizes only one scale to account for both frequency and intensity. The single scale provides for simplicity without affecting the overall impact of the inventory. The instrument contains questions to evaluate all three domains of burnout. Cronbach's alpha, a measure of internal consistency, has been found to be 0.7 or higher for all three sub-scores (Poghosyan et al., 2009). The expected time to complete the MBI is 10 minutes (Maslach et al., 2018).

The inventory has proven invaluable to providing an objective means of measuring burnout and has resulted in a dramatic increase in burnout research (Schaufeli et al., 2009) which helped the syndrome gain legitimacy within the scientific community. The multidimensional theory forms the foundation of the MBI and the use of the instrument is predicated on acceptance of the theory (Maslach, 2017). Further research also unveiled that individuals involved in fields other than the caring professions are susceptible to burnout (Maslach et al., 2018). As a result,

additional versions of the MBI were created and validated to identify and expand burnout research in those employed in sectors other than the caring professions. While burnout was first thought to be a North American phenomenon, the translation of the MBI into dozens of languages has helped to demonstrate that burnout is a global issue.

While the MBI has provided numerous benefits to the field, its limitations must also be acknowledged. Scores for each domain must be calculated separately and cannot be combined to generate a single burnout score. Further, while the instrument provides an objective means of measurement, sufficient research does not exist to utilize the instrument as a diagnostic tool to identify with certainty the absence or presence of burnout in an individual (Maslach et al., 2018).

Multi-Dimensional Theory

The theories of burnout, including causes, prevention, and treatment, continue to evolve. While once thought to only afflict those in the caring professions in North America, the body of research now suggests that burnout is a global phenomenon and extends beyond just those entrenched in caring professions. Even individuals engaged in non-paid positions, such as volunteers and students, have been identified as being susceptible to the syndrome.

In addition to identifying three core dimensions of burnout, including a) emotional exhaustion, b) cynicism/depersonalization, and c) reduced personal performance and achievement (Maslach, 2003a), the multi-dimensional theory also provides additional avenues to understand why and when burnout will occur. In particular, the multi-dimensional theory provides for six means for a person-job mismatch. The six mismatches described by Maslach (1998) include: a) workload that exceeds human limits (i.e., high workload with low time and/or resources), b) lack of control/autonomy, c) lack of recognition or reward, d) lack of positive connection at work with colleagues that can lead to increased frustration and decreased social

support, e) inequity or lack of fairness, and f) conflict between an individuals' code of ethics and the job requirements. The larger the mismatch, the higher the likelihood that burnout will occur, often resulting in either the subject leaving their job or field of work or staying in the position but with poor performance (Maslach & Goldberg, 1998). While many jobs will have acute periods of stress and high workload, it is the chronic condition of high workload and stress without appropriate time and ability to recover that can lead to a higher burnout burden (Maslach & Leiter, 2008).

The multi-dimensional theory also includes engagement, the diametrically opposed position of burnout (Maslach, 1998). The results of more current research suggest that there are several permutations of the three dimensions of burnout (emotional exhaustion, cynicism, and loss of personal achievement) that can occur on the continuum between engagement and burnout, thus negating the concept that a singular remedy is beneficial for all who suffer from the disorder (Leiter & Maslach, 2016). It has also been suggested that individuals demonstrating burden on one or two dimensions represents an unstable pattern. In essence, it is thought that this pattern can serve as a warning sign of the potential to progress to full burnout (across all three dimensions) in the absence of some sort of intervention or relief (Maslach & Leiter, 2008).

Alternate models have also been proposed to explain those factors that contribute to burnout. The conservation of resources (COR) theory, for example, suggests that workers assign high value to job resources such as sufficient staffing in their workplace, stability of income, and continuing education (Hobfoll & Freedy, 2017). Perceived or implicit threats to highly valued resources can result in workplace stress and precipitate burnout. Further, the theory suggests that individuals are more sensitive to the loss of resources than they are to gains. Joyner & Leake (2018) framed this concept in terms of a member of the armed forces, "… should a service

member lose a comrade in battle, receiving a medal to recognize her/her exemplary efforts during the battle would not mitigate the loss of a friend." While the COR theory has been used alone to explain burnout, it appears incomplete to explain the phenomena in totality. Instead, the theory likely compliments and expands on the workload/resource mismatch identified in the multi-dimensional theory.

Medical Errors

Since the publication of the Institute of Medicine's landmark publication *To err is human: Building a safer health system* (2000), considerable attention has been placed on medical errors. Yet the medical field has often been slow to acknowledge and embrace the lessons learned from other high-reliability organizations, including those in the field of aviation. For example, pilot fatigue was determined to be a contributing factor in the 2009 crash of a Colgan airplane outside of Buffalo, New York, resulting in the death of 49 people. Despite the airline industry already having hard limits in place to limit the number of continuous hours worked by a pilot, these regulations were further expanded as a direct result of this crash. Maximum-allowed flight times were limited to 9 hours per day, with additional considerations for factors such as the number of time zones crossed and the time of the first flight; a guaranteed 10 hours of rest between work shifts was implemented (Tumulty, 2014).

In 2019, a decade after the Colgan flight 3407 crash, a research article in *The New England Journal of Medicine* suggested there was no negative impact in care provided by residents working either 16 or 28-hour shifts (Silber et al., 2019). The authors thereby suggested that resident program directors should have the ability to schedule longer shifts as needed, a restriction that had been put in place after an error made by a fatigued resident resulted in the death of an 18-year-old student. In Wisconsin, experienced nurse Julie Thao worked nearly 17

straight hours in a busy labor and delivery unit and returned for a third shift after having less than 6 hours of sleep when she made a fatal error (Wahlberg, 2006). Not only did the patient lose her life, but Julie was fired from her position, criminally charged for the error, and was temporarily admitted to an inpatient psychiatric care facility due to the stress of the event. Data from 1,812 AAPM members working in community and academic hospitals demonstrated 59.5% and 38% of respondents work more than 45 and 50 hours, respectively, each week (AAPM, 2020). While it is unclear how the work hours are distributed (including the amount of time between shifts for rest and recovery), there is concern that the hours and high mental demand experienced by a medical physicist could create an environment ripe for error propagation.

Mistakes made by a single physicist can affect hundreds of patients. In 1973, a new physicist, without enough experience to sit for a board certification exam, was hired at Riverside Methodist Hospital. The new physicist worked alone, without anyone to double-check his work, and was tasked with an extraordinarily high workload that often left him working 12 or more hours a day, seven days a week. Over a period of two years, proper quality assurance testing was omitted and a mistake in the Cobalt-60 treatment time calculations went unnoticed. The error resulted in approximately 400 patients being over-radiated (Stern Rubin, 1978).

Non-maleficence is a cornerstone of medical ethics and the majority of caregivers enter the field to positively impact the lives of those in need. Methods to reduce errors, such as an increase in the use of technology and incident learning, cannot be all-encompassing solutions. The human beings involved in the caregiving must not be overlooked. Health care professionals may be ripe for both burnout and the commission of errors due to working in settings with decreased resources, such as staff and equipment, increased workloads, and complex health care situations.

The Organization

Despite evidence that burnout is influenced by organizational culture and is bad for business, many employers fail to address underlying issues within the workplace that can promote burnout. Instead, the syndrome is often perceived to be a "personal issue" and those who suffer from it are deemed incapable of handling professional pressure. Instead of providing work-related resources, such as sufficient staffing, work-life balance, or autonomy over one's schedule, there is an expectation that it is the individual's responsibility to handle the stress (Maslach & Leiter, 1997). In a review of 25 studies on intervention effectiveness, Awa et al. (2010) found that long term reduction in burnout was achieved through a combination of both organizational and personal interventions, while personal interventions only were associated with just short-term improvement.

The results from one meta-analysis determined that organizational interventions, including structural and workload changes, had a greater impact on burnout reduction in physicians when compared to personal interventions such as mindfulness techniques (De Simone et al., 2019). In a systematic review, DeChant et al., (2019) found that organizational changes, such as the utilization of a team approach for patient care and decreased documentation burden, had a positive effect on burnout reduction amongst physicians while another study demonstrated that the leadership rating of a direct superior was negatively correlated with burnout amongst their direct reports (Shanafelt et al., 2015). The Civility, Respect, Engagement in the Workforce (CREW) model was developed to address organizational level issues in the workplace that can negatively impact burnout, staff retention, and health care outcomes (Osatuke et al., 2009) and the American College of Radiology called upon practices to make significant changes to their organizations, including appropriate staffing, restoration of work-life balance, and improved

efficiency through the use of scribes, in order to curb the annual increase in burnout amongst radiologists (Harolds et al., 2016).

Burnout in Radiology

Guenette and Smith (2017) conducted an evaluation of burnout in radiology residents. Potential participants (n = 472) were contacted about the study via the 20 radiology resident program directors in New England. The study included nine demographic questions and the MBI. A total of 94 responses were received (20% response rate), which revealed that 37%, 48%, and 50% of respondents were experiencing high levels of emotional exhaustion, depersonalization, and decreased personal achievement, respectively. The study also found a positive correlation between burnout and years of residency, suggesting that burnout increases with each year of residency. While the researchers used an objective measure to determine burnout in this subgroup, the small sample size and response rate are limiting factors. The use of recruitment via program directors may be partially to blame for the low response rate due to concern that results might be shared with the program. Further, emotional exhaustion is often the most common (i.e., highest prevalence) dimension of burnout. It is concerning that 50% of the individuals scored highest on decreased personal achievement. This casts some doubt on the applicability of the results to the larger population of radiology residents.

A 2018 survey of radiology practice managers across the United States was conducted as part of an annual workforce study (Parikh et al., 2020). A total of 367 practice managers (23% response rate), representing 30% of practicing radiologists, responded to the survey. A staggering 77% responded that burnout was either a very significant problem (55%) or a significant problem (22%). Geographic location had no significant impact on the results. While the majority of respondents indicated that burnout was a serious issue, only about one in five had

a mechanism to measure burnout or address the issue. This study represents an interesting approach wherein an observer was utilized to indicate the impact of burnout on radiologists. While this negates the ability to utilize the MBI, it does provide a measure of the observed impact of the syndrome on colleagues and patients.

Burnout in Oncology

A number of burnout studies have been conducted with oncology staff members in both the United States and other countries. A cross-sectional nationwide burnout survey was conducted with oncology personnel in Australia (Girgis et al., 2009). A total of 740 respondents were included in the survey, representing 56% of the Clinical Oncological Society of Australia members. In addition to demographics questions, the survey consisted of the following: a) the MBI to provide an objective measure of burnout, b) a psychological distress survey, c) a communication skills survey, d) a single question asking respondents to rate their level of burnout, and e) open-ended questions seeking to identify causes and prevention of burnout. One-third of oncology professionals whose position included direct patient contact were found to be suffering from burnout versus 26.7% of oncology professionals without direct patient contact. The odds ratio for experiencing emotional exhaustion increased with increasing hours of direct patient contact each week. For example, the odds ratio for experiencing the emotional exhaustion dimension of burnout was 0.86 with $\leq$ 10 hours of direct patient contact weekly versus an odds ratio of 2.24 with $\geq$ 31 hours of direct patient contact per week. The authors did note that the single question to self-rate burnout was highly correlated ($r = 0.56$, $p < 0.001$) with the emotional exhaustion results from the MBI. While this research has a large sample size, one potential issue is the heterogeneity of respondents. The research was inclusive of participants from different sub-specialties within oncology (e.g., radiation and medical oncology) and different professions

(e.g., nurses, other clinical staff, researchers, and administrators). Nurses made up the bulk (53% of respondents) while other health professionals, defined as psychiatrists, psychologists, pharmacists, social workers, dieticians, and counselors, only comprised 12% of the sample. As a result, the application of the results to other professions, even within oncology, may be difficult due to their underrepresentation in the sample. It is also important and interesting to note that 79% of respondents were female, leading to further concerns about the sample. Another potential issue with this study is the introduction of the term burnout in the survey. The creators of the MBI strongly advise researchers to avoid using the term burnout in order to limit potential bias by the introduction of the concept. The same issue of potential bias was present in a recent study evaluating needs for social support amongst medical physicists primarily based in the United States. While it was not the primary aim of the research study, a single question asking respondents about their level of burnout was included in the survey. More than 70% of over 1,000 respondents indicated that they experienced some level of burnout (Johnson et al., 2019).

In the United Kingdom, a study was undertaken to determine burnout amongst therapy radiographers (Probst et al., 2012). Radiation therapists interact with patients under treatment every day and are responsible for the delivery of the radiation treatments. A total of 87 respondents (25.3% response rate) completed the entire survey, which included the MBI, to determine burnout in this profession. Nearly 40% of respondents demonstrated emotional exhaustion. Further, a correlation was found between burnout, job satisfaction, and intention to leave the job. While the researchers did utilize the MBI to obtain an objective measure of burnout, they obtained access to participants via agreements with department managers. The low response rate may be attributed to concern that department managers may receive or have access

to the results. Further, it is unclear how well the sample represents the larger population since some potential participants may have been excluded by unwilling department managers.

