MUSCULOSKELETAL DISORDERS IN PERIOPERATIVE PERSONNEL AND RELATED FACTORS

by

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Background: The nursing profession is physically demanding with increased rates of occupational injuries. Operating room nurses (ORNs) experience rates of musculoskeletal disorders (MSDs) between 66.1% to 92.5%. Surgical technologists (STs), functioning similar to that of a scrub nurse, remain underrepresented in MSDs research. Multiple factors contribute to the development of MSDs; however, little is known about the rates of adherence to ergonomic safety practices. Further, differences in risks among surgical team members, specifically ORNs and STs, is poorly understood.

Purpose: The purpose of this study is to examine effects of physical workload, prevalence of the Association of periOperative Registered Nurses (AORN) high-risk tasks and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed.

Methods: A secondary analysis of cross-sectional survey data was performed for this descriptive correlational study. Data includes personal (age, gender, and experience), organizational (hours worked during shift, shifts worked in a row, teamwork), tasks (seven high risk tasks, physical workload, adherence to safety guidelines), and outcome (injury, musculoskeletal pain and days of missed work) variables of interest for ORNs and STs.

Results: Overall, 90.6% of ORNs and 89.7% of STs reported pain in at least one area of the body (N = 156). Back pain was highly prevalent for both groups. Adherence to AORN safety guidelines ranged from 49.95 – 64.78% for both groups. The mean physical workload was significantly higher for STs compared to ORNs ($p < .001$). Additionally, a significant difference was found in STs who were injured related to lifting weight while in the inclined body position. For both ORNs and STs, physical workload was significantly correlated with the frequency of non-adherence to the majority of AORN tasks.

Conclusion: ORNs and STs experience high rates of MSD pain affecting their health and organizational workflow. Improved adherence to AORN safety guidelines may lead to decreased rates of MSD pain. Additional research is needed to identify barriers and facilitators for adherence to AORN safety guidelines.

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by

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DEDICATION

This dissertation is dedicated to my husband, Will.

Your kindness, patience, and encouragements are seemingly endless.

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CHAPTER 1: INTRODUCTION

The nursing profession is physically demanding with increased rates of occupational injuries (Dressner & Kissinger, 2018). Operating room nurses (ORNs) experience rates of musculoskeletal disorders (MSDs) estimated between 66.1% to 92.5% (Asghari et al., 2019; Nützi et al., 2015). Surgical technologists (STs), who function in a similar role to that of a scrub nurse in the operating room, remain underrepresented in research related to MSDs. A variety of factors contribute to the development of MSDs in perioperative personnel; however, little is known about the rates of adherence to ergonomic safety practices. Further, differences in risks among surgical team members, specifically ORNs and STs, is poorly understood.

Background

The general nursing workforce experiences strenuous work environments with increasing physical demands. Nurses work long shifts that involve increased time on their feet as they care for patients (U.S. Bureau of Labor Statistics, 2021a). Most registered nurses (60%) work in hospital systems where care of patients requires them to lift, push, pull, and transfer patients, also contributing to the physically demanding nature of their work (Ogg, 2011; U.S. Bureau of Labor Statistics, 2021a). Additionally, there is an increased prevalence of obesity among hospitalized patients and researchers recently found 66% of hospitalized adult patients were overweight or obese (Hossain et al., 2018). The strenuous physical working conditions experienced by nurses has led to increased rates of occupational injuries among nursing professionals (Dressner & Kissinger, 2018).

Injuries or disorders of the musculoskeletal system and connective tissues are commonly referred to as MSDs (CDC, 2020). Work-related MSDs can occur when activities of the work environment contribute to the development of disorders or injuries either through prolonged stress to the system or the demands of the job exceeding the capabilities of the worker (CDC 2020; Ogg, 2011). Activities encountered by the registered nurse (RN) that may result in work-related MSDs include routine lifting of heavy objects, overexertion, repetitive motions, and working in awkward positions.

In the United States, Dressner and Kissinger (2018) found RNs had a significantly higher incidence of MSD injuries requiring days away from work compared to all occupations. The incidence of MSDs in private industry RNs in 2016 was 46 cases per 10,000, compared 29.4 cases per 10,000 for all occupations. These high rates of MSDs resulted in 8,730 days away from work for private industry RNs, with most (67%) injuries caused by healthcare patient handling. This data comes even after the introduction of the Safe Patient Handling and Mobility programs and advocacy by the American Nurses Association (American Nurses Association, 2013). Additionally, the average estimated cost of an injury due to patient handling is $15,600 with potential indirect costs increasing by two to four times the average (Occupational Safety and Health Administration, 2013).

The strenuous work environment and rates of MSDs are frequently reported as aggregate data of the general nursing workforce. In 2017, ORNs made up 5.8% of the nursing workforce, surpassed as a specialty only by medical-surgical (10.1%) and acute/critical care (11.4%) nursing (Smiley et al., 2018). Although perioperative nurses may work in a variety of settings, including preoperative, intraoperative, and postoperative, the perioperative nurses working in the intraoperative setting are the focus of this this research and are referred to as ORNs. ORNs experience similar strenuous working environments as the general nursing workforce, but those working within the intraoperative setting have additional unique physical demands placing them at increased risk for MSDs. These unique demands include prolonged standing, tissue retraction, moving large equipment, and holding patient extremities for prolonged periods of time (Ogg, 2011). International estimates of MSD prevalence for ORNs are significant and range from 66.1% to 92.5% for any region of the body (Asghari et al., 2019; Nützi et al., 2015).

In the United States, nurses in the intraoperative setting perform in roles including circulating nurse, scrub nurse, and first assistants. Working alongside ORNs in the operating room are the STs. STs are important allied health partners within the operating room and their contributions have continued to increase since the 1970s (Association of Surgical Technologists, n.d.-b). Surgical technologists perform similar duties to that of a scrub nurse and are typically non-degree or associate degree prepared unlicensed personnel (U.S. Bureau of Labor Statistics, 2021b). Importantly, the work environment and responsibilities of the ST includes similar risks for MSDs to that of the ORN functioning in the role of scrub nurse. However, little research exists examining differences in MSD risk for STs and ORNs.

In response to the importance of reducing MSDs in the intraoperative settings, the Association of periOperative Nurses (AORN) identified seven common ergonomic risk factors experienced by perioperative nurses and introduced ergonomic toolkits for each with safety measures to prevent MSDs (Ogg, 2011). The toolkits provide specific ergonomic safety measures to use during lateral transfer of patients, position and repositioning the supine patient, lifting and holding of patients and body parts, prolonged standing, tissue retraction, lifting and carrying supplies, and pushing, pulling and moving of beds and equipment. A description of each AORN toolkit and safety guidelines can be found in Appendix A. Although these toolkits were implemented into AORN’s Safe Patient Movement and Handling Guidelines in 2018, it is not known if ORNs or surgical technologists adhere to these safety measures.