Guerra & Patricio (2018) conducted a systematic review and meta-analysis on burnout in radiation therapists. Non-duplicate research articles that used a validated burnout survey tool and published in English, Portuguese, or Spanish were chosen for inclusion. A total of 10 studies from six countries that met the inclusion criteria were found. Eight of the ten studies utilized the MBI as the burnout survey tool. The pooled prevalence of emotional exhaustion was 38.7%, depersonalization was 21.5%, and decreased personal accomplishment was 28% amongst radiation therapists. The researchers noted that there was a large variation in both response rates and burnout across the studies. A portion of this variation was attributed to cultural differences across the six countries from which the articles originated. It was further noted that the two articles that did not utilize the MBI added an additional layer of difficulty in correlating responses and results.

Canadian researchers also used the MBI to investigate burnout amongst oncology residents (Dahn et al., 2019). Over 40% of the 57 respondents were found to be experiencing burnout and a significant association between burnout and less than eight hours of sleep per night ($p = 0.02$) was identified. While the authors did use an objective measure to measure burnout (i.e., the MBI) in the respondents, the sample was comprised of a heterogenous group of three oncology sub-specialties including radiation oncology, medical oncology, and hematology. Further, some respondents were contacted and enlisted via their program director. Respondents may have been less than truthful if there was concern that results would be shared with the program directors. There is also concern about how well the results represent the larger population given the small sample size and the lack of group homogeneity. Ramey et al. (2017)

conducted a similar study in the United States. Unlike the Canadian study, the study had a larger sample size and participation was limited to radiation oncology residents. Using the MBI, one-third of the 232 respondents scored high on either emotional exhaustion or depersonalization, with 6% reporting that they felt "at the end of their rope" at least weekly. While researchers utilized an objective measure (i.e., the MBI) to determine burnout, they again also utilized program directors to help recruit participants. As in the Canadian study, this leaves the potential that some respondents may have been less than truthful due to concern that results would be shared with the program director. The issues present in the American and Canadian studies were rectified by Leung and Rioseco (2016) in a burnout study with radiation oncologist trainees in Australia and New Zealand. Nearly 50% of the 107 respondents demonstrated emotional exhaustion or depersonalization while 13% demonstrated high scores in all three dimensions of burnout. The MBI was utilized to obtain an objective measure of burnout and researchers contacted potential participants directly via email. Further, the response rate was nearly 80%, indicating that the results should represent the larger population well.

A German study looking to quantify burnout in radiation oncology workers included medical physicists in the sample (Sehlen et al., 2009). Local coordinators at 11 centers distributed and recollected the questionnaires. A total of 406 individuals participated with only 39 (10.8%) respondents being medical physicists. The study utilized the "Stress Questionnaire of Physicians and Nurses", which consists of 42 items, many of which are specifically tailored to physicians and nurses. Example survey questions include the following: "We don't have enough single rooms for mortally ill patients" and "It happens that several patients lie dying at the same time." These conditions represent situations that physicists would not normally be exposed to. It is unsurprising, with the chosen instrument, that physicians and nurses scored higher on job

stress than physicists. As a result of using a questionnaire that is customized to test stress amongst other medical professionals, the results of this study may not accurately or fully reflect the unique stressors experienced by medical physicists.

Just recently, a study was conducted to evaluate burnout amongst therapeutic medical physicists in Europe (Di Tella et al., 2020). A total of 308 participants were included in the study. A quality-of-life instrument, utilized to determine the level of burnout burden amongst the cohort, demonstrated that 30% of medical physicists scored high in burnout. In addition to determining the prevalence of burnout, the study also found a significant relationship between burnout, empathy, and alexithymia, the inability (or difficulty) to understand and relate to emotions. While the authors utilized known instruments to assess all three aspects, burnout was not assessed or reported using the three standard burnout domains. Instead, the burnout scale used appears to be a subset of the compassion fatigue portion of the instrument, and measures items such as frustration, job effectiveness, and hopelessness. Thus, the equivalency of burnout assessed in this manner, compared with the "gold-standard" MBI, is unknown. Additionally, respondents were recruited from across Europe with no data on their country of origin or healthcare setting (i.e., government hospital or private clinic). It is also unclear how the results of a study in the primarily socialized medical environment in Europe will translate to the medical environment in the United States.

Summary of the Literature

The concept of burnout appeared on the scene in the 1970's when two researchers on different coasts of the United States identified a pattern of negative emotional consequences in workers employed in the caring fields. Interestingly, in both cases, the phenomenon was noticed by those working in the trenches and thus inspired a new line of research. While originally

considered to be a fad, the introduction of the multi-dimensional theory and the MBI prompted many studies, resulting in an evolution of burnout theories and prevention strategies. Burnout became a legitimate effect that could have a significant negative impact not only on the workers suffering from the syndrome but also those receiving services from the afflicted, including the higher possibility of medical errors. Despite a link between the characteristics of an organization and burnout, many employers have ignored the problem or relegated it to a "personal issue" that can be overcome with personal intervention such as meditation or wellness regimens.

Numerous studies have demonstrated high rates of burnout amongst medical professionals, including in the fields of radiology and radiation oncology. Medical physicists have often been completely overlooked in these studies or were a small percentage of respondents included with other health professionals. Only one study has recently been published to look at the effect of burnout amongst therapeutic medical physicists. However, there are limitations to this study including the use of a non-standard burnout inventory for prevalence assessment. This dissertation study is therefore essential as it utilizes the MBI to examine burnout in medical physicists in the United States, filling the identified gap in the literature.

Chapter 3: Methodology

Introduction to the Chapter

Medical physicists are tasked with ensuring safety to both patients and staff as well as making sure that the medical equipment for diagnostic and therapeutic purposes is properly used. Most errors made by medical professionals are random and affect a single patient. However, in addition to random errors affecting a single individual, there is a risk for systematic errors in the field of medical physics that can impact hundreds of patients.

This dissertation work was conducted with existing instruments to determine the prevalence of burnout amongst medical physicists, including the impact of sub-specialty and clinic type on the prevalence of the syndrome. Beyond just identifying trends in prevalence, the aim was also to investigate the relationship between burnout and organizational features, work hours, and the number of error reports amongst those in the therapy sub-specialty. This chapter provides an in-depth review of the study design utilized in this dissertation study, including the theoretical underpinnings, participant selection, ethical consideration, threats to the internal and external validity of the results, and other components of the methodology.

Research Design and Methodology

Theoretical Underpinnings

Post-positivism provided the epistemological and ontological basis of the dissertation study. Post-positivism moves beyond the positivist era and acknowledges the ability to study that which is not directly observable (i.e., emotions), the recognition of bias on behalf of the researcher, the likelihood of error in experimentation, and the need to revise theories to reflect updated data and results (Mackenzie & Knipe, 2006). The theoretical underpinnings of post-positivists are associated with quantitative research, based on some level of *a priori* knowledge,

including the following research methodologies: a) correlational, b) causal-comparative or experimental, and c) quasi-experimental. The topic of burnout, as well as some of the constructs in the organizational instrument, are inherently based on subjective measures of emotions and feelings, necessitating a theoretical foundation that supports the measure of characteristics that are inherently not directly observable.

Study Design

The dissertation study utilized a quantitative research design to collect primary data. A cross-sectional correlational study of medical physicists practicing in the United States was conducted utilizing pre-existing survey instruments. Demographic questions included in the instrument were developed to identify respondent characteristics such as sub-specialty, years in practice, work setting, and the impact of COVID-19 on job-related feelings. Given that the relationship between the geographic and cultural setting on burnout prevalence is still inconclusive, a single question was also included in the demographics portion of the survey to collect data on the percentage of time each respondent has lived in North America.

Rationale

Due to the nature of the study, it was neither practical (nor ethical) to conduct a true experimental study to produce burnout in an investigational group. While a cross-sectional correlational research study has inherent limitations that must be acknowledged, it was a reasonable and appropriate method to obtain information on the burnout burden amongst medical physicists working in the United States and to determine the impact of sub-specialty and clinic type (i.e., academic or non-academic) on the prevalence of the syndrome.

With the potential for severe, systematic errors to propagate to numerous patients, a correlational study design was an appropriate method to determine the relationship between

burnout, clinic features, work hours, and errors. It is also important to note that the creators of the MBI recently noted that additional burnout research is "badly needed", particularly that which considers institutional contexts that shape the work experience (Maslach et al., 2018, p. 5). This provided further justification for the utilization of an organizational instrument in this study to investigate the relationship between the MBI and the specific work-related features in the therapeutic medical physicist.

Internal Validity

Internal validity is the level of confidence in the derived relationship between variables. It can be impacted by the reliability of the survey tool utilized to test the constructs. To address this threat, this dissertation study employed survey tools that had been previously evaluated by other researchers using either a Cronbach alpha statistic or test-retest reliability.

Beyond the reliability of the instruments, additional threats to the internal validity of the dissertation study were the participants history, or the events that occurred prior to or during the survey. For example, a demographic question to assess the impact of the COVID-19 pandemic was included to account for its impact on the internal validity of the survey. The survey was kept as short as possible to minimize experimental mortality.

External Validity

External validity is the extent to which the results of the research are generalizable to the population. Burnout is a hot button topic and individuals have a variety of opinions on it. The practice of avoiding the term "burnout", to prevent participant sensitization, is suggested by the creators of the MBI. The MBI manual further states that the survey should be promoted using terms such as "wellness" or "job-related attitudes." To avoid the intentional or unintentional swaying of results and increase external validity, participants were unaware that they were

participating in a burnout study. Instead, participants in this dissertation study were recruited to a survey on job-related attitudes amongst medical physicists working in the United States.

Convenience sampling was utilized in this dissertation study with recruitment materials sent to one-half of the AAPM "full-member" roster. In addition to providing a large population for study recruitment, all individuals who apply for a full membership are vetted by the organization to ensure appropriate educational and employment status. However, there is no clear data to demonstrate how well the membership of the organization represents the profession as a whole. Currently only the states of Florida, Texas, and New York require medical physicists to be licensed in order to practice. Individuals are also able to practice, to varying degrees based on local regulations, without board certification thereby negating the ability to use licensure and board certification databases as a measure of the number of practicing medical physicists in the country. Data from the U.S. Bureau of Labor Statistics (2011) suggests that there are less than 17,000 physicists total in the United States. However, the data lacks the granularity to determine labor statistics as a function of physics sub-specialty. In a presentation on the status of medical physicists, a researcher from McGill University (Podgorsak, 2010) stated that there were roughly 18,500 medical physicists globally, with developed countries having approximately 15–20 medical physicists per million people. Utilizing this statistic and a population of 330 million people, a range of 4,950–6,600 medical physicists in the United States was predicted. Based on the totality of the information, the AAPM membership was assumed to be representative of the profession. A large sample size aided in limiting the impact of both internal and external threats to the dissertation study, including participants completing the survey in an uncontrolled environment, self-selection bias, and the convenience sampling used in this dissertation study.

Study Setting

Subject Characteristics

Medical physicists are highly trained medical professionals. All participants have a graduate-level education (master's or Ph.D.) in physics or a closely related subject. The resulting sample had nearly equal representation from both individuals employed in academic and non-academic facilities. Approximately three-fourths of respondents reported working as therapeutic medical physicists, which is in good agreement with the characteristics of the AAPM membership.

Power

A type II error is the failure to identify and accept an alternate hypothesis (i.e., the null hypothesis was accepted incorrectly). The statistical power provides the sensitivity of the study or how likely it is that a type II error is avoided. An underpowered study can provide incorrect results that mar the significance and legitimacy of the research. Power is influenced by several factors, including: a) effect size, b) significance level, and c) statistical tests. For this dissertation study, a significance level of $\alpha = 0.05$ and a power of 0.80 ($\beta = 0.20$ where β = 1-power) was used. Correlation coefficients can hold any value between -1 and +1 with a value of 0 indicating no correlation. While the correlation between two variables increases as $|\rho|$ approaches 1, it would be a disservice to only consider an effect size approaching +/-1. Correlation values of +/-0.1, +/-0.3, and +/-0.5 are often associated with small, medium, and large effects, respectively (McLeod, 2019). A medium effect size ($|\rho| = 0.30$) was utilized in upfront power calculations for this dissertation study. In the analysis of burnout burden as a function of clinic type, several similar types (e.g., community, free-standing, and government-based) were combined to form a non-academic clinic grouping to increase statistical power. Multiple specialties including

diagnostic, nuclear medicine, and health physics were combined into a single non-therapy grouping to aid in the statistical power of tests based on sub-specialization.

Sample Size

A calculation was conducted up-front to provide an estimate of the requisite sample size needed to meet the selected power. With an $\alpha = 0.05$, a power of 0.80 ($\beta = 0.20$), and an effect size of $|\rho| = 0.30$, the minimum required sample size was determined ($n = 85$). There were 337 total overall participants included in the dissertation study, which exceeded the calculated minimum sample size required for the desired power.

Inclusion Criteria

Half of the AAPM full-member roster was approached for this study. Participants were employed by a single employer in the United States at the time of the survey. Since there is no known time threshold below which burnout fails to occur, level/years of experience was not considered as an inclusion factor. However, a demographic question was included to collect data on the participants' years of postgraduate work experience.

Exclusion Criteria

Individuals still in training, including students, medical physics residents, and post-doctoral fellows, are not considered full members of the organization and were excluded from the study. Medical physicists employed by a vendor were also excluded due to a lack of direct clinic and patient care responsibilities. In addition, participants working as a full-time consultant, providing services to multiple institutions/clinics concurrently were also excluded. Individuals working in multiple institutions simultaneously may lack the in-depth knowledge of any one clinic to fully answer the questions or may provide answers based on an aggregate experience across multiple facilities.

Recruiting Procedures

After obtaining approval from the Institutional Review Board, permission was obtained from the AAPM to query one-half of the full members of the society for this study. The organization provided the email addresses for recruitment purposes. Email requests for participation were sent to 1,958 members (Appendix A). Follow-up emails were sent to those who had not responded or who had only partially completed the survey at approximately the half-way point and 24 hours prior to the close of the survey.

Specific Procedures

Instruments and Measures

Several demographic questions (Appendix B) were included as part of the instrument for this dissertation study. The demographic questions were used to verify that participants met the inclusion criteria and to evaluate the relationship between demographic features and burnout burden (e.g., academic or non-academic setting). Additional items were included in the demographics portion to account for feelings related to the COVID-19 pandemic as well as any cultural or geographic variations in burnout.

The MBI was utilized in this dissertation study to quantify burnout burden. The MBI has been used in over 90% of burnout research publications and dissertations (Schaufeli et al., 2009) and is considered the gold standard in this field of research. The instrument was purchased from Mindgarden, a provider of validated psychological assessment tools, with permission to administer the instrument using an independent web-based hosting environment. The MBI questionnaire utilizes a Likert scale on 22 items to provide burnout scores across each of the three domains. Due to copyright, the full MBI cannot be reproduced. However, three sample items, one from each of the burnout domains, can be reproduced. The MBI example items for

emotional exhaustion, personal accomplishment, and depersonalization respectively are a) “I feel emotionally drained from my work,” b) “I have accomplished many worthwhile things in this job,” and c) “I don’t really care what happens to some recipients” (Maslach et al., 2018).

An organizational survey tool (Appendix C) was utilized to assess organizational features, safety culture, and the number of reported errors. The original instrument was developed and validated by the Agency for Healthcare Research and Quality (2018) to be used in any medical setting and is open for public use. The survey underwent slight adaptations and has been utilized in the radiation oncology-specific environment (Hartvigson et al., 2019). This survey tool was chosen due to the five themes included within the single instrument. It provided the ability to evaluate multiple organizational facets that may be correlated with burnout, such as teamwork and social support, as well as errors/safety culture, while limiting the number of instruments utilized and the time for completion. In addition, this instrument has already been used in multiple peer-reviewed articles with a similar target audience as this dissertation study.

Reliability and Validity

It has been suggested that reliable instruments have a minimum Cronbach alpha score of 0.70 (Tavakol & Dennick, 2011). One study found that all three dimensions measured by the MBI has a Cronbach alpha of 0.70 or higher (Poghosyan et al., 2009). With thousands of published burnout articles, a meta-analysis was also performed to confirm the reliability of the MBI. Based on 84 articles where coefficients were provided for the MBI, Wheeler et al. (2011) found that the mean Cronbach alpha coefficient was between 0.70 and 0.80 for all three dimensions measured by the instrument, with the emotional exhaustion scale having the highest mean score.

The organization instrument utilized in this dissertation study was based on the Agency for Healthcare Research and Quality Hospital Survey on Patient Culture (version 1.0). The original version was found to have a mean Cronbach alpha coefficient of 0.77 (range: 0.62 to 0.85) across all dimensions evaluated by the study with the staffing dimension having the sole Cronbach alpha score below 0.70 (Sorra & Dyer, 2010). As mentioned, the original version underwent slight adaptations and was utilized in the radiation oncology-specific setting. While a Cronbach alpha coefficient was not reported for the adapted version of the survey, the instrument was utilized for multiple years within the same clinic with consistent results suggesting test-retest reliability (Hartvigson et al., 2019). In this dissertation study, a Cronbach alpha coefficient was calculated for each of the MBI domains as well as the investigated constructs of the organizational tool.

Strengths and Weaknesses

The ability to conduct a study to investigate relationships quickly and efficiently between variables was one strength of this research design. While a correlational study allows an evaluation of relationships between variables, it precludes the ability to draw conclusions about causation. The lack of causation was the largest weakness of this study design. Another weakness of this design was that relationships cannot be extrapolated beyond the acquired data. Finally, due to the cross-sectional nature of the research, the results represent a single moment in time and long-term implications cannot be determined.

Ethical Considerations

Individuals experiencing burnout may be in a fragile psychological state. Further, honest reporting of errors as well as rating one's employer and colleagues, even in the absence of burnout, can be a delicate topic. While this dissertation study was not an experimental design,

there was acknowledgement of the ethics of handling sensitive data. All data was collected anonymously and treated in a confidential manner. The participation letter (Appendix A) indicated that participants could withdraw from the survey at any time and should do so if the questions induced significant stress or discomfort. Further, the participation letter indicated that continuing to the survey would indicate consent for the study.

Resource Requirements

SurveyMonkey (https://www.surveymonkey.com), an internet-based program, was utilized to administer the survey. The survey tool allowed for all question types used in this work, including a) Likert scale, b) multiple-choice questions with a single response allowed, and c) open response questions. SurveyMonkey has a variety of both standard and optional security features. Standard security tools include the prevention of unintended access to the data by encrypting data during transit, maintaining all information on servers behind a firewall, and the utilization of ISO 27001, an internet security management standard that dictates a robust and continuous evaluation of data security. Optional security features of the software are designed to prevent unintended recipients, including bots, from taking part in the survey. This investigator utilized some of these features in this dissertation study. Email addresses obtained from the AAPM were loaded into the survey tool. While invitations were emailed to specific members, all responses were anonymous; information such as the IP, email addresses, and names of the respondents were not collected. However, software options were selected that limited participants to a single response and prevented ballot stuffing and data skewing.

A working copy of SPSS (Version 27) was required to conduct the necessary statistical testing. Further, a working copy of Microsoft Office was utilized to write the dissertation report.

Additionally, in order to devise the internet-based survey and communicate with participants, a working internet connection was also required.

Funding

This dissertation research was entirely self-funded. The largest cost associated with the dissertation study was the utilization of the MBI. The total cost for that component was based on the number of participants accessing the MBI portion of the survey, regardless of whether the instrument was completed in its entirety. However, volume pricing was available and a discount was offered for students conducting non-funded research. In addition to the MBI, the other major costs of this dissertation study were the web-hosting platform for conducting the survey (SurveyMonkey) and the SPSS (Version 27) statistical tool.

Study Setting

The dissertation study was conducted via virtual means and participants were able to choose the time (relative to the open survey period) and setting in which they responded to the survey. This investigator conducted all data analysis using a personal computer at her home.

Data Analysis

Once the data collection period was complete, the responses were exported from the web-based platform in SPSS format. The raw data was cleaned prior to analysis. For example, several individuals participated in the survey despite falling into one of the explicit exclusion criteria (e.g., working for a vendor). Those participants who did not proceed past the initial demographic portion of the survey were also removed.

All statistical analysis was conducted on the clean data set. The collected data provided descriptive information for the respondents. The MBI was analyzed per guidance from the

creator, to determine scores for each of the three burnout dimensions (emotional exhaustion, depersonalization, and personal accomplishment). Both cut score and z-score techniques were utilized to quantify the prevalence of each of the three dimensions of burnout amongst this group of medical professionals. The independent samples t-test and Welch t-test were utilized, as appropriate, to identify statistically significant differences in burnout prevalence as a function of sub-specialty and clinic type (i.e., non-academic or academic clinics) while Cohen's d was calculated for effect size.

The relationship between emotional exhaustion and organization features, clinic safety grade, average hours worked each week, and error reporting in the prior 12 months were evaluated for those respondents working as therapeutic physicists. The Pearson product-moment correlation test was utilized to determine the relationship between emotional exhaustion and the organizational features of teamwork and staffing and open communication and punitive concerns. Due to the existence of a continuous dependent variable and ordinal independent variables with six categories, the Spearman Rank Correlation was utilized to determine the relationship between emotional exhaustion and the average hours worked each week as well as the number of error reports in the preceding 12 months. Finally, the relationship between emotional exhaustion and the department safety grade, a 5-category ordinal independent variable, was evaluated using Kendall's tau-b correlation test statistic.

Summary of the Chapter

Post-positivism formed the theoretical foundation of this correlational dissertation study. The instrument utilized included demographic questions, the MBI, and an organizational survey. Numerous studies have demonstrated the reliability of the MBI with Cronbach alpha coefficients generally greater than 0.7 across each of the three domains. The original organizational survey

has also been shown to have sufficient reliability. While Cronbach alpha was not calculated for the slightly modified version used in this study, test-retest reliability was previously demonstrated.

Permission was obtained from the AAPM to query the membership for participation in this dissertation study. The instrument was deployed on-line and respondents were assured anonymity while safety procedures were implemented to prevent ballot stuffing or responses by bots. The number of participants exceeded the minimum calculated threshold to have sufficient power. The prevalence of each of the three dimensions of burnout was determined from the MBI using instructions from the creator. A variety of statistical tests were utilized, as appropriate, to determine the relationship between burnout burden and both demographic and organizational features.

Chapter 4: Results

Introduction to the Chapter

The Institutional Review Board at Nova Southeastern University approved a one-time anonymous survey in order to conduct this cross-sectional correlational dissertation study. Members of the AAPM, with approval of the organization's executive committee, were recruited, and all participants consented to participate in this study. The MBI, a validated survey tool that is considered the gold standard in burnout research, was utilized to quantify the prevalence of the burnout domains amongst medical physicists working in the United States as well as the impact of sub-specialization and institution setting on burnout levels. Utilizing an organizational survey tool, the relationship between emotional exhaustion, the most studied dimension of burnout, and key organizational features and errors were also determined for those specializing in therapeutic medical physics.

Data Analysis Results

Survey

The instrument was built on the SurveyMonkey web-based platform. Tools within the application were utilized to perform a high-level review of the instrument, including an assessment for typos and conflicting answers. Ahead of the launch, a test group of approximately six individuals from varying backgrounds also evaluated the system for: a) ambiguity in the instructions, b) continuity between the original instruments and the transcribed instruments on the SurveyMonkey platform, c) typos, d) prevention of ballot stuffing (by either the same individual or via a forwarded invitation), e) ability to complete the survey over multiple sessions, and f) average time for survey completion. Any identified issues were rectified prior to the survey launch. Based on the test group, the estimated time for completion was 20 minutes. The

options on the SurveyMonkey platform were set to ensure complete anonymity (including IP logging) of responses.

The AAPM executive committee approved the request to query the membership for this work. Based on advice from the American Institute of Physics (AIP) statistics division, the AAPM membership was split into two randomized groups. This allowed the organization to run two different surveys concurrently while maintaining an appropriate sample size and minimizing survey fatigue. The email addresses for 1,962 full members of the AAPM with a United States-based practice location was provided by the organization and permission was granted to officially launch the survey on 10 November 2020. The survey closed, after four weeks of data collection, on 9 December 2020. Reminder emails were sent to those who had not responded or had a partially complete response at both the approximate mid-point of the survey period and 24-hours prior to the end of the data collection period. In all communication with participants, care was taken to use only terms such as “job-related attitudes” or “wellness” to avoid sensitizing the recipients to the topic of burnout.

Of the 1,962 individuals contacted, 34 (1.7%) had an invalid email account resulting in an undeliverable invitation, 63 (3.2%) opted out of the survey and further reminder emails, and 728 (37.1%) email invitations were never opened. It should be noted that less than two weeks prior to the release of the survey, multiple hospitals in the United States were targets of a ransomware/cyber-attack. As a result, many institutions increased restrictions on access to third-party websites and incoming emails. These increased restrictions may have contributed to the high percentage of un-accessed invitations. Of the remaining invitations, 387 unique responses were obtained, representing a 20.1% response rate (relative to deliverable invitations). The

average survey completion time was just under 16 minutes, demonstrating good agreement with the estimate obtained from the trial group.

Clean Data Set

The raw dataset was downloaded, reviewed, and cleaned to ensure that all data utilized in the analysis was aligned with the inclusion and exclusion criteria of the research study. Forty participants did not proceed past the seven demographics questions at the beginning of the survey and their entries were removed. An additional three responses were removed from the data set for either practicing outside of the United States (n = 1) or for failing to provide an answer to the location of their practice (n = 2). Seven responses from self-identified vendors, one of the exclusion criteria for this study, were also removed from the data set. A total of 337 responses remained in the clean data set and were included in the analysis. All data analysis was conducted with IBM SPSS Statistics (version 27).

Demographics

The demographic breakdown of the 337 respondents included in the clean data set is summarized in Table 1. There was a nearly equivalent number of academic-affiliated and community hospital-based medical physicists. Almost three-fourths of participants (72.1%) reported therapeutic medical physics as their primary area of specialty and 95% had spent more than half of their life in North America. Most respondents were well established in their careers, with 89.6% of participants reporting at least 16 years of post-graduate experience. While the majority of respondents (64.7%) reported that the COVID-19 pandemic has had no to only a mild impact on their job-related feelings, 25.8% reported that it has had a moderate impact. Nearly one in ten respondents reported a significant impact on their job-related feelings as a

result of the pandemic, with a similar distribution of both therapeutic (9.1%) and diagnostic (9.5%) medical physicists experiencing this level of impact.