Research Problem

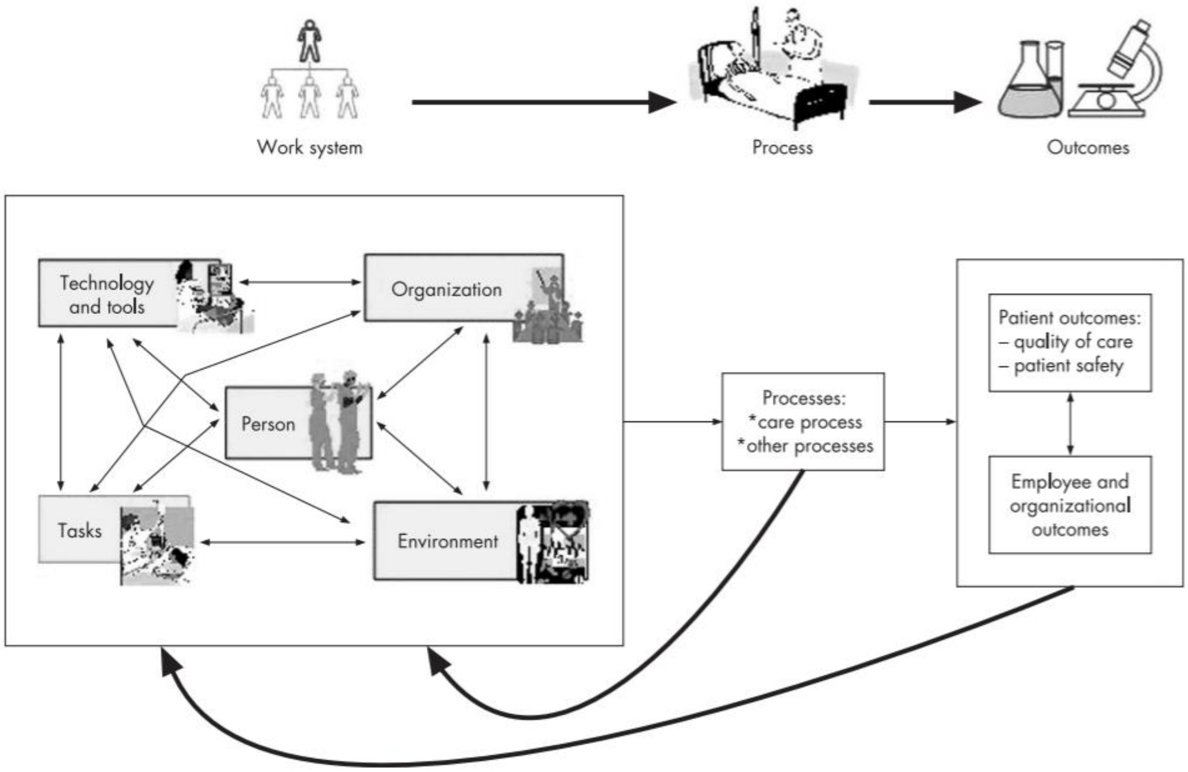
Despite the work of professional organizations including ANA and AORN to decrease injuries, rates of MSDs remain high for ORNs and are widely unknown in STs. There is limited research on factors related to the development of MSDs in ORNs and only a small portion of the research includes the ST as part of the surgical team (Yu et al., 2016). ORNs and STs work in the same environment with similar ergonomic demands, but differences between these groups are poorly understood. Further, no research, to this authors knowledge, has explored the adherence to AORN ergonomic safety recommendations of perioperative personnel. Adherence to ergonomic safety measures in the intraoperative setting is important to understanding MSDs in perioperative personnel and remains unexplored. Additionally, understanding differences that may exist between STs and ORNs is needed to further illuminate MSD risks within the surgical team and begin targeted interventions to decrease rates of MSDs.

Theoretical Framework

The Systems Engineering Initiative for Patient Safety (SEIPS) model is the theoretical framework used to guide this study. The SEIPS model focuses on how components of the work system (person, organization, technologies and tools, tasks, and environment) impact processes and outcomes in the health care setting (Carayon et al., 2006). In this model, each component of the work system interacts with the others and has an impact on outcomes involving the patient, employee, and organization and is visually represented in Figure 1. The person within the work system may be the patient, a health care provider, or a health care worker. Each additional element of the work system should be supporting the person within the model to carry out the process of interest. Although the name of the model indicates a focus on patient safety, employee outcomes are also included in the model.

Figure 1

SEIPS Model of Work System and Patient Safety



Note. From "Work System Design for Patient Safety: The SEIPS Model," by P. Carayon, A. Schoofs Hundt, B-T. Karsh, A. P. Gurses, C.J. Alvarado, M. Smith, P. Flatley Brennan, 2006, *BMJ Quality & Safety*, *15*(suppl 1), i51 (https://doi.org/10.21916/mlr.2018.27).

Carayon et al. (2006) note that the SEIPS model expands on Donabedian's structure-process-outcome (SPO) model providing further theoretical underpinnings (Donabedian, 1966). It is the opinion of Carayon and colleagues (2006) that the SPO model did not provide a broad enough description of the work system (structure) and the description of processes was too limited. The updated model shows signs of underpinnings related to general systems theory. General systems theory focuses on the whole, rather than the sum of parts (Skyttner, 2001). Additional assumptions of general systems theory include the interactions of the system to reach some goal through the transformation of inputs to outputs. General systems theory underpinnings can be seen in the interactive work system and the effects on processes and outcomes within the SEIPS model.

Assumptions of the model are anchored by ergonomics, or human factors, where humans interact with their environment and contribute to processes and outcomes (Wilson, 2014). Relationships depicted within the model are the interaction of the person with tasks performed, technology and tools, the environment, and the organization. These components of the work system interact with each other and may influence each other in a positive or negative way. The interactions within the work system can impact the process, and the process can influence the work system. Similarly, the interactions within the work system can impact employee outcomes, and the outcomes can influence the work system.

Major Components

Work System

According to Carayon et al. (2006), the work system within the SEIPS model is an enhancement to the structure component of Donabedian's model. The work system depicted in Figure 1 identifies multiple components which form complex interactions within the structure. These components include person, organization, environment, tasks, and technology and tools. No one component is given higher importance or focus within the model. The addition of these components changes the focus of the structure from the individual role, as in Donabedian's model, and emphasizes the role of multiple components within the system on outcomes produced. The work system must be well designed and balanced to provide safe, quality care to patients.

Person. The person at the center of the work system can be conceptualized as a healthcare worker, such as a nurse or physician, or a patient depending on the focus of the system (Carayon et al., 2006). The work system must be designed to support the person at the center by enhancing performance and decreasing negative consequences. Additionally, each component should work towards meeting the needs of the person at the center of the work system. Elements of the person may include skills and knowledge, physical characteristics, and motivations.

Organization. Elements of organizations can impact the employee, organization, and patient outcomes (Carayon et al., 2006). Examples of possible elements of the organization concept including work schedules, teamwork, leadership style, and organizational culture. These elements within the work system are underpinned by the increasing shift of healthcare to a just culture model supporting patient safety. Just culture acknowledges that health care workers should not be blamed for the failings of the system where they practice (American Nurses Association, 2010).

Environment. The environment component may include elements such as layout, design of the workstation, lighting, and noise levels (Carayon et al., 2006). The environment component of the model is adapted to the individual at the center of the work system.

Tasks. Examples of the task component may include workload (physical and cognitive), variety of tasks performed, and autonomy or control (Carayon et al., 2006). Tasks may include everyday duties of the individual at the center of the work system.