Table 1

Demographic Characteristics of the Respondents (n = 337)

	%	n		%	n
Practice type			Number of physicists in respondents' practice		
Academic affiliate	36.2	122	1	17.5	59
Community	33.5	113	2–3	29.1	98
Government	3.0	10	4–5	11.9	40
Free-standing	11.6	39	6–10	19.3	65
Consulting	13.1	44	11–20	10.4	35
Other	2.7	9	> 20	11.9	40
Years of post-graduate experience*			Primary specialization*		
0–2	3.0	10	Therapy	72.1	243
3–5	4.7	16	Diagnostic	22.0	74
6–10	1.2	4	Health Physics/RSO	1.8	6
11–15	1.2	4	Nuclear Medicine	3.0	10
16–20	15.1	51	Other	0.9	3
21+	74.5	251			
Impact of COVID-19 on job-related feelings			Percentage of life spent in North America*		
None	20.2	68	< 25%	1.5	5
Very mild	18.7	63	25–50%	3.3	11
Mild	25.8	87	51–75%	12.8	43
Moderate	25.8	87	> 75%	82.2	277
Significant	9.5	32			

*Demographic questions with 336 total responses due to a single missed response from three different participants.

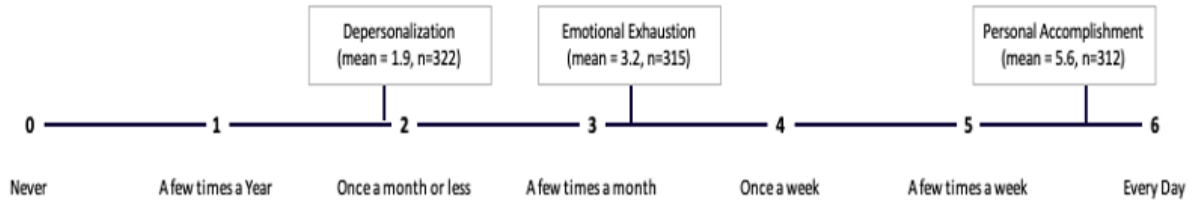
Burnout Amongst Medical Physicists in the United States

Prior to conducting any analysis, the internal consistency of each of the three constructs was tested. Using Cronbach's alpha, the internal consistency was 0.93, 0.70, and 0.75 for the emotional exhaustion, depersonalization, and personal achievement domains, respectively, which is at or above the minimum recommended threshold for an instrument to be deemed reliable. The results are also consistent with other published values for the MBI, including the pattern of emotional exhaustion having the highest internal consistency of the three constructs.

This investigator hypothesized that a large percentage (> 40%) of medical physicists would be suffering from burnout. To test this hypothesis, the MBI was first scored according to the directions from the creator. Average and sum scores were generated for each of the three burnout domains for every participant. The sum score in the emotional exhaustion domain was calculated by summing the scores of the nine MBI questions related to emotional exhaustion for each participant. The average score for each respondent was then obtained by dividing the sum score by 9. This process was repeated for depersonalization and personal achievement based on the 5 and 8 respective MBI questions for each of these domains. Domain scores were only calculated if every question related to that domain were answered. It is important to note that higher levels of burnout burden are associated with higher scores on the depersonalization and emotional exhaustion domains and lower scores on the personal achievement domain.

Figure 1

The Mean Scores for the Three Dimensions of Burnout for all Respondents



Note: The average scores for each of the three dimensions of burnout (emotional exhaustion, depersonalization, and personal accomplishment) for all respondents are juxtaposed on the MBI scoring scale to provide the relationship between the scores and the frequency of the feelings. Scores were tallied for each dimension when the respondent answered all questions related to the respective burnout dimension.

The mean emotional exhaustion score across the 315 participants who answered all domain related MBI questions was 3.2. The mean depersonalization score was 1.9 (n = 322) and the mean personal achievement score was 5.6 (n = 312). The scores were superimposed on the

MBI scale to provide a visual means of interpreting the frequency of each dimension across all respondents (Figure 1). Overall, respondents in this sample experience emotional exhaustion more than a few times a month but less than once a week, while depersonalization is experienced between a few times a year but less than once a month. The respondents scored high in personal achievement with general feelings of personal achievement being experienced more than a few times a week but not on a daily basis.

Table 2

Categorizations of Respondents Across Three Burnout Domains Using MBI Cut Scores

	Cut score thresholds	%	n
Emotional exhaustion			
High	27+	50.8	160
Moderate	17–26	32.4	102
Low	0–16	16.8	53
Depersonalization			
High	13+	20.5	66
Moderate	7–12	47.5	153
Low	0–6	32	103
Personal achievement			
High	39+	83.3	260
Moderate	32–38	13.5	42
Low	0–31	3.2	10

The creators of the MBI once utilized “cut scores” to categorize the feelings of burnout exhibited by respondents (high, moderate, or low) across the three burnout domains. Given that the cut scores were somewhat arbitrarily derived, the technique and cut score thresholds were removed with the publication of the fourth edition of the MBI manual. However, the results using cut scores is presented in this work (Table 2) to provide a means of comparing the results of this study to the numerous publications that utilized the technique before it was abandoned in 2016. Based on this categorization technique, moderate to high levels of emotional exhaustion

and depersonalization were displayed in 83.2% and 68% of respondents, respectively, while only 16.7% of respondents scored in the low–moderate range on the personal achievement domain.

In lieu of cut scores, a new concept for evaluating and categorizing MBI scores has been proposed by the creators of the MBI (Maslach et al., 2018). The "z-score" defines thresholds of burnout burden relative to the characteristics of the sample. Equations 1–3 outline the framework for calculating the z-score for each of the three burnout domains based on the mean and standard deviation (SD) of the population studied. Utilizing these equations, the z-scores for each dimension were tabulated for the total sample (Table 3).

$$Z(\text{emotional exhaustion}) = \text{mean} + (SD*0.5) \quad (1)$$

$$Z(\text{depersonalization}) = \text{mean} + (SD*1.25) \quad (2)$$

$$Z(\text{personal achievement}) = \text{mean} + (SD*0.1) \quad (3)$$

Table 3

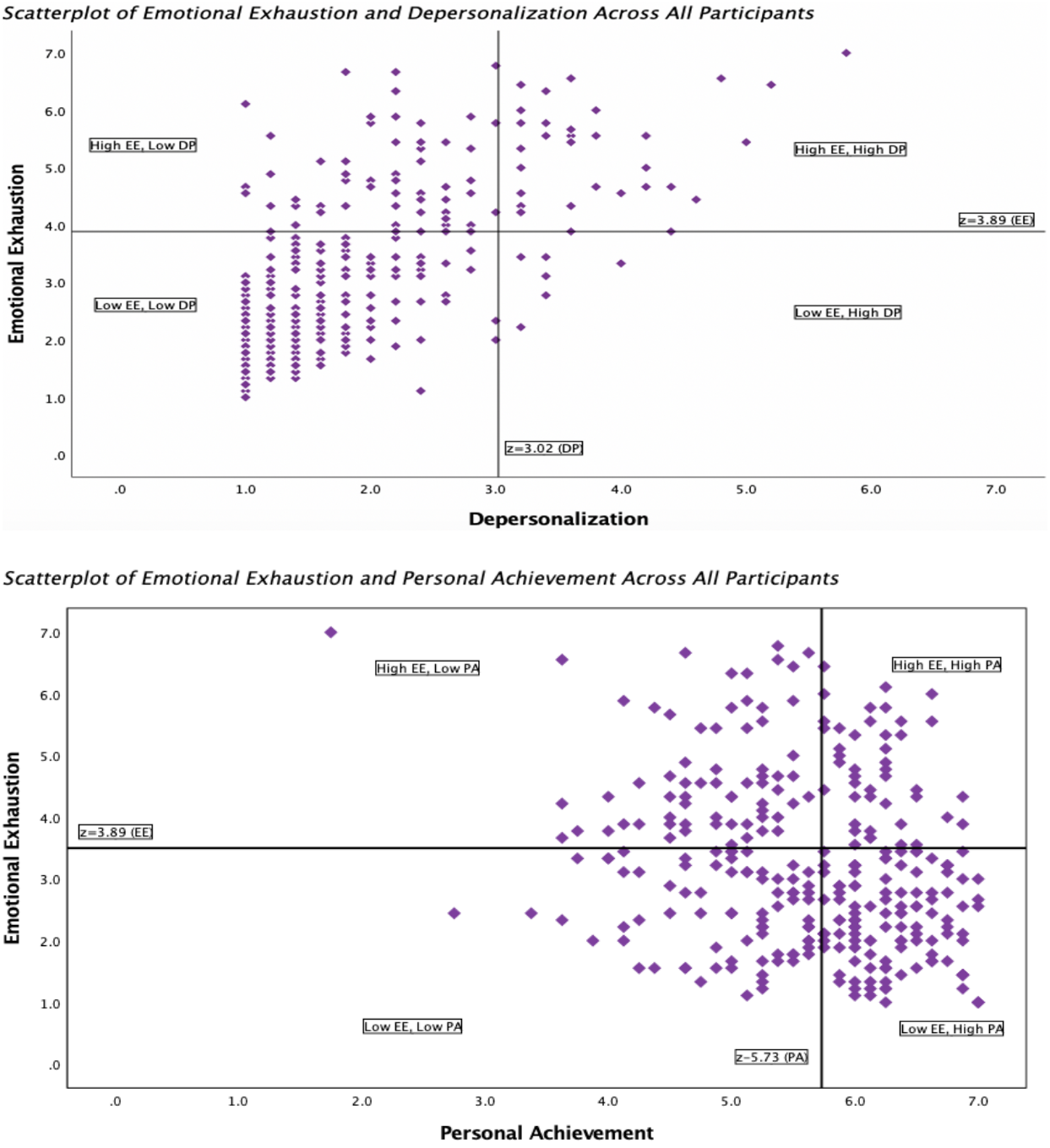
Z-scores Across all Respondents for Each of the Three Burnout Domains

	Emotional exhaustion	Depersonalization	Personal achievement
Mean	3.20	1.89	5.64
SD	1.39	0.90	0.86
Z-score threshold	3.89	3.02	5.73
Respondents with a positive z-score	30.1% (n = 95)	12.4% (n = 40)	46.5% (n = 145)
Mean domain score for participants with positive z-scores	4.96	3.77	4.89

Note: Positive z-scores reflect the potential for higher rates of burnout. Positive scores are indicated for responses higher than the relative z-score threshold on the emotional exhaustion and depersonalization domains and lower than the z-score threshold on the personal achievement domain.

Scatterplots (Figure 2) demonstrate the relationship between emotional exhaustion, the most studied aspect of burnout, and depersonalization (top panel) and personal achievement (bottom panel). The calculated z-score thresholds are indicated on the plots for each dimension. The top

Figure 2



Note: Scatterplots of emotional exhaustion - depersonalization (top panel) and emotional exhaustion - personal achievement (bottom panel). The z-score threshold for each domain is displayed resulting in four quadrants on each plot. Participants who scored positively (higher burnout potential) on one or both domains and participants who scored negatively (lower burnout potential) on both domains are identified.

right quadrant in the emotional exhaustion - depersonalization scatterplot represents participants who scored positively (higher burnout potential) on both domains while the bottom left quadrant demonstrates participants who scored negatively (lower burnout potential) on both domains. The upper left quadrant on the emotional exhaustion - personal achievement scatterplot represents participants who scored positively on both domains while the bottom right quadrant demonstrates participants who scored negatively on both domains.