Technology and Tools. Electronic health records, medical devices, and their usability may all be elements of the technology and tools component (Carayon et al., 2006). The technologies and tools within the work system must consider the interactions with all components of the work system, as well as processes and outcomes.

Process

Processes are an additional area that Carayon et al. (2006) further expand on Donabedian's SPO model. In the SEIPS model, an expanded view of processes includes those involving care, as well as those supporting care processes. For example, in the perioperative setting sterile processing of surgical instruments is vital to the care of surgical patients. However, those involved in sterile processing processes are not directly involved in the care of surgical patients. These ancillary support chains are important considerations within the SEIPS model and can have an impact on components of the work system as well as care processes. In the example provided, sterile processing supports care of the surgical patient, and a breakdown of this support process could prevent safe care of surgical patients. The SEIPS model depicts a feedback loop where problems with a process should initiate a review of the work system design.

Outcomes

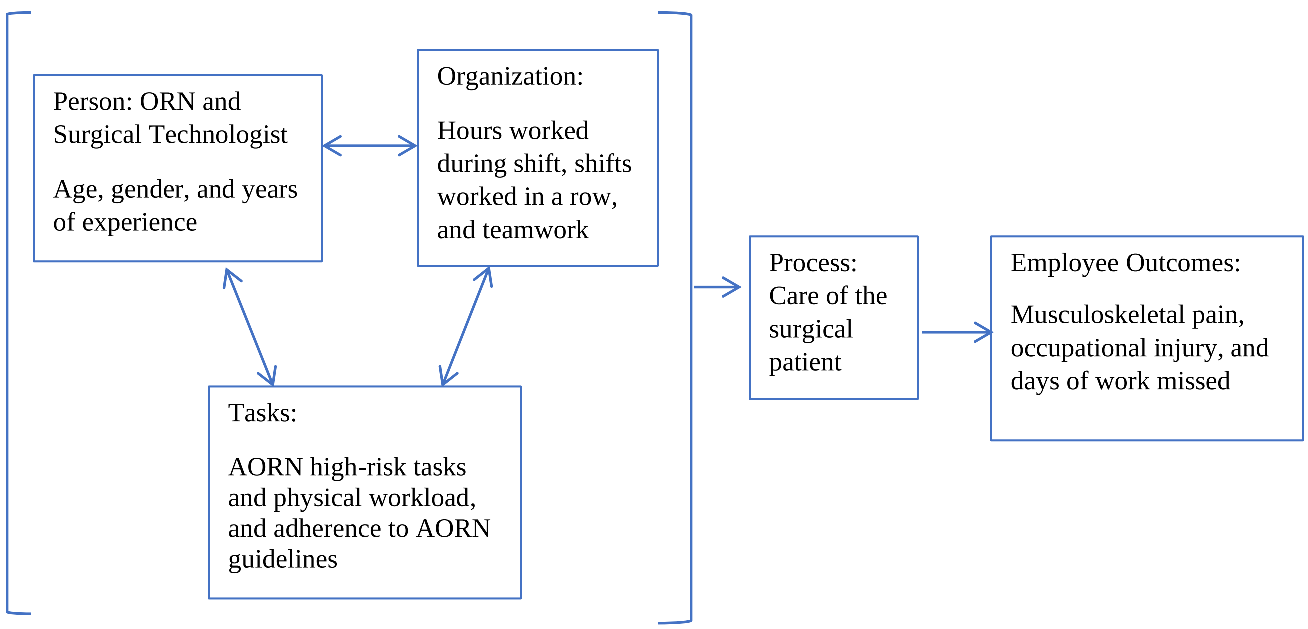
As described by Carayon et al. (2006), outcomes of the work system and processes can include the patient and the employee/organization. There is an emphasis on the close relationship of patient outcomes with employee/organizational outcomes where the work system design can impact all three outcomes. For example, an ORN who experiences an MSD may not be able to perform safe patient handling, impacting patient outcomes. Further, the presence of an MSD may result in lost days of work, impacting organizational outcomes. Similar to the feedback loop depicted with the process and work system, a feedback loop also exists with outcomes and the work system and negative outcomes should initiate a review of the work system design.

Purpose

The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. An adaptation of the SEIPS Model with associated variables for the study can be found in Figure 2.

Figure 2

Adaptation of SEIPS Model with Associated Variables



Research Questions

1. What is the adherence rate to AORN safety guidelines when performing seven high-risk physical tasks in the operating room and the frequency of performing each task without adherence to the safety guidelines in ORNs and STs?
2. What is the frequency of unfavorable postures (bending, twisting, kneeling, or squatting) of the trunk, arms, and legs, frequency of lifting/carrying light, medium, and heavy loads in upright and inclined body positions, and physical workload based on the frequency of unfavorable postures and lifting/carrying of light to heavy loads in upright and inclined positions for ORNs and STs?
3. What is the correlation of frequency of AORN tasks performed without following AORN guidelines and proportion of time safety guidelines were followed with frequency of unfavorable postures and handling of heavy loads and workload associated with the postures and lifting of heavy loads during work in ORNs and STs?
4. What is the relationship of frequency of task non-adherence to AORN safety practices, percent of time adhering to AORN safety practices, and workload on age, surgical experience, and teamwork?
5. Over a twelve-month period, what is the prevalence of pain/discomfort experienced in the body areas of back, neck, shoulders, hands/wrists, and feet, severity of pain in each body area, prevalence of an occupational injury, and days of missed work because of the injury in ORNs and STs?
6. What is the relationship between the physical workload on severity of pain in any of the body areas and occurrence of an occupational injury?

7. What is the relationship between severity of pain in any of the body areas and occurrence of an occupational injury with age, experience in a surgical setting, and attitudes toward teamwork?

Theoretical and Operational Definitions

Person

The individuals at the center of the work system were the ORNs and STs for this study. The ORN was defined as any staff nurse who works in the intraoperative setting and encounters ergonomic demands during their workday. The ST was defined as any unlicensed scrub person working in the intraoperative setting who encounters ergonomic demands during their workday.

Age

Age was defined as the beginning of existence to a given point in time (Merriam Webster, n.d.-a). Age was operationalized by asking participants the numerical age on their last birthday.

Gender

Gender was defined as "the behavioral, cultural, or psychological traits typically associated with one sex" (Merriam Webster, n.d.-b). For this study, gender was operationalized by participants selecting one of three categories including male, female, or non-binary.

Years of Experience

An individual's years of experience was defined as the length of time someone begins a new role to a given point in time. For this study, years of experience was operationalized as the number of years participants have experience in the intraoperative setting.

Organization

According to Carayon et al. (2006), organizational elements impact the individual at the center of the work system. Data for this study included multiple hospitals and surgical centers within the same healthcare system.

Teamwork

Teamwork was defined as the ability to work together through effective communication and coordination to achieve a collective action (Salas & Cannon-Bowers, 2001). Teamwork was operationalized by measuring the constructs of team structure, leadership, situation monitoring, mutual support, and communication using the TeamSTEPPS ® Teamwork Attitudes Questionnaire Manual (Baker et al., 2008).

Hours Worked During Shift

Hours worked during a shift was defined as the number of clocked hours spent performing the same job role. For this study, hours worked during a shift was operationalized as the average number of hours worked in a typical shift.

Shifts Worked in a Row

Shifts worked in a row was defined as the number of shifts worked consecutively while performing the same job role. Shifts worked in a row was operationalized as the number of days typically worked in a row.

Tasks

According to Carayon et al. (2006), examples of tasks within the SEIPS model may include workload and job content. For this study, ergonomic risks, adherence to ergonomic safety measures, and physical workload of the ORN and ST were of particular interest.

Ergonomic Risk Factors

Ergonomic risk factors were defined as tasks that place physical stress on the musculoskeletal system of the worker (Iowa State University, n.d.). Ergonomic risk factors were operationalized as the number of times ORNs and STs did not adhere to the seven ergonomic safety practices identified by AORN over the past 14 days. These high-risk activities include lateral transfer of patients, positioning and repositioning the supine patient, lifting and holding of patient and body parts, prolonged standing, tissue retraction, lifting and carrying supplies, and pushing, pulling, and moving of beds and equipment (Ogg, 2011).

Adherence to Ergonomic Safety Measures

Adherence to ergonomic safety measures was defined as compliance with best practice recommendations during work activities. Adherence was operationalized using the seven AORN ergonomic toolkits where a percentage of time over the last 14 days was measured for adherence to each recommendation.

Physical Workload

Physical workload was defined as the physical demands caused by handling weight, working posture, or repetitive movements (Bot et al., 2004; Genç et al., 2016). Physical workload was operationalized using the Physical Workload Index (Bot et al., 2004).

Outcome

According to Carayon et al. (2006), outcomes of interest consistent with the SEIPS model include employee safety and health. For this study, musculoskeletal pain, occupational injury, and days of work missed were the outcomes of interest.

Musculoskeletal Pain

Musculoskeletal pain is pain that affects the bones, muscles, connective tissue, or nerves (Cleveland Clinic, 2021). Musculoskeletal pain was operationalized by asking participant if they experience pain, aching, stiffness, burning, numbness, or tingling in the back, neck, shoulders, hands/wrists, or feet over the past 12 months. Participants also rated any pain experienced on a numerical pain scale where zero is no pain, and 10 is the highest severity of pain. This was asked for the back, neck, shoulders, hands/wrists, and feet.

Occupational Injury

An occupational injury was defined when the demands or requirements of an individual's occupation results in injury or illness (Varacallo & Knoblauch, 2021). For this study, occupational injury was operationalized by asking participants if they experienced an occupational injury within the past 12 months. If participants answered yes, they were asked to identify which body part or parts were affected by the injury and how many days of work were missed due to injury.

Significance

The anticipated findings of this study are significant to the safety of perioperative personnel. Adherence to ergonomic safety practices is critical to preventing MSDs and injuries for both ORNs and STs. Current research employing interventions to decrease MSDs is primarily focused on educational needs (Abdollahi et al., 2020; Ali & Abdel-Hakeim, 2018). Interventions to enhance adherence cannot be designed or implemented without an understanding of adherence rates on a systems level. Without viewing the problem of MSDs in perioperative personnel as a whole system, interventions only addressing one factor may be insufficient in reducing injury.

Because this study was grounded in a systems theory, findings will provide valuable data to nurse managers and healthcare organizations about perioperative worker safety with consideration to the multidimensional nature of the healthcare system. These finding are expected to offer insight into the complex and multidimensional nature of ergonomic safety adherence. Further, the knowledge generated by this study is critical for the future development of interventions to reducing MSDs, decreasing time away from work for perioperative personnel, decreasing health care costs, and enhancing quality care of surgical patients.

Summary

Musculoskeletal disorders remain high in ORNs despite the work of professional organizations to provide guidance on decreasing risks. The unique physical challenges experienced by nurses in the intraoperative setting cannot be solved through education on safe patient handling alone. Understanding areas of low or high adherence to best practices is needed to move science forward in developing interventions targeted at decreasing MSDs for perioperative personnel. ORNs and STs experience comparable environments and ergonomic risks but differences may exist requiring different approaches and interventions to decrease MSDs for these similar but separate groups.

CHAPTER 2: REVIEW OF THE LITERATURE

The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. The following review of the literature provides an overview of the associated risk factors for ORNs and STs for MSDs utilizing the SEIPS model as a framework. The literature is organized within the context of the work system, process, and outcomes, consistent with the SEIPS model. Associated risk factors for MSDs within the work system will be reviewed at the organization and task level. Employee outcomes synthesized include MSD injuries and pain. Finally, a review of gaps identified within the literature is discussed.

Risk Factors Associated with the Work System

The work system, according to Carayon et al. (2006), includes the concepts of person, organization, tasks, environment, and technology and tools forming complex interactions with the process and outcomes of the SEIPS model. The following provides a review of the literature where risk factors within the concepts of person, organization, and tasks impact perioperative personnel related to their MSDs and MSD associated pain (employee outcomes).

Person

An effective work system is designed to support the person at the center of the system and meet their needs (Carayon et al., 2006). Elements of the person, ORNs and STs, found in the literature include physical characteristics, knowledge and experience, and physical activity level. A review of these elements and their relationship to MSD risk follows.

Physical Characteristics

Although age was collected in most studies, it was only explored as a risk factor by some researchers. Abdollahzade et al. (2016) explored working posture of nurses in operating rooms in Iran using the Rapid Entire Body Assessment (REBA) tool. Abdollahzade and colleagues found that as age of the participants increased, posture became more awkward, increasing risk for MSD injury. Moscato et al. (2010) looked more specifically at low back pain intensity and found operating room nurses older than 35 had higher pain intensity and more frequently reported forgoing pleasant activities than those younger than 35 years old. Findings were different in a similar study exploring MSDs and related factors where Nasiri-Ziba et al. (2017) found no statistically significant relationship with age and prevalence of MSDs among operating room nurses. Additionally, Asghari et al. (2019) also found no relationship in MSD related pain and age of operating room nurses.

Gender was explored in relation to posture, upper extremity disability, and MSD prevalence (Abdollahzade et al., 2016; Clari et al., 2019; Nasiri-Ziba et al., 2017). Abdollahzade et al. (2016) found a significant relationship with female gender and awkward working posture scores in operating room nurses using the REBA tool. Clari et al. (2019) investigated associated risk factors for upper limb work-related MSDs and found female operating nurses had a three-fold increased risk for upper limb MSDs when compared to male participants. Nasiri-Ziba et al. (2017) found no statistically significant relationship between gender and prevalence of MSDs.

Body Mass Index (BMI) was also analyzed for a relationship with MSD prevalence (Asghari et al., 2019; Cavdar et al., 2020; Nasiri-Ziba et al., 2017). Two studies used the Nordic Musculoskeletal Questionnaire, researchers did not find any significant relationship between BMI and MSD prevalence in operating room nurses (Asghari et al., 2019; Nasiri-Ziba et al., 2017). However, one study determining the presence of low back pain and associated factors found operating room nurses with normal BMI had higher rates of low back pain when compared with those under or over normal BMI ranges (Cavdar et al., 2020). Cavdar et al. (2020) did not propose a rationale for these contradicting findings.