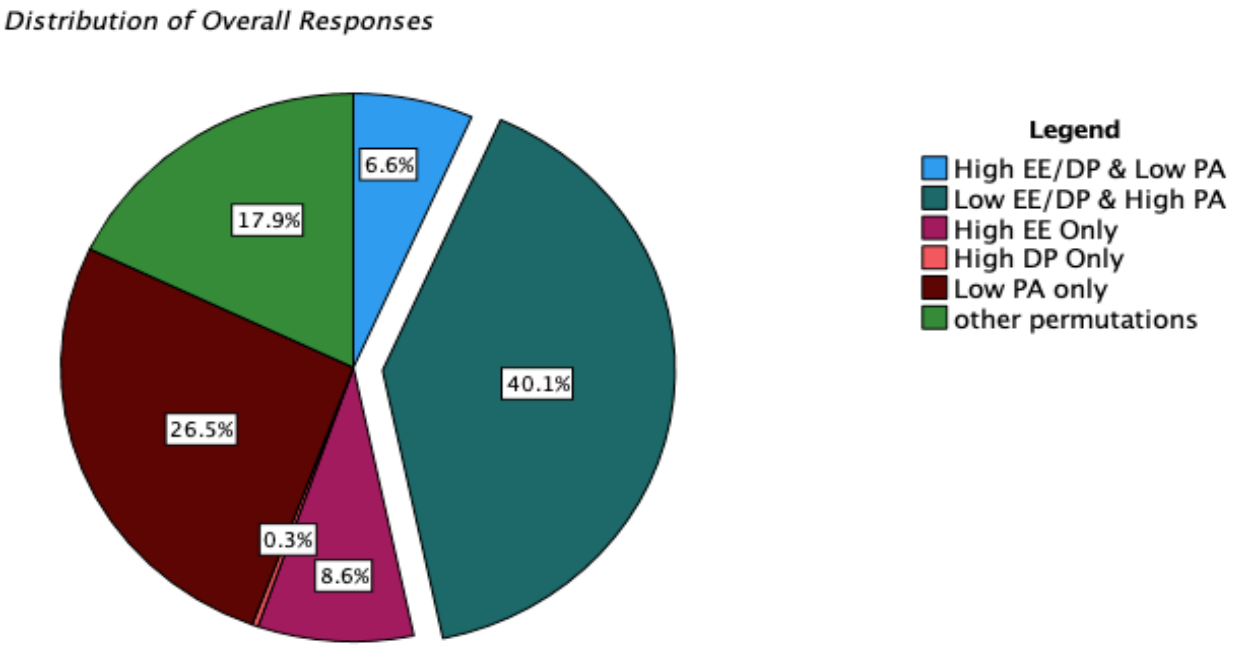
The participants were also evaluated as a function of the totality of their responses, across all three domains simultaneously, using the z-score threshold technique (Figure 3). Participants who failed to provide an answer for all 22 MBI questions (n = 35) could not be fully evaluated and are not accounted for in this figure. Approximately four in ten medical physicists (40.1%) demonstrated no tendency for burnout with negative results across all three dimensions. The remaining 59.9% of respondents demonstrated a tendency toward burnout with a positive result in at least one dimension. A very small fraction (0.3%) of respondents demonstrated positive scores on depersonalization alone with negative scores on the emotional exhaustion and personal achievement domains, while 8.6% scored positively on emotional exhaustion alone with negative scores on depersonalization and personal achievement, and 26.5% scored positively on personal achievement alone with negative scores on depersonalization and emotional exhaustion. Just 6.6% of respondents demonstrated positive z-scores across all three dimensions while the remaining 17.9% of respondents scored positively on two of the domains.

Impact of Sub-Specialty on Burnout

This investigator also hypothesized that therapeutic medical physicists experience burnout at higher rates than medical physicists practicing in different sub-specialties. The majority of participants identified practiced therapeutic medical physics (n = 243). There were 74

responses from individuals identifying themselves as diagnostic medical physicists with the remaining participants (n = 19) identifying a primary specialty in another category (health physics, nuclear medicine, and other). Due to the low response rate of the three later categories, a meaningful statistical analysis could not be performed on these groups individually. The responses of the health physics/RSO, nuclear medicine, and diagnostic medical physics categories were combined to form a single group ("non-therapy") while those in the "other" category (n = 3) were excluded from this portion of the analysis.

Figure 3



Note: The overall distribution of responses with participants is categorized as scoring low or high relative to the calculated z-score threshold for each of the domains. Only participants who answered the MBI in its entirety (n = 302) are included in this distribution.

The independent samples t-test was utilized to evaluate the statistical significance of differences between the two groups across each of the burnout domains in this unbalanced sample. Prior to conducting the test, the data was evaluated to establish that the assumptions of the test were not violated. The assumptions of the independent samples t-test include: 1) the

dependent variable is continuous, 2) the independent variable has exactly two categories, 3) there are independent observations between the two categories, 4) no outliers exist in the data, 5) there is an approximately normal distribution of the dependent variable for each category, and 6) homogeneity of variance exists. For the three burnout domains, the first three assumptions were always met. Outliers for each domain were evaluated using boxplots. Due to the sensitivity of the Shapiro-Wilk test to larger sample sizes, a determination of normality was established using Q-Q plots while Levene's test of equality of variances was used to test for assumption six. Note that when Levene's test failed ($p < 0.05$), equal variance was not assumed and the Welch t-test was utilized instead. The results for each domain are summarized in Table 4.

Table 4

T-test and Cohen's d Results for Each Burnout Domain: Therapy and Non-Therapy

Domain	Therapy	Diagnostic	p Value	Cohen's d
Emotional exhaustion	3.28 ± 1.43	2.90 ± 1.26	0.027	0.27
Depersonalization	1.96 ± 0.93	1.60 ± 0.61	< 0.001	0.42
Personal achievement	5.65 ± 0.88	5.63 ± 0.83	0.86	0.023

For emotional exhaustion, no outliers existed for the therapy category ($n = 232$). However, four outliers were identified in the non-therapy category ($n = 79$). These outliers were within 1.5 box lengths. Upon further evaluation, there was no evidence of erroneous data entry with these cases. The presence of the outliers had no effect on the acceptance or rejection of the null hypothesis. The outliers were retained, and the Q-Q plots demonstrated an approximately normal distribution. Using a Welch t-test, therapeutic medical physicists demonstrated higher emotional exhaustion (3.28 ± 1.43) when compared to the non-therapeutic medical physics

grouping (2.90 ± 1.26), a statistically significant difference of 0.38 (95% CI, 0.043 to 0.71), t(151.9) = 2.227, p = 0.027, d = 0.27.

On the depersonalization domain, eight outliers existed on each the therapy and non-therapy categories. However, two of the outliers on the non-therapy grouping were extreme outliers located over 3 box lengths away. Only the extreme outliers were removed from the data but the remaining outliers (1.5 box lengths) were retained resulting in 236 respondents in the therapy group and 80 respondents in the non-therapy group. The Q-Q plots demonstrated an approximately normal distribution. Using a Welch t-test, therapeutic medical physicists demonstrated higher depersonalization (1.96 ± 0.93) when compared to the non-therapeutic medical physics group (1.60 ± 0.61), a statistically significant difference of 0.36 (95% CI, 0.18 to 0.54), t(209.2) = 3.98, p < 0.001, d = 0.42.

Three outliers existed on the therapy grouping (n = 226) while no outliers were observed on the non-therapy grouping (n = 82) on the personal achievement domain. The existence of the outliers did not affect the rejection or acceptance of the null hypothesis and were retained in the dataset. The Q-Q plots also demonstrated approximate normality. Based on an independent samples t-test, the null hypothesis was accepted as there was no significant difference (p = 0.86) between the therapy group (5.65 ± 0.88) and the non-therapy group (5.63 ± 0.83) on this domain.

Impact of Facility Setting on Burnout

The third hypothesis of this dissertation study was that burnout would be more prevalent in medical physicists employed in non-academic facilities (community, government hospitals, or free-standing centers) than in medical physicists employed in an academic-affiliated hospital. There were 122 respondents who indicated working in an academic-affiliated hospital and 162 working in a non-academic institution comprised of community-based hospitals (n = 113),

government hospitals (n = 10), or a free-standing facility (n = 39). An additional 44 participants reported working as part of a consulting group while nine participants chose the "other" category. Participants in the last two categories were excluded from this portion of the analysis. An independent samples t-test was utilized to evaluate for statistically significant differences between the two groups (academic and non-academic) across each of the three burnout domains. The first three assumptions (a continuous dependent variable, two categories for the independent variable, and independence of observations) were always met. Outliers, and normalcy were determined as previously outlined. On the emotional exhaustion domain, only a single outlier was observed on the academic grouping. For the depersonalization domain, five outliers were observed in the academic grouping and four in the non-academic grouping, while only a single outlier was observed on each of the groupings for the personal achievement domain. None of the outliers were identified as extreme (all were within 1.5 box-lengths) and they had no effect on the acceptance of rejection of the null hypothesis. All data was retained. Further, approximate normalcy was verified and, in all cases, Levene's test demonstrated equal variance. The results for each domain are summarized in Table 5. There were no statistically significant differences in the three burnout domains as a function of the two work settings investigated.

Table 5

Independent Samples T-Test Results for Each Burnout Domain for Medical Physicists Working in Academic and Non-Academic Facilities

Domain	Academic	Non-Academic	p Value
Emotional exhaustion	3.43 ± 1.40	3.13 ± 1.46	0.091
Depersonalization	1.97 ± 0.96	1.92 ± 0.91	0.63
Personal achievement	5.63 ± 0.89	5.66 ± 0.84	0.73

The results are based on the total sample with no consideration for the sub-specialty. The independent samples t-test was utilized to evaluate for a statistically significant effect of the facility on the therapy and non-therapy sub-groups separately. As in hypothesis 2, only the extreme outliers for the depersonalization domain were removed. Therapeutic medical physicists employed in an academic facility demonstrated higher emotional exhaustion (3.57 ± 1.40) when compared to the therapeutic medical physicists in a non-academic facility (3.16 ± 1.47), a statistically significant difference of 0.41 (95% CI, 0.0070 to 0.81), $t(215) = 1.98$, $p = 0.049$, $d = 0.28$. The facility type did not have a significant effect on the depersonalization and personal achievement domains for therapeutic physicists. Amongst the non-therapy group, no significant differences were observed based on facility type for the three burnout domains.

Emotional Exhaustion and Organizational Features

This investigator hypothesized that there is a negative correlation between emotional exhaustion and organizational features amongst therapeutic medical physicists including a) teamwork and staffing, and b) open communication and punitive concerns. The entire organization instrument used in this survey is located in Appendix C. However, the subset of survey questions utilized to assess teamwork and staffing are summarized in Table 6, while those used to assess open communication and punitive concerns are summarized in Table 7. It is important to note that both positively and negatively worded questions are utilized in this instrument. The scoring of all negatively worded questions was inverted. Internal reliability, using Cronbach's alpha, was 0.82 and 0.89 for the teamwork/staffing and open communication/punitive concerns construct respectively. A sum score was then generated for teamwork and staffing by summing the scores of the nine survey questions associated with this feature. This process was repeated for the 10

questions associated with open communication and punitive concerns. Sum scores were only calculated for those respondents who answered all questions for that organizational topic.

Table 6

Organizational Survey Instrument Questions Used to Determine a Department Score for Teamwork and Staffing

Survey Question	Wording
We have enough staff to handle the workload	Positive
We use more agency/temporary staff than is best for patient care	Negative
When one area in this unit gets really busy, others help out	Positive
When a lot of work needs to get done quickly, we work together as a team	Positive
In this department, people treat each other with respect	Positive
People support one another in this department	Positive
We work "in crisis mode", trying to do too much, too quickly	Negative
When pressure builds up, my supervisor wants us to work faster, even if it means taking shortcuts	Negative
Staff in this unit work longer hours than is best for patient care	Negative

Table 7

Organizational Survey Instrument Questions Used to Determine a Department Score for Open Communication and Punitive Concerns

Survey Question	Wording
In this unit, we discuss ways to prevent errors from happening again	Positive
I'd be more likely to report errors/near misses if it were anonymous	Negative
Staff are afraid to ask questions when something does not seem right	Negative
My colleagues would report an error or near-miss that they caused	Positive
Staff worry that mistakes they make are kept in their personnel file	Negative
My colleagues would report an error or near miss that I caused	Positive
Staff feel like their mistakes are held against them	Negative
Staff feel free to question decisions/actions of those with more authority	Positive
When an event is reported, it feels like the person is being written up, not the problem	Negative
Staff freely speak up if seeing something that may negatively affect patient care	Positive

The Pearson product-moment correlation was chosen to evaluate the relationship between emotional exhaustion and the chosen organizational features of teamwork and staffing and open communication and punitive concerns. The five assumptions of this test include: a) two continuous variables, b) paired observations, c) a linear relationship between the two variables, d) no significant outliers, and e) a normal data set. For these tests, the first two assumptions were always met. A scatterplot was used to evaluate the linear relationship between emotional exhaustion and the two organizational features in question. In both cases, a linear relationship was observed and there were no significant outliers, and the data was determined to be approximately normal via Q-Q plots. With all assumptions met, a Pearson's product-moment correlation coefficient was calculated. There was a moderate to strong negative correlation between emotional exhaustion and the teamwork and staffing feature, with $r(217) = -0.61$, $p < 0.001$, explaining 37.2% of the observed variation in emotional exhaustion. The Pearson's product-moment correlation coefficient indicated a moderate negative correlation between emotional exhaustion and the open communication and punitive concerns feature, with $r(182) = -0.34$, $p < 0.001$.

Emotional Exhaustion, Error Reports and Hours Worked

Finally, this dissertation study hypothesized that the number of reported events in the prior 12 months and the department safety grade are each negatively correlated with emotional exhaustion while the average hours worked each week has a positive correlation with emotional exhaustion amongst the therapeutic medical physicist cohort. A total of 214 therapeutic medical physicist participants provided an answer to the number of filed reports in the previous year. The majority (60.3%) reported filing two or less reports in the prior 12 months, including 27.6% who had filed no reports. Just 8.9% of respondents filed 11 or more reports. The Spearman Rank

Correlation coefficient was chosen due to the existence of both a continuous and an ordinal variable with six categories. In addition to the types of variables, the additional assumptions of the test are met including paired observations and the existence of a monotonic relationship. A negligible, non-significant correlation was found between emotional exhaustion and the number of reports in the prior 12 months amongst therapeutic medical physicists, with $r_s(203) = 0.13$, $p = 0.068$.

Participants were also asked to provide a safety grade for their department using one of five categories from excellent to failing. Of 215 participants who answered this question, 17.6% gave their department a safety score between failing and acceptable while the remaining participants provided a very good (52.6%) or excellent (29.8%) safety score. Kendall's tau-b was selected to quantify the relationship between the continuous variable (emotional exhaustion) and the five-category ordinal variable (department safety grade). With 205 paired observations, a mild but statistically significant negative correlation exists between emotional exhaustion and the assigned safety grade of the department amongst therapeutic medical physicists, with $\tau_b = -0.20$, $p < 0.001$.