Knowledge and Experience

In the literature, educational interventions have been used to increase ergonomic knowledge levels for operating room nurses (Abdollahi et al., 2020; Ali & Abdel-Hakeim, 2018; Moazzami et al., 2016). However, there is mixed results as to the effectiveness of these interventions. Researchers found ergonomic education to improve the posture of participants in the intervention group compared with a control group (Abdollahi et al., 2020; Moazzami et al., 2016). Ali et al. (2018) used pre- and post-test data to identify increased ergonomic knowledge after an educational intervention as well as self-reported improvements in changes to practice. Interestingly, 50% of operating room nurses (N=44) in a study investigating ergonomic risk factors for MSDs reported attending education on MSD safety but only 14% reported the education as adequate (Bakola et al., 2017). Additionally, a qualitative study exploring occupational risks of operating room nurses found participants reported educational activities as inadequate for protection against occupational injury (Çelikkalp & Sayilan, 2020).

In all studies, work experience was found to significantly affect posture and prevalence of MSDs (Abdollahzade et al., 2016; Cavdar et al., 2020; Moscato et al., 2010; Nasiri-Ziba et al., 2017). Abdollahzade et al. (2016) found operating room nurses with more work experience had higher REBA scores indicating awkward posture and increased risk for MSD injuries. Other researchers have found high rates of low back pain in operating room nurses with more years of experience (Moscato et al., 2010). When looking at years of experience with occurrence of low back pain, Cavdar et al. (2020) found the highest rates in operating room nurses with six to 10 years of experience when compared to those with less than six years and more than 11 years of experience. Additionally, prevalence of MSD and increased working experience were significantly related (Nasiri-Ziba et al., 2017).

Physical Activity Level

Physical activity levels with and without exercise were analyzed for a relationship with posture, low back pain, and prevalence of MSD pain (Abdollahzade et al., 2016; Asghari et al., 2019; Cavdar et al., 2020; Moscato et al., 2010; Nasiri-Ziba et al., 2017). Abdollahzade et al. (2016) found participants who reported exercising regularly had better posture. Moscato et al. (2010) observed operating room nurses with no physical activity reported low back pain caused them to decline engaging in pleasant activities more frequently and their pain intensity was higher than those who participated in physical activity. Similarly, Cavdar et al. (2020) found regular exercise to be associated with less low back pain in operating room nurses.

Only two studies looked at exercise with MSDs. However, one of the studies looked at prevalence while the other was focused on the outcome of MSD pain. Nasiri-Ziba et al. (2017) found no statistically significant relationship with MSD prevalence and regular exercise in operating room nurses, while Asghari et al. (2019) found decreased levels of physical activity to be significantly associated with MSD pain.

Organization

As depicted in the SEIPS model, organizational factors are part of the work system (Carayon et al., 2006). Examples of organizational elements include teamwork, work schedule, culture, and social relationships. The following paragraphs discuss the literature on organizational elements and their relationship with the outcomes of MSD pain or injury.

Hours and Shifts Worked

Researchers used the REBA tool to compare working posture of operating room nurses with the number of shifts worked per month and shift type (i.e., whether the shift occurred in the morning, evening or rotating) (Abdollahzade et al., 2016). A major finding indicated a statistically significant negative relationship with posture and number of shifts worked per month. Additional findings showed no statistically significant relationship with working posture of operating room nurses and shift type. Asghari et al. (2019) found a statistically significant relationship in shift type worked by ORNs and MSD pain symptoms. Additionally, Nasiri-Ziba et al. (2017) did not find a statistically significant relationship between the number of hours worked daily and the prevalence of MSDs.

Teamwork

In a study identifying ergonomic risk factors and the relationship with MSDs, researchers surveyed ORNs about their perception of factors contributing to the development of MSDs (Bakola et al., 2017). When asked to rank categories of contribution to work-related MSDs, participants placed teamwork as highly important. A total of 79.5% of participants (N = 33) agreed or strongly agreed that there was good teamwork and collaboration in their department. Bakola et al. (2017) did not analyze the relationship of teamwork with the prevalence of MSDs.

Although additional studies did not specifically measure teamwork, measures of influence on type of work performed and social support at work were explored (Baur et al., 2018; Nützi et al., 2015). Baur et al. (2018) investigated influence at work and social support and found no relationship with cervical or low back pain in surgical nurses. Nützi et al. (2015) investigated influence at work and found a statistically significant relationship with lumbar pain, but no relationship with cervical pain in operating room nurses.

Work Related Attitudes

Attitudes about quality of work life, influence at work, job stress, and work family conflict were all explored as potential risk factors for MSDs in ORNs and STs (Asghari et al., 2019; Baur et al., 2018; Jeyakumar & Segaran, 2018; Nützi et al., 2015; Sheikhzadeh et al., 2009). Work family conflict is described as job stress interfering with family duties (Baur et al., 2018). Two studies found work family conflict to be significantly related to both cervical and lumbar pain in ORNs (Baur et al., 2018; Nützi et al., 2015). These results are similar to Jeyakumar et al. (2018), who also found a significant relationship between a stressful workplace and lower back pain in operating room nurses. Researchers investigating quality of work life and musculoskeletal pain found a relationship with MSD pain and the dimensions of health and safety and knowledge and esteem (Asghari et al., 2019). One study measured operating room nurses influence at work and found that as control over work decreased, lumbar pain increased (Nützi et al., 2015).

Additional perceptions of stress as an ergonomic risk factor in the operating room were explored using mixed methods survey data and focus groups by Sheikhzadeh et al. (2009). They found 100% of operating room nurses and technicians (N=32) agreed that work in the operating room was stressful and demanding. Findings from the focus groups included perceptions of increased physical and mental stress related to inadequate communication. Although prevalence of MSDs was collected by Sheikhzadeh et al. (2009), no statistical analysis was used to explore relationships with perceived stress from quantitative data.

Tasks

Within the work system, various tasks are performed and involve interactions with the organization, person, care process, and outcomes (Carayon et al., 2006). According to Carayon et al. (2006), elements of tasks may include job demands such as workload, variety in the tasks performed, and job content. ORNs and STs perform a wide variety of tasks to support and carry out the care of the surgical patient that place them at risk for MSDs. The following literature reviews the tasks performed and relationships with MSD risk, pain, and injury.

Workload

Workload in the operating room was measured quantitatively and qualitatively using the Surgical Task Load Index (SURG-TLX), NASA Task Load Index (NASA TLX), and researcher developed questions (Çelikkalp & Sayilan, 2020; Simonsen et al., 2012; Wijsman et al., 2019; Yu et al., 2016). Yu et al. (2016) compared workloads across the surgical team, including circulating nurses and surgical technologists using the SURG-TLX with scores greater than 50 indicating increased risk for MSD injury. They found circulating nurses and surgical technologists exceeded workload scores on the SURG-TLX 7% and 5% of the time, respectively, increasing their risk for MSD injury. Qualitative findings support this, with high workloads reported among operating room nurses and technicians (Çelikkalp & Sayilan, 2020; Sheikhzadeh et al., 2009). Additionally, Wijsman et al. (2019) found perceptions of workload were lower when first assistants used a robotic camera holder during laparoscopic procedures compared to those manually holding the camera.

Tasks Increasing MSD Risk

Several studies used the REBA tool to asses posture as an indicator of MSD risk (Abdollahi et al., 2020; Abdollahzade et al., 2016; Asghari et al., 2019; Mahmoudifar & Seyedamini, 2017; Shahijani et al., 2019). The REBA tool uses observations of posture during a variety of tasks to create a risk score ranging from 1-15, where 1 is negligible and 11-15 are very high risk for MSD (Hignett & McAtamney, 2000). REBA scores of high or very high risk were found ranging from 46% to 74% of ORNs and STs performing a variety of tasks (Abdollahzade et al., 2016; Asghari et al., 2019; Mahmoudifar & Seyedamini, 2017). Where specified, tasks observed by researchers included retracting, transferring instruments, table setup, equipment relocation, assisting the surgeon, and patient relocation (Abdollahzade et al., 2016; Asghari et al., 2019; Shahijani et al., 2019). Transferring instrument sets and retracting had the highest rates of very high risk for MSDs (Abdollahzade et al., 2016; Asghari et al., 2019). Similarly, researchers observing posture found high risks in postures of first assistants during tissue tacking and traction (van't Hullenaar et al., 2019).

Job Content

Numerous job responsibilities performed by ORNs placed them at risk for MSDs. Two studies investigated factors associated with low back pain in operating room nurses (Cavdar et al., 2020; Jeyakumar & Segaran, 2018). Lifting heavy instrument sets and prolonged standing were statistically significant risk factors for low back pain in both studies. Additional findings indicated assisting surgeons in awkward positions, work posture, and incorrect body mechanics were also statistically significant risk factors for low back pain (Jeyakumar & Segaran, 2018). Cavdar et al. (2020) found additional significant risk factors for low back pain included leaning, rotating backwards, and pushing/pulling movements.

Several researchers explored tasks performed by ORNs and STs that were perceived to contribute to MSDs (Chomem & Motter, 2021; Meijsen & Knibbe, 2007a; Sheikhzadeh et al., 2009). Using structured interviews to explore physical loads, Chomem and Motter (2021) found operating room nurses reported walking, standing and packing as perceived contributors to lower limb and lumbar spine pain. Researchers of another study involving operatieassistenten (Dutch term for non-nurses who circulate and scrub in operating rooms) from the Netherlands reported MSDs related to static stress and movement/lifting/pushing/pulling (Meijsen & Knibbe, 2007a). Static stress activities included prolonged standing, awkward positions, and standing for long periods with lead aprons on. Similarly, ORNs and technicians in the United States reported awkward positions, static stress, moving heavy equipment, and repetitive movements as tasks associated with MSDs (Sheikhzadeh et al., 2009).

Most of the literature reviewed focused on ORNs without differentiating between the circulating role and scrub role and did not account for surgical technologists. Researchers reported percentages of time spent by operantieassistenten in circulating (39%), scrubbing (35%), and first assistant (16%) roles but did not further analyze this related to MSDs or risk factors (Meijsen & Knibbe, 2007a). When assessing the prevalence of low back pain in operating room nurses, Moscato et al. (2010) found no statistically significant differences in acute events, forgoing pleasant activities, or intensity related to role as circulator versus scrub nurse. Yu et al. (2016) compared mental and physical workloads of circulating nurses and surgical technologists and found no statistical differences in mental workload, physical workload, difficulty, and complexity but did find a statistically significant difference in the level of distractions reported by participants. Level of distraction was rated nine to 13 points lower by surgical technologists compared to circulating nurses.

Clari et al. (2019) investigated upper limb MSDs in operating room nurses with a specific interest in the time spent working in the role of scrub nurse. The researchers used the disabilities of the arm, shoulder, and hand (DASH) questionnaire and asked operating room nurses if less than or more than 120 hours per month was spent working in the scrub nurse role. They found a weak positive correlation with DASH scores and hours spent as a scrub nurse. Additionally, operating room nurses who worked more than 120 hours a month in the scrub nurse role had double the risk of upper limb MSDs compared to those working less than 120 hours per month.

Process

Carayon et al. (2006) describe the process within the SEIPS model as both the delivery, management, and provision of care, as well as support processes such as sterile processing for surgical procedures. For this study, the care process is care of the surgical patient as provided by ORNs and STs. Process improvement activities are an element of the care process as described by Carayon. A review of literature discussing process improvement efforts to decrease MSD risk and injury is outlined below.

Process improvement studies covered a variety of changes to the setup of operating rooms hoping to improve ergonomics and decrease MSD risk (Neumann et al., 2020; Papp et al., 2009; van Det et al., 2008). Researchers in one study investigated improving the setup for total hip and total knee arthroplasty procedures (Neumann et al., 2020). Using data on instrument handover time, and rotational movement, they implemented new setups for both procedures and found improved position of the scrub nurse leading to decreased instrument handover time. In another study, posture of scrub nurses was measured during a minimally invasive procedure using two different setups for the monitor display (Papp et al., 2009). In one setup, the monitor was placed at the patient head, while the other setup placed the monitor in front of the scrub nurse on the patient right side. The researchers found when the monitor was at the right side of the patient, the scrub nurse posture was closer to a comfort posture measurement. Van Det et al. (2008) found improved posture for the scrub nurse during a minimally invasive procedure when monitor displays were set up in a specialized minimally invasive suite versus a regular operating room. They also found scrub nurses reported statistically significant less MSD complaints when using the minimally invasive suite display monitors.

Wijsman et al. (2019) investigated the use of a robotic camera holder on ergonomics of first assistants. The role of first assistant was not well defined by the Dutch researchers, but the description of the tasks completed (i.e., camera holding) is similar to those by ORNs and STs in the United States. Posture of first assistants was observed by researchers using a Rapid Upper Limb Assessment tool while the intervention group used the robotic camera holder, and the control group held the camera normally. They found first assistants using the robotic camera holder had better posture compared to the control group.

Employee Outcomes

According to Carayon et al. (2006), a balanced work system positively impacts outcomes of the patient, employee, and organization. Employee and organizational outcomes are closely linked with patient outcomes in the SEIPS model. For example, an increased number of nursing staff who are out of work due to MSD injury can impact staffing ratios and, ultimately, patient safety. The study explored outcomes including employee MSD injuries and pain associated with the injury. A review of these outcomes follows.

MSD Injury

Most articles explored MSD injury in terms of risk for ORNs and STs which has been discussed above with other concepts. Additional research has also examined MSD injuries relevant to diagnoses or occupational health referral (Diaz, 2001; Mahmoudifar & Seyedamini, 2017). Mahmoudifar and Seyedamini (2017) explored ergonomics and work-related MSDs compared occupational health referrals of intensive care nurses and operating room nurses. The researchers found 30% of operating room nurses (N=50) were referred to occupational health for MSD complaints, compared to 18% of intensive care nurses. Diaz (2001) investigated prevalence of operating room nurses and nurse anesthetists who had been diagnosed with carpal tunnel syndrome or met clinical criteria. Findings showed 5.52% of operating room nurses (N=181) were diagnosed with carpal tunnel syndrome compared to 15.87% of nurse anesthetists (N=63), indicating lower risk for operating room nurses. Researchers noted the unique mechanical exposures during laryngoscopy experienced by the nurse anesthetists as a possible explanation for this difference.