The Spearman Rank Correlation was used to determine the relationship amongst therapeutic medical physicists between emotional exhaustion and the six-category ordinal variable, average number of hours worked each week. Of the 215 therapeutic respondents who answered this question, no one reported working over 100 hours per week but 11.2% reported working between 60 and 99 hours weekly. Over three-fourths (77.2%) of respondents work between 40 and 59 hours weekly while the remaining 11.6% of participants work 39 hours a week or less. Unsurprisingly, with 206 paired observations, there is a moderately positive

correlation in this cohort between emotional exhaustion and the number of reported hours worked each week with $r_s(204) = 0.34$, $p < 0.001$.

Summary

With approval of the executive committee, members of the AAPM were recruited to participate in this dissertation study to establish the prevalence of burnout amongst medical physicists in the United States, the relationship between burnout and organizational features, and the relationship between burnout and safety. Overall, utilizing a z-score threshold developed by the MBI creators, 59.9% of the 302 participants demonstrated high scores in one or more of the burnout domains. Only 6.6% exhibited positive scores across all three dimensions. The sub-specialty practiced by the participants had no impact on the personal achievement scores. However, therapeutic physicists experienced significantly higher emotional exhaustion ($p = 0.027$, $d = 0.27$) and depersonalization ($p < 0.001$, $d = 0.42$) when compared to non-therapeutic colleagues. Academic therapeutic physicists were found to experience higher emotional exhaustion than therapeutic physicists in non-academic settings ($p = 0.047$, $d = 0.28$), while no differences were observed in non-therapeutic physicists as a function of institutional setting.

Amongst therapeutic physicists, emotional exhaustion had a strong negative relationship with teamwork and staffing ($r = -0.61$, $p < 0.001$). A moderately negative correlation was found between emotional exhaustion and open communication and punitive concerns ($r = -0.34$, $p < 0.001$), while a mild but significant relationship was found with the safety grade of the department ($\tau_b = -0.20$, $p < 0.001$). A moderately positive correlation was determined to exist between emotional exhaustion and the average number of hours worked each week ($r_s = 0.34$,

$p < 0.001$). However, the number of errors reported in the prior 12 months was not found to be correlated with emotional exhaustion ($r_s(203) = 0.13$, $p = 0.068$).

Chapter 5: Discussion

Introduction to the Chapter

Burnout is a recognized work-related phenomenon that is comprised of three domains: emotional exhaustion, depersonalization, and decreased levels of personal achievement. In addition to having a negative impact on the individual suffering from the syndrome, there can also be negative consequences for colleagues, the organization, and the customers or clients receiving services from a burned-out employee, including inferior quality of services and an increase in error rates. Burnout has been studied extensively in a broad range of medical professionals, including physicians and nurses. Despite the role played by medical physicists in providing safe, quality care in both the diagnostic and therapeutic realms, there has been minimal research into the prevalence of burnout in this cohort and its relationship with organizational features. This dissertation study determined the prevalence of the syndrome amongst medical physicists practicing in the United States, including statistical differences due to the facility setting and practiced sub-specialty. The relationship between emotional exhaustion, the most studied burnout domain, and key clinic features including work hours, resources, errors, and the safety grade of the department were also determined for the therapeutic physicist cohort. In this chapter, a discussion of the results, including potential impact, limitations of the study, and suggestions for future research are discussed.

Discussion and Interpretation of Results

Demographics

Over 1,700 members of the AAPM have self-identified their facility type as well as area of sub-specialty. Seventy percent of AAPM members who supplied this information indicated working primarily as therapeutic medical physicists compared to 72.1% of respondents included

in this dissertation study. There is nearly an even split in the AAPM membership data between physicists employed in a community-based practice and an academic environment. It is important to note that additional options beyond these two choices are not available, thereby limiting the granularity of facility data provided by AAPM members. A separate AAPM survey consisting of 1,526 therapeutic medical physicist respondents demonstrated that 39% work in a community hospital setting, 31% in an academic-affiliate facility, 19% in free-standing, and 7% in a government hospital, with the remainder of respondents working in either a consulting, vendor, or other role (Ford et al., 2020). In this dissertation study, a nearly even split was also observed between those who identify as practicing in an academic environment (36.2%) compared to a community practice (33.5%). An additional 11.6% work in free-standing facilities and 3% are employed in government hospitals. Based on the total available data, the participants of the dissertation study appear to be representative of the AAPM membership. Further, 95% of respondents indicated that they have lived more than half of their life in North America, which should limit cultural and geographic influences on the burnout results obtained in this dissertation study.

Prevalence of Burnout

Utilizing the z-score methodology previously discussed, 59.9% of respondents had a positive burnout score in at least one of the three dimensions. While full burnout was experienced by just 6.6% of respondents, the remaining 53.3% are at risk of progressing into full burnout without some level of intervention, particularly the 17.9% of participants demonstrating positive scores across two domains.

The personal achievement score is of particular interest. Across the entire sample, the mean personal achievement score was 5.6 (n = 312). This indicates that respondents, for

example, have feelings of accomplishing many worthwhile things in their job several times each week. While participants who scored positively on this domain had a lower level of personal achievement than their peers, the average value (4.89) still indicated feelings of achievement at least weekly. High scores on this domain indicate a lower burnout burden. As a result, high scores on the personal achievement domain, which leaves participants with regular feelings of personal accomplishment, may be providing an insulating effect that aids in protecting this cohort from full-blown burnout.

On the emotional exhaustion and depersonalization domains, it is important to note the difference in frequency of these feelings between the overall sample and those who scored positively for burnout burden using the z-score thresholding technique. Just under one-third of respondents (30.1%) scored positively on the emotional exhaustion domain, resulting in feelings of being emotionally drained a few times a week (4.96), compared to the overall sample who experience these feelings several times each month (3.2). Potential side effects of emotional exhaustion, experienced by nearly one-third of respondents, include absenteeism and presenteeism.

Respondents who scored positively on the depersonalization domain (12.4%) experience, for example, a lack of caring about what happens to recipients nearly once per week (3.77), compared to the overall sample (1.89) who experience these feeling just several times per year. While the percentage of respondents who scored positively on depersonalization is relatively low, the frequency is concerning with respect to the quality of care delivered by these respondents.

Impact of Sub-Specialty on Burnout

The results of the MBI were evaluated as a function of the therapy and non-therapy sub-specialties. The independent samples or Welch t-tests were utilized to evaluate for statistical differences between the two groups across each burnout domain. Interestingly, there was no statistically significant differences between the two groups on the personal achievement domain, indicating that medical physicists in both the non-therapy and therapy specialty experience a similar, high frequency of personal achievement through their work.

A significant difference between the two groups was observed for both the emotional exhaustion and depersonalization domains. Therapeutic medical physicists experience higher emotional exhaustion (3.28) compared to the non-therapy group (2.90), which was statistically significant ($p = 0.027$), with an effect size of 0.27. Therapeutic physicists also experience a higher rate of depersonalization (1.96) compared to the non-therapy grouping (1.60), which was statistically significant ($p < 0.001$), with a moderate effect size of 0.42. In both groupings, physicists must perform quality assurance testing outside of normal patient hours including in the evenings and/or over weekends to minimize clinical impact. In addition to the after-hours work, therapeutic physicists are often needed during patient treatment hours to attend to issues as they arise in the clinic (e.g., machine errors, emergent patient calculations, and special procedures), while similar demands may be more limited amongst non-therapeutic physicists. Expanded work hours and a lower feeling of autonomy may contribute to the higher rate of burnout burden in this cohort.

Therapeutic physicists are employed in the treatment of cancer patients and can be directly involved with patients during their treatment. While many cancer treatments are definitive and used for a potential cure, other patients are offered radiation treatment for

palliation in late-stage diseases or to provide pain relief during end-of-life care. Non-therapeutic physicists, on the other hand, often have limited direct patient contact. While the various imaging modalities overseen by diagnostic physicists are used for the diagnosis of severe illnesses, they are also used for occasions that can be viewed as happy and joyous such as ultrasound during pregnancy or for less severe conditions such as routine screenings and broken bones. It is unclear whether the underlying patient cohort serviced plays a role in the burnout differences observed in these groups.

In addition to the differences in patient populations receiving care from these two groups of medical physicists, there are orders of magnitude difference in the levels of radiation delivered in the two settings. Some imaging modalities, such as MRI and ultrasound, impart no radiation at all. A course of definitive radiation therapy can deliver up to 8,000 times the radiation doses delivered during an abdominal CT scan. Further, while radiation doses delivered to the patient continue to decrease in the diagnostic realm, therapy doses, particularly fractional doses, continue to increase. There is considerable stress placed on the therapeutic physicist to ensure that these high doses of radiation can be delivered correctly and accurately and may contribute to the observed differences in emotional exhaustion and depersonalization between the therapy and non-therapy grouping.

Impact of Facility Setting on Burnout

This researcher hypothesized that there would be statistically significant differences in burnout as a function of facility setting, with non-academic physicists experiencing higher levels of burnout. This hypothesis was premised on the concept that non-academic physicists have access to less staff and resources than those employed in academic facilities. However, no

differences were observed on the overall sample between the academic and non-academic grouping for the three burnout domains.

Since it was already determined in this dissertation study that therapeutic physicists experience higher levels of burnout than non-therapeutic physicists, it was unclear whether variations as a function of clinic type was obscured in the larger overall sample. The independent samples t-test was utilized to evaluate for differences between facility settings on each sub-specialty separately. The only observed difference was on the emotional exhaustion domain amongst therapeutic physicists, with those in an academic facility experiencing a statistically significant higher level of emotional exhaustion than those in a non-academic setting. While a higher availability of resources may exist in an academic setting, additional factors beyond clinical duties such as teaching, grant applications, expectations for research and publication, and the stress of seeking tenure may contribute to the higher level of emotional exhaustion amongst academic physicists. Further, a strong relationship between teamwork and emotional exhaustion was established in this dissertation study. It should be considered that perhaps the competitive nature of tenure and grant applications leads to decreased feelings of teamwork and helps drive emotional exhaustion in the academic therapy grouping.

Emotional Exhaustion and Organizational Features

The relationship between organizational features and burnout has been demonstrated in multiple studies (DeChant et al., 2019; Maslach & Leiter, 1997; Awa et al., 2010). The teamwork and staffing construct used in this dissertation study included items such as having enough staff to handle the workload as well as respect and help/support amongst members of the department. Using a Pearson's product-moment correlation, this construct was found to have a significant negative relationship with emotional exhaustion amongst therapeutic physicists

($r(217) = -0.61$, $p < 0.001$). The result is supported by the COR model (Hobfoll & Freedy, 2017) where sufficient staffing, support, and a team mentality are viewed as resources. The lack of these resources can be more important than the demands of the job itself. The results also support the CREW model (Osatuke et al., 2009), in which burnout can be driven by poor interpersonal communications and lack of respect.

The organizational construct of open communication and punitive concerns was comprised of items such as the ability to speak up, whether mistakes are held against the staff, and the ability to openly discuss methods to prevent errors. Using a Pearson's product-moment correlation coefficient, this construct had a moderate but significant relationship with emotional exhaustion ($r(182) = -0.34$, $p < 0.001$). Like the teamwork and staffing construct, the CREW model offers both an explanation and solution. Those respondents who felt respected and had the autonomy and right to question those in higher authority, for example, demonstrated lower emotional exhaustion.

Emotional Exhaustion, Error Reports, and Hours Worked

There was no available mechanism in this dissertation study to independently evaluate the number of errors actually made by a participant. Instead, the self-reported number of incidents filed in the prior 12 months was utilized as a surrogate. Studies have demonstrated a positive correlation between burnout and errors (West et al. 2006; Shanafelt et al., 2010; Tsiga et al., 2017; Tawfik et al., 2018). However, in this dissertation study, a negative correlation was hypothesized to exist between emotional exhaustion and the number of error reports as those suffering from emotional exhaustion were thought to be less inclined to file a report. A negligible, non-significant correlation between emotional exhaustion and error reports was determined. However, the lack of a significant correlation may be a function of the limitations of

the study and instrument. The question on error reporting in this dissertation study relied on participant recall over the prior one-year period, which may be inaccurate. It is also reliant on respondent honesty. While participants were aware of the anonymous nature of the survey, a negative stigma may still exist when reporting a high number of incident reports. Further, this question relies on the inherent safety culture of the clinic. The lack of a robust incident learning system or a punitive environment would lead to lower (or no) incident reports filed regardless of the number of errors that occurred. The majority of respondents (60.3%) filed two or less reports in the prior 12 months, including 27.6% who filed no reports, which suggests that these factors may play a role in these findings. Finally, there is the additional difficulty of correlating emotional exhaustion, measured at a single point in time, with error reports over a longer period. Relatively new feelings of emotional exhaustion, for example, compared to a 12-month error reporting timeframe complicates and potentially may obscure the understanding of the true relationship.