MSD Pain

Instruments Used to Measure MSD Pain

In the literature, some consistency with instruments is used to measure MSD pain. The Nordic Musculoskeletal Questionnaire, a body map of nine body regions indicating MSD problems in the last 12 months and 7 days, was used by a majority of researchers (Abdollahi et al., 2020; Asghari et al., 2019; El Ata et al., 2016; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a; Nasiri-Ziba et al., 2017; Rypicz et al., 2020; Shahijani et al., 2019, 2020). Cronbach’s alpha was not reported by researchers who administered the tool to perioperative personnel. The North American Spine Society Instrument for cervical and lumbar problems (Baur et al., 2018; Nützi et al., 2015), the Modified Oswestry Low Back Pain Disability Questionnaire (Jeyakumar & Segaran, 2018), the Disabilities of the Arm, Shoulder and Hand questionnaire (Clari et al., 2019), and the Quebec Scale of Disability (Moscato et al., 2010) were also used to measure MSD pain. Additionally, researcher developed questionnaires were used for low back pain (Bin Homaid et al., 2016; Cavdar et al., 2020) and other body regions (Bakola et al., 2017; Sheikhzadeh et al., 2009) but no reliability or validity measures were reported.

Total MSD Pain in Any Body Region

Researchers have examined prevalence of MSD pain related to body region. For measures of any body region, pain is reported by participants in at least one area where researchers measured multiple body regions. In a majority of the studies, operating room nurses were the sample measured, however one study measured surgical technologist only and another measured a combination of both operating room nurses and surgical technologists.

For operating room nurses, MSD prevalence ranges for any body region included 66.1% (N=116) (Nützi et al., 2015) and 92.5% (N=144) (Asghari et al., 2019). Researchers also found prevalence of MSD pain in two or more regions of the body was 74.9% and 45.9% (N=148) for operating room nurses, respectively (Bakola et al., 2017; Clari et al., 2019). For surgical technologists, MSD prevalence ranges were 96.74% (N=123) (Shahijani et al., 2020) and 98.87% (N=49) (Shahijani et al., 2019). Where surgical technologists and operating room nurses were not separated, rates of MSD pain in any body region was 90% (Sheikhzadeh et al., 2009).

MSD Pain by Body Region

Looking at specific body regions where MSD occurred, low back pain has been a specific area where researchers have measured MSD pain (Abdollahi et al., 2020; Bin Homaid et al., 2016; Cavdar et al., 2020; Jeyakumar & Segaran, 2018; Moscato et al., 2010). Researchers investigating only low back pain at any time found prevalence in operating room nurses to be 67.7% (N=96) (Cavdar et al., 2020), 76.5% (N=34) (Bin Homaid et al., 2016), and 84% (N=250) (Jeyakumar & Segaran, 2018). Moscato et al. (2010) measured only acute events of low back pain in operating room nurses (N=185) and found a 17.3% prevalence. Prior to intervention, Abdollahi et al. (2020) found prevalence of low back pain at 54.1% and 62.2% for an intervention and control group (N=74), respectively. Additionally, other researchers explored low back pain in operating room nurses within instruments that measured multiple body regions. For those measured within instruments, prevalence of low back pain for operating room nurses was 50% (Mahmoudifar & Seyedamini, 2017), 52.7% (Nützi et al., 2015), 54.5% (Bakola et al., 2017), 57.5% (N=73) (Rypicz et al., 2020), 58% (N=463) (Meijsen & Knibbe, 2007a), 61.7% (N=133) (Nasiri-Ziba et al., 2017), and 61.9% (Asghari et al., 2019). For surgical technologists, 66.1% reported low back pain on the Nordic Musculoskeletal Questionnaire (Shahijani et al., 2020). Sheikhzadeh et al. (2009) found a low back pain prevalence of 84% in operating room nurses and surgical technologists within the past year.

Prevalence of neck or cervical pain found in operating room nurses ranged from 5.6% to 58.9% (Asghari et al., 2019; Bakola et al., 2017; Clari et al., 2019; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a; Nasiri-Ziba et al., 2017; Nützi et al., 2015; Rypicz et al., 2020). For surgical technologists, prevalence of neck pain was 57.5% (Shahijani et al., 2020). Where operating room and surgical technologists were combined, researchers found neck pain prevalence of 71% within the past year (Sheikhzadeh et al., 2009). Table 1 provides an overview of specific prevalence rates for each article where measured quantitatively. A qualitative study exploring occupational risks for operating room nurses using content analysis found a subtheme of health concerns related to lumbar and cervical pain in operating room nurses.

Upper extremities were also a prevalent area of musculoskeletal pain with specific areas of the shoulders, elbows, and wrists/hands resulting in injury. Shoulder pain prevalence was the most common injury site with operating room nurse injury ranging from 30 to 45.2% (Asghari et al., 2019; Bakola et al., 2017; Clari et al., 2019; Mahmoudifar & Seyedamini, 2017; Nasiri-Ziba et al., 2017; Rypicz et al., 2020). Elbow pain prevalence for operating room nurses ranged from 4.9 to 31.5% (Asghari et al., 2019; Bakola et al., 2017; Clari et al., 2019; Mahmoudifar & Seyedamini, 2017; Nasiri-Ziba et al., 2017; Rypicz et al., 2020). Wrists/hands pain prevalence for operating room nurses ranged from 4.2 to 45.2% (Asghari et al., 2019; Bakola et al., 2017; Clari et al., 2019; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a; Nasiri-Ziba et al., 2017; Nützi et al., 2015; Rypicz et al., 2020). For surgical technologists, prevalence of upper extremity MSD pain was neck 57.5%, shoulder 57.5%, elbow 16.5%, and wrist 40.9% (Shahijani et al., 2020). Where operating room nurses and surgical technologists were combined, upper extremity MSD pain in the shoulder was 74%, elbow 52%, and wrists/hands 61% according to Sheikhzadeh et al. (2009).

Lower extremity pain was measured in areas of the hip/thigh, knees, and ankle/feet. For operating room nurses, hip/thigh pain prevalence ranged from 22 to 43% (Asghari et al., 2019; Bakola et al., 2017; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a; Rypicz et al., 2020). For knee pain, prevalence for operating room nurses ranged from 20.5 to 60.5% (Asghari et al., 2019; Bakola et al., 2017; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a;

Nasiri-Ziba et al., 2017; Nützi et al., 2015; Rypicz et al., 2020). Ankle/feet pain prevalence in operating room nurses ranged from 6.8 to 55.8% (Asghari et al., 2019; Bakola et al., 2017; Mahmoudifar & Seyedamini, 2017; Nasiri-Ziba et al., 2017; Rypicz et al., 2020). For surgical technologists, prevalence of lower extremity MSD pain was hip and thigh 18.1%, knee 59%, leg and ankle 44.1% (Shahijani et al., 2020). Where operating room and surgical technologists were combined, lower extremity MSD pain was hips/thigh 52%, knee 58%, ankle/foot 74% (Sheikhzadeh et al., 2009).