The relationship between the department safety grade assigned by the therapeutic medical physicist participant and emotional exhaustion was also evaluated in this dissertation study. Nearly 30% of participants gave their department an excellent safety grade. The remainder provided a safety score of very good (52.6%) while 17.6% gave a safety score between failing and acceptable. Overall, this indicates room for improvement in department level safety. While a mild but statistically significant relationship ($\tau_b = -0.20$, $p < 0.001$) was found between emotional exhaustion and the assigned safety grade, causation cannot be determined. For instance, it cannot be determined whether the safety grade was assigned because the participant was experiencing emotional exhaustion and was, perhaps, more critical of the department or whether the safety culture of the clinic was driving the emotional exhaustion experienced by the respondent.

The vast majority of therapeutic medical physicists (88.4%) work an average of 40 hours or more on a weekly basis with more than one in ten (11.2%) working between 60 and 99 hours weekly. The Spearman Rank Correlation found a moderately positive relationship ($r_s(204) = 0.34$, $p < 0.001$) between emotional exhaustion and the number of reported hours worked each week. The hours worked each week supports the description of the extended hours that are required of this cohort. It is unsurprising that an increased workload, which results in a decreased work-life balance and time for rest and recovery, is linked to an increase in emotional exhaustion. Allowing increased levels of autonomy and flexibility may provide additional aid in preventing burnout in the face of a high workload. While this dissertation study demonstrated increased emotional exhaustion as a function of work hours, an even stronger relationship was determined between emotional exhaustion and teamwork/staffing.

Literature Review

It is important to note that there is a wide variation in the use of the term “burnout” in research and the literature. While the MBI has been utilized in many studies, most of the research conducted prior to 2016 used arbitrary cut score thresholds to identify those participants experiencing high, moderate, and low levels of burnout burden across each of the three domains. Due to the arbitrary nature of these thresholds, large percentages of participants were being identified as suffering from burnout. Further, “burnout” statistics were often presented based on a single domain only. There were also numerous additional studies that did not utilize an objective measure, such as the MBI, to measure burnout. Instead, a single question was utilized to make the determination of prevalence. Beyond the potential for inherent bias by utilizing the term, the single question method often lacked a description or explanation of the term “burnout”, which could lead to inter-user variability in the interpretation of the term. As a result, caution

must be used when comparing the results of this dissertation study with the published literature due to the wide variety of measures and interpretations utilized.

Table 8

Cut Score Comparison of Burnout Scores Amongst Medical Physicists and Chairs of Academic Radiation Oncology Programs

	Cut score thresholds	Medical physicists	Radiation oncology academic chairs
Emotional exhaustion			
High	27+	50.8	25
Moderate	17–26	32.4	39
Low	0–16	16.8	36
Depersonalization			
High	13+	20.5	10
Moderate	7–12	47.5	18
Low	0–6	32	72
Personal achievement			
High	39+	83.3	52
Moderate	32–38	13.5	33
Low	0–31	3.2	15

Note: Scores for the radiation oncology academic chairs were extracted from Kusano et al., 2014.

In a study investigating peer support needs amongst medical physicists, more than 70% indicated feelings of burnout on a single question (Johnson et al., 2019). Utilizing a quality-of-life instrument, more than 30% of medical physicists in Europe scored “high” in burnout (Di Tella et al., 2020). The results of this dissertation study fall in between with 59.9% of responding physicists experiencing a burnout burden in one or more domains. Again, due to variations in the instruments used, the wide range in prevalence rates is unsurprising.

Given the relative lack of studies on medical physicists, the results from this dissertation study were compared to publications from other practitioners within radiation oncology. Table 8 is a comparison of cut scores between medical physicists and chairs (physicians) of academic radiation oncology programs (Kusano et al., 2014). The rate of high emotional exhaustion and

depersonalization amongst medical physicists is more than double that of physicians. Medical physicists also experience higher personal achievement (lower burnout burden) than the physicians in the study. While the use of cut scores is no longer encouraged, this comparison still offers a relative means of comparing burnout trends to physicians, a profession with high expected and documented burnout.

Implications

Implications for Practice

Medical physicists are critical in ensuring patients receive proper and safe clinical care. With demonstrated links between burnout, decreased quality of care, and the potential for an increased number of errors, the level of burnout burden amongst these medical professionals is concerning. While the high level of personal achievement experienced by medical physicists may be providing a level of insulation from full-blown burnout, a call to action is still necessary. Approximately 53% of participants demonstrated a burnout burden in one or two domains. In the absence of proper interventions, these individuals are likely to progress to full-blown burnout. It should also be acknowledged that even without full-blown burnout, the manifestation of even a single burnout domain can have negative consequences on the individual, colleagues, the organization, as well as the patients. It is also clear that key features of the organization can have a significant impact on the health and well-being of the staff and the delivered care.

It is understood that institutions operate within the confines of limited resources. However, the results demonstrate the need for implementation of the CREW model and a “just culture”, where staff are treated uniformly and fairly, to reduce burnout. These methods would also improve the team mentality and encourage respectful communications across all members of the department. Additionally, these interventions come with little or no cost. While a “just

culture" mentality is reliant on acceptance by the leaders of the department, CREW can be implemented amongst the staff themselves. Professional organizations can promote the positive implications of respectful and helpful interactions amongst all staff. In addition to providing a positive and rewarding environment, empowering staff to take control over their own interactions, without awaiting approval from department leaders, can provide a sense of autonomy to further protect them against burnout.

Lower levels of emotional exhaustion and depersonalization were calculated in the non-therapy cohort than in the therapy cohort. There may be several reasons for this difference, including the coverage requirement during regular clinic hours amongst the therapy cohort, the patient population, and the relative danger of the radiation dosage used in the two fields. The patient population and radiation doses are fixed parameters that cannot be altered to reduce burnout. While both groups work "after-hours", the non-therapeutic physicists tend to play less of a role during the traditional clinic hours, which may allow for an improved work-life balance and a feeling of autonomy. Providing some flexibility in physics coverage amongst therapeutic physicists may provide some benefit. Medical physicists should also be educated on the negative effects of burnout, as well as high workloads and demands without sufficient time for recovery. While it is acknowledged that the staffing models are often not within the control of the medical physicist, providing "permission" to recognize one's limitations and the negative potential implications for the patient when exceeding these thresholds is necessary to ensure high-quality care.

Despite high-intensity focus on quality and safety in radiation oncology over the last decade, including the development of a free, radiation oncology-specific incident learning system, it is clear that there is continued work to be done to improve the quality and safety of the

profession. Nearly three in ten respondents (27.6%) had not filed a single error report in the prior 12 months and 70% provided a department safety score of less than excellent.

Implications for Further Research

The majority of physicists who responded to this survey were in their mid to late career. Just 8.9% of respondents reported having 10 years or less of post-graduate experience. Given that burnout is thought to be largely influenced by organizational features and lack of resources, there is no known timeframe below which burnout does not exist. Additional research to determine the impact of burnout on early career professionals is warranted. It would also be worthwhile to evaluate the effect of burnout amongst student and resident professionals who often must contend with limited financial resources while simultaneously working extended hours.

One goal of this dissertation study was to evaluate the relationship between emotional exhaustion and errors. The instrument relied on participant recall, a willingness to disclose the number of errors reported in the prior 12 months, and the assumption that every participant and organization had a similar, robust error-reporting system and non-punitive environment. The inconclusive results of the relationship between error reporting and emotional exhaustion obtained in this dissertation study may be due to the underlying limitations associated with the study design than with reality. As a result, a more robust means of evaluating the relationship between these variables is warranted.

One current theory suggests that burnout burden across only one or two domains is an unstable pattern (Maslach & Leiter, 2008). A move to a “stable” pattern of either full-blown burnout (across all three dimensions) or resolution occurs as a result of the ensuing job conditions or interventions. A longitudinal study to evaluate this theory, including detailing work

conditions between data collection time points, may assist in providing an increased level of knowledge on the pattern of burnout expression as a function of work conditions. A mixed-methods study, including in-depth qualitative data collection, may also provide the necessary context around the work conditions that can lead to burnout in this cohort.

Expanding this research, to include the international medical physics community, may provide further evidence of the role culture and geography play in promoting burnout. A study on an international scale could also provide insight into the relationship between the health care system (e.g., private insurance compared to socialized medicine) and burnout burden. Further, there is a vast inequity in global healthcare distribution. The number of medical physicists in Latin America and Africa account for only 6% of the total international medical physicist workforce (Tsapaki et al., 2018), despite the regions having both large populations and high cancer burdens. Burnout could be an additional hardship for medical physicists in these locations where minimal staffing and low resource environments already create a challenging work environment. Understanding the full scope of barriers in this workforce will allow for the development and implementation of optimal solutions.

Limitations and Delimitations

One limitation of the dissertation study was the use of convenience sampling using the AAPM membership directory. Given that there is no repository from which to determine the total number of medical physicists in the United States, it is difficult to say with certainty how well the AAPM membership represents the profession as a whole. The individuals who chose to participate may have had a specific reason to do so and therefore may be inherently different from the general population to which the results were applied or extrapolated. The inherent bias of investigating the “healthy worker” cannot be overlooked. For instance, those who remain in

the workforce (and were included in the study), may be different than those left the workforce due to severe work-induced psychological issues or extreme burnout.

As a cross-sectional correlational study at a single time point, the dissertation study lacks the ability to determine causation. Further, the results are gathered at a single point in time and no information regarding longitudinal results or impact can be implied. One also cannot neglect the limitation of studying burnout in health care workers amidst the COVID-19 pandemic. Health care systems and workers have been stretched thin, often working with increased patient loads, decreased staffing, and altered work environments amidst increased individual health risks. While nearly two-thirds of respondents indicated that the pandemic had no to only a mild impact on their work-related feelings, the remaining participants indicated a moderate to severe effect from the pandemic.

Another limitation is the instruments selected for use. The MBI has been the gold standard for burnout research for decades and has demonstrated excellent reliability. However, one of the disadvantages of the instrument is the use of all positively worded statements. Beyond the MBI, there is a concern with the use of the organizational survey to ascertain errors. In addition to relying on recall, it also relied on the honesty of the participant as well as the safety culture of the organization.

As an anonymous survey, a delimitation of this dissertation was the inability to link participants working for the same organization. As a result, multiple participants from a large organization could have a negative impact on the overall results due to over-sampling within a single clinic. Large sample sizes aides in limiting the effects of over-sampling. Further, it is understood that individuals within a single organization may experience different work

environments, such as varying degrees of inter-personal communication and conflict or of workload as a function of clinical role.

A second delimitation was the inclusion and exclusion criteria for the study. Individuals, such as students and residents, are not considered full members or the AAPM and were excluded from the study. While burnout may be a serious issue for these individuals, the implications and causes are likely to be different than for those actively engaged and working in the field. Consultant medical physicists supplying services across multiple institutions were also excluded as it was unclear how well these individuals could properly identify organizational features or whether the answers would be based on an aggregate response across multiple clinics. The results of this dissertation study cannot be extrapolated or applied to these populations.

Recommendations

One recommendation is to educate administrators on the prevalence of burnout amongst medical physicists as well as the implications for unchecked burnout including decreased quality of care and increased errors. Additional layers of education should focus on tangible means by which administrators can reduce or avoid occurrence of the syndrome, such as promoting staff autonomy and improving levels of teamwork and staffing. A sense of community and respect amongst all staff and members of the administration, including the use of the CREW method, can help minimize the occurrence of the syndrome. Simple techniques, such as spacing out projects to allow for rest and recovery following large effort, can also aid in reducing the effects of limited resources in the face of high demands. Another component of the administrator's education should focus on reviewing clinic staffing levels against national standards. Ensuring that each organization maintains an appropriate work force can help to improve the quality of care delivered and reduce burnout and the rate of errors.

A second recommendation is to educate medical physicists. While burnout is a recognized condition, there is still a stigma associated with the syndrome. Fear of not being viewed as a team player or having a negative professional reputation, particularly in a very small field such as medical physics, are common concerns. Educating these professionals as to the symptoms and effects of burnout are necessary. Placing a higher value on quality over quantity of work, methods of maintaining a work-life balance, and individual coping mechanisms should also be included as part of the medical physicist education. The AAPM code of ethics currently includes the requirement for each physicist to recognize the limitations of their skillset and knowledge. Perhaps this code should also be expanded to include a recognition of physical and mental limitations due to workload and burnout.

The medical physicist community must also evaluate methods to protect its members. For example, AAPM task group reports are robust, topic-specific scientific reviews designed to improve standardization and safety through formal recommendations. While these reports provide invaluable knowledge and serve as a resource to the community, an inadvertent side effect has been their use to set minimum regulatory standards. This has added considerable burden to the physicists' workload, sometimes with minimal safety improvement. The AAPM recognized the problem and, in response, developed an additional reporting mechanism, Minimum Physics Practice Guidelines (MPPG). However, it is unclear at the current time whether regulators will utilize these relatively new reports when establishing standards. An additional issue is that task group reports are often published in advance of MPPG reports on the same topic. This may result in regulations being adopted based on the more rigorous task group reports in lieu of the more realistic MPPG due merely to timing. As highly trained professionals, medical physicists command a significant salary. With ever-looming threats of reduced

reimbursements in the United States, the community must also evaluate appropriate mechanisms for achieving economically feasible high reliability and safety without any additional burden to the current workforce. Examples to achieve this end include the expansion of automation/artificial intelligence and/or the increased use of medical physics assistants. Automated systems can assist in reducing some work burden, particularly for routine and mundane tasks. For example, a challenge to increase the availability of automated systems to assist with the physics plan check process was issued to vendors in the recent AAPM Task Group 275 report (Ford et al., 2020). Medical physics assistants can provide lower price-point services, under the supervision of a medical physicist, thereby helping to balance the competing demands of quality and economics.

Academic therapeutic physicists demonstrated higher levels of emotional exhaustion than therapeutic physicists working in a community hospital. There may be several reasons for this such as competing demands including tenure, grants and research, and teaching in addition to a clinical load. As a result, the leadership of academic departments and medical schools should evaluate their internal processes to balance the clinic load against these competing demands for promotions and tenure. Further, department leadership should ensure there is sufficient support of faculty members and encourage a collaborative environment.

Radiation oncology-specific accreditation should also be encouraged. Accreditation is a means to provide an independent peer review of the department/organization including in-depth reviews of the work of both physicians and physicists, two cohorts of medical professionals subject to high rates of burnout. In addition to providing the benefit of honest feedback as to the quality of services being provided, accreditation programs can provide staffing benchmarks for the organization and provide an independent and unbiased means to advocate for necessary

changes. Further, accrediting bodies and professional organizations such as the AAPM should evaluate the recommended staffing models of medical physicists, particularly in relation to high-touch procedures such as brachytherapy and stereotactic procedures.

Summary

Over the last 45 years, burnout has evolved from a "fad" rejected by academic journals to being included in the ICD-10 and 11. Many of the prior theories regarding the syndrome, including the belief that it only affected those involved in the caring professions and was only a North American construct, have been dispelled. Further, the relationship between burnout and organizational features have helped to minimize the stigma of it being a "personal issue." While many studies have evaluated burnout in a wide array of health care professionals, until recently, burnout in medical physicists had not been studied.

Utilizing validated instruments, approximately 60% of medical physicists who participated in this study were identified as suffering from some level of burnout burden, including nearly 7% who scored positively across all three domains. It is important to note that these values were obtained using the most recent, and more conservative, z-score thresholding techniques. A comparison to the literature, using the cut score thresholds, demonstrated that medical physicists are suffering from higher burnout rates than physician chairs of academic radiation oncology programs. While levels of emotional exhaustion and depersonalization were more than twice that of the radiation oncology chairs, it is also important to note that the level of personal achievement was also much higher amongst all medical physicists. Even the cohort of physicists with a positive burnout burden on personal achievement, respective to their peers, regularly experienced feelings of personal achievement. High personal achievement may be providing an insulating effect and helping prevent full-blown burnout. Beyond personal

achievement, however, therapeutic medical physicists experience a significantly higher level of emotional exhaustion and depersonalization than their non-therapeutic colleagues. There are several potential explanations for the effect but the exact cause(s) are currently unclear. The facility setting (i.e., academic or non-academic) was demonstrated to have no impact on the prevalence of the three domains except when evaluating emotional exhaustion amongst therapeutic physicists. Academic therapeutic physicists experience higher emotional exhaustion than their non-academic therapeutic colleagues, perhaps due to the additional responsibilities and pressures of the position such as grant applications, publications, teaching, and tenure.

While a positive relationship was demonstrated between work hours and emotional exhaustion, the teamwork and staffing construct had an even more dramatic impact on this domain amongst therapeutic physicists, statistically explaining 37% of the observed effect. Having an organizational environment where topics and issues can be openly discussed without fear or punitive action was also shown to have an inverse relationship with emotional exhaustion in this cohort.

An inverse relationship was found between the assigned department safety grade and emotional exhaustion. While the relationship between burnout and errors have been demonstrated in other studies, the relationship between emotional exhaustion and error reports in this dissertation study were inconclusive. However, this may be due to issues with the construct, which relied on recall over a one-year period, honesty in providing true number of error reports submitted, and the additional problem of attempting to relate emotional exhaustion at a single point in time with errors made over a 12-month period. Given the relationship demonstrated in prior studies, and the potential high severity associated with errors during the delivery of radiation treatment, additional and more focused research is needed. While there has been

significant progress with respect to patient safety and error reporting within radiation oncology, it is evident from the data that the community still has room for improvement. While medical physicists have some power in ensuring this happens, the community needs to engage the broader radiation oncology community, including our administrator and physician colleagues, to make lasting improvements.

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Appendix A

Participant Letter for Anonymous Surveys

NSU Consent to be in a Research Study Entitled

Job-Related Attitudes Amongst Medical Physicists in the United States

Who is doing this research study?

The person conducting this study is Deborah Schofield with the Nova Southeastern University, Dr. Pallavi Patel College of Health Care Sciences, Department of Health Sciences. She will be helped by Dr. Akiva Turner (chair), Dr. C. Lynn Chevalier, and Dr. Laurence Court.

Why are you asking me to be in this research study?

You are being asked to take part in this research study because you are a full member of the AAPM and currently employed as a medical physicist within the United States. Students, medical physics residents, and fellows are excluded from the current study. Participants working as a full-time consultant providing services to multiple institutions/clinics concurrently or employed by a vendor are also excluded.

Why is this research being done?

The purpose of this study is to investigate and understand job-related attitudes amongst medical physicists working in the United States.

What will I be doing if I agree to be in this research study?

You will be taking a one-time, anonymous survey. The survey will take approximately 30 minutes to complete.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?

There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private?

Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. The data will be deidentified and analysis/reporting will only be done in aggregate form. No attempt will be made to identify an individual participant. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely on a password protected device behind a firewall. All data will be kept for 36 months from the end of the study and destroyed after that time by the appropriate purging of the data files.

Who can I talk to about the study?

If you have questions, you can contact Deborah Schofield at 781-552-1328. You can also contact the dissertation chair, Dr. Akiva Turner, at 954-262-1862. If you have questions about the study but want to talk to someone who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily consent to participate in this research study, please click on the provided link to access the survey.

Appendix B

Demographics

1. Location of your practice
    a. USA
    b. Canada
    c. Other. Please Specify

2. Please identify the primary medical physics sub-specialty that you practice
    a. Therapeutic medical physics
    b. Diagnostic medical physics
    c. Health Physics/RSO
    d. Nuclear medicine
    e. Other. Please specify

3. What best describes your current practice
    a. Academic-affiliated hospital
    b. Community hospital
    c. Government hospital
    d. Free-standing facility
    e. Consulting group
    f. Vendor
    g. Other. Please specify

4. Number of physicists in your group
    a. 1
    b. 2–3
    c. 4–5
    d. 6–10
    e. 11–20
    f. > 20

5. Number of years of post-graduate medical physics experience
    a. 0–2
    c. 3–5
    c. 6–10
    d. 11–15
    e. 15–20
    f. > 20

Appendix C

Organizational Survey

Please indicate your agreement or disagreement with the following statements about the department.

Likert Scale: ***strongly disagree/ disagree/ neither/ agree/ strongly agree***

1. People support one another in this department
2. We have enough staff to handle the workload
3. When a lot of work needs to be done quickly, we work together as a team to get the work done
4. In this department, people treat each other with respect
5. Staff in this department work longer hours than is best for patient care
6. We are actively doing things to improve patient safety
7. We use more agency/temporary staff than is best for patient care
8. Staff feel like their mistakes are held against them
9. Mistakes have led to positive changes here
10. It is just by chance that more serious mistakes don't happen around here
11. When one area in this department gets really busy, others help out
12. When an event is reported, it feels like the person is being written up, not the problem
13. After we make changes to improve patient safety, we evaluate their effectiveness
14. We work in "crisis mode" trying to do too much, too quickly
15. Patient safety is never sacrificed to get more work done
16. Staff worry that mistakes they make are kept in their personnel file
17. We have patient safety problems in this department
18. Our procedures and systems are good at preventing errors from happening

Please indicate your agreement or disagreement with the following statements about your immediate supervisor/manager or person to whom you directly report.

Likert Scale: *strongly disagree/ disagree/ neither/ agree/ strongly agree*

19. My supervisor/manager says a good word when he/she sees a job done according to established patient safety procedures
20. My supervisor/manager seriously considers staff suggestions for improving patient safety
21. Whenever pressure builds up, my supervisor/manager wants us to work faster, even if it means taking shortcuts
22. My supervisor/manager overlooks patient safety problems that happen over and over

How often do the following things happen in the department?

Likert Scale: never/ rarely/ sometimes/ most of the time/ always

23. We are given feedback about changes put into place based on event reports
24. Staff will freely speak up if they see something that may negatively affect patient care
25. We are informed about errors that happen in this unit
26. Staff feel free to question the decisions or actions of those with more authority
27. In this unit, we discuss ways to prevent errors from happening again
28. Staff are afraid to ask questions when something does not seem right

Minor and Major Near-misses and Errors.
NEAR-MISSES: A near-miss is any error that almost happened but was averted because of luck, safety measures or some other intervening factor.
ERRORS: An error is any preventable event that results in radiation misadministration, patient injury or discomfort or treatment delay and range in severity from those that result in no harm to those that result in serious harm or death.
MINOR vs. MAJOR: The questions below draw a distinction between 'minor' errors and near-misses and 'major' errors and near-misses. Minor errors and near misses are problems that could result in delay, discomfort or treatment deviation but are unlikely to harm patients. Major errors and near misses are therefore those problems which are likely to lead to patient harm.
For the following questions, please select the level to which you agree with the statement.
Likert Scale: *I would prefer not to answer/ strongly disagree / disagree/ neutral/ agree/ strongly agree*

29. It is my responsibility to report errors/near-misses within my department
30. I know how to report errors/near-misses within my department
31. I know what kinds of errors/near-misses should be reported to my department
32. I would report errors/near-misses if I were not so busy.
33. I would be more likely to report errors/near-misses to my department if it were easier to do
34. I would be more likely to report errors/near-misses to my department if it were anonymous
35. I would be more likely to report errors/near-misses to my department if I received feedback afterwards
36. I have confidence that my error/near-miss reports get used to improve our system
37. I know errors/near-misses happen, but my team is so careful we do not have events to report
38. I believe that my colleagues value error and near-miss reporting
39. I believe that my colleagues would report an error or a near-miss that I caused
40. I believe that my colleagues would report an error or a near-miss that they caused

For the following statement, please select the most appropriate selection to complete the statement.
Likert Scale: I have both REPORTED and NOT REPORTED instances of which I was aware / Always REPORTED it to my supervisor or department reporting system / Never REPORTED it to my supervisor or department reporting system / I have never caught a minor "near-miss" in our department / I would prefer not to answer this question / Other:

41. Have you ever caught a MINOR mistake before it happened (a “near-miss”) that would have resulted in care being prolonged or delivered incorrectly and, after correcting the problem:
42. Have you ever caught a mistake before it happened (a “near-miss”) that would have resulted in MAJOR harm or disability and, after correcting the problem:
43. Have you ever made a MINOR mistake (error) or observed someone else make a minor mistake that resulted in treatment being delivered incorrectly and:
44. Have you ever made a mistake (error) or observed someone else make a mistake that caused MAJOR harm or disability and:

Barriers to reporting: In general, when thinking about reporting errors/near-misses, I am concerned about:

Yes / No

45. Departmental or professional sanctions
46. Getting my colleagues into trouble
47. Admitting liability
48. Embarrassment in front of colleagues
49. Provoking retribution from colleagues
50. The effect it may have on our department's reputation

What are important sources of errors/near misses in your department?

Likert Scale: never/ rarely/ sometimes/ most of the time/ always

51. Communication failures
52. Failure to follow standard operating procedures
53. Technical failures (hardware and software errors)
54. Insufficient training
55. Too high a workload
56. We do not have errors or near-misses occur in our department

Scale: failing/ poor/ acceptable/ very good/ excellent

57. Please give you department an overall grade on patient safety.

Scale: No reports/ 1–2 reports/ 3–5 reports/ 6–10 reports/ 11–20 reports/ > 20 reports

58. In the past 12 months, how many event reports have you filled out and submitted.

Scale: < 20 / 20–39 / 40–59 / 60–79 / 80–99 / > 100

59. Typically, how many hours per week do you work in this hospital?

60. What is your staff position in the hospital?

Scale: Yes/No

61. In your staff position, do you typically have direct interaction or contact with patients?

62. Describe how you think the next patient in your department will be harmed.
63. Describe what you think can be done to prevent or minimize this harm.
64. Please feel free to write any comments about patient safety, error, or event reporting in your hospital.

Appendix D

Institutional Review Board

NOVA SOUTHEASTERN UNIVERSITY
Institutional Review Board

MEMORANDUM

To: Deborah Schofield

From: Vanessa A Johnson, Ph.D.,
Center Representative, Institutional Review Board

Date: August 25, 2020

Re: IRB #: 2020-407; Title, "Job-Related Attitudes Amongst Medical Physicists in the United States"

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review under **45 CFR 46.101(b) (Exempt 2: Interviews, surveys, focus groups, observations of public behavior, and other similar methodologies)**. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms, they must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research,and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE EVENTS/UNANTICIPATED PROBLEMS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and Vanessa A Johnson, Ph.D., respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactionsor events may include, but are not limited to, injury, depression as a result of participation in thestudy, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed inPart 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Carol L Chevalier, DHSc, MPH, MS,
BSRose M Colon, PhD

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