Table 1

Musculoskeletal Pain Prevalence by Body Region (%)

Study(N)	Neck	Shoulder	Elbows	Wrists/ Hands	Hip/thigh	Knees	Ankle/ feet
Operating Room Nurses							
Asghari et al. (144)	44.9	33.3	19	31.3	23.8	60.5	55.8
Bakola et al. (44)	47.7	45.5	22.7	31.8	27.3	25	6.8
Clari et al. (148)	5.6	36.1	4.9	4.2	-	-	-
Meijsen & Knibbe (463)	53	-	-	14	43	22	-
Nasiri-Ziba et al. (133)	41.4	34.3	11.3	35.3	-	46.6	29.3
Nützi et al., (116)	38.4	-	-	9.8	-	20.5	-
Rypicz et al. (73)	58.9	45.2	31.5	45.2	38.4	37	34.2
Surgical Technologists							

Shahijani et al. (123)	57.5	57.5	16.5	40.9	18.1	59	44.1
Surgical Technologists and Operating Room Nurses Combined							
Sheikhzadeh et al. (32)	71	74	52	61	52	58	74

MSD Pain Intensity

Few articles measured pain intensity associated with MSD pain or injury. Bin Homaid et al. (2016) measured intensity of low back pain in operating room nurses using a mild to very severe scale. In those with low back pain, researchers found 36% mild, 53.9% moderate, 7.9% severe, and 2.2% very severe. Moscato et al. (2010) measured low back pain intensity in operating room nurses using a visual analogue scale, however, researchers were most interested in intensity associations with additional factors and univariate analysis was not reported. Asghari et al. (2019) investigated pain severity for operating room nurses in multiple regions using a scale from zero to five. Researchers found mean ranges of pain between 3.1 and 3.5 for body regions including neck, shoulders, upper back, elbows, low back, wrists/hands, hips/thighs/buttocks, knees, and ankles/feet.

Gaps in the Literature

In 2009, the AORN created the Safe Patient Handling and Movement Tool Kit based on high-risk perioperative tasks including patient transfers; repositioning patients; lifting and holding extremities; prolonged standing; tissue retraction; lifting, carrying supplies and equipment; and pushing, pulling, and moving equipment (Ogg, 2011). These guidelines were created to decrease MSD rates among ORNs. Although some researchers identified these tasks being performed by participants, no researchers have measured or discussed the AORN guidelines in their studies (Cavdar et al., 2020; Chomem & Motter, 2021; Jeyakumar & Segaran, 2018; Meijsen & Knibbe, 2007a, 2007b). Additionally, when researchers explored high risk tasks encountered by participants, frequencies with which the tasks were encountered was not reported. Further, only three of the 32 articles included in this review had ORNs or STs working in the United States (U.S.) in their samples (Diaz, 2001; Sheikhzadeh et al., 2009; Yu et al., 2016). Given the guidelines were created by the U.S. based organization, AORN, it is possible guidelines in other countries vary and there is a need for research within the U.S. to gain knowledge about MSDs in ORNs and STs who practice within the U.S.

Literature which included surgical technologists has been noted throughout this review and is notably insufficient to consider generalizable (Shahijani et al., 2019, 2020; Sheikhzadeh et al., 2009; Yu et al., 2016). It is possible that surgical technologists were included by other researchers, however, the significant amount of research conducted outside the U.S. confounds the samples because of differences in education levels and terminology. For example, operantieassistentens in the Netherlands are non-nursing personnel who function in the role similar to that of circulating, scrubbing, and first assistant nurses in the U.S. (Meijsen & Knibbe, 2007a, 2007b). Even researchers in the U.S. identify certified surgical technologists as *scrub nurses* creating more confusion about the role of participants. Additionally, surgical technologists in some countries, such as Iran, also function in the role of circulating or scrubbing personnel (Shahijani et al., 2019, 2020). Research is needed to explore MSD risk specific to the role of surgical technologists who practice in the U.S.

Only two articles explored differences among circulating and scrub roles (Clari et al., 2019; Yu et al., 2016). In the U.S., surgical technologists may assist a registered nurse in the role of circulator (Association of Surgical Technologists, n.d.-a) and registered nurses are frequently found in the scrub role. Importantly, both ORNs and STs perform similar high-risk tasks identified by AORN. However, research is needed to identify if differences exist among ORNs and STs to understand MSD risk in both groups.

Summary

A review of the literature has been presented using the SEIPS model as a guiding framework. Literature within the context of the work system, processes, and outcomes for ORNs and STs related to MSDs was reviewed. Within the work system, literature explored the person, organization, and task elements. Processes within the literature included those seeking to improve setup and decrease workload for ORNs and STs in the operating room. Outcomes included MSD injury and various factors related to MSD pain. Finally, gaps identified within the literature included utilization of AORN guidelines, lack of surgical technologist representation, and limited understanding of MSD risk difference for scrub versus circulating roles. This study looks to fill the gap of knowledge on rates of MSDs in operating room nurses and surgical technologist in the U.S. as well as related factors.

CHAPTER 3: METHODS

This chapter reviews the methodology of the study and includes the study design, setting, sample, ethical considerations, instruments, data collection procedures, and data analysis strategies. Additionally, a discussion of limitations and a summary are provided. The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. The study research questions (RQ) were:

1. What is the adherence rate to AORN safety guidelines when performing seven high-risk physical tasks in the operating room and the frequency of performing each task without adherence to the safety guidelines in ORNs and STs?
2. What is the frequency of unfavorable postures (bending, twisting, kneeling, or squatting) of the trunk, arms, and legs, frequency of lifting/carrying light, medium, and heavy loads in upright and inclined body positions, and physical workload based on the frequency of unfavorable postures and lifting/carrying of light to heavy loads in upright and inclined positions for ORNs and STs?
3. What is the correlation of frequency of AORN tasks performed without following AORN guidelines and proportion of time safety guidelines were followed with frequency of unfavorable postures and handling of heavy loads and workload associated with the postures and lifting of heavy loads during work in ORNs and STs?
4. What is the relationship of frequency of task non-adherence to AORN safety practices, percent of time adhering to AORN safety practices, and workload on age, surgical experience, and teamwork?

5. Over a twelve-month period, what is the prevalence of pain/discomfort experienced in the body areas of back, neck, shoulders, hands/wrists, and feet, severity of pain in each body area, prevalence of an occupational injury, and days of missed work because of the injury in ORNs and STs?
6. What is the relationship between the physical workload on severity of pain in any of the body areas and occurrence of an occupational injury?
7. What is the relationship between severity of pain in any of the body areas and occurrence of an occupational injury with age, experience in a surgical setting, and attitudes toward teamwork?

Design

A secondary analysis of cross-sectional survey data was performed for this descriptive correlational quantitative study. Data was obtained from prior research completed by this researcher and colleagues. Data included personal (age, gender, and years of experience), organizational (hours worked during shift, shifts worked in a row, and teamwork), task (seven high risk tasks, physical workload, adherence to safety guidelines), and outcome (occupational injury, musculoskeletal pain and days of missed work related to injury) variables of interest.

According to Polit and Beck (2021), the cross-sectional descriptive correlational design of this study is an appropriate method for answering research questions exploring relationships among phenomena. Correlational research cannot prove a causal relationship and is appropriate for investigating associations among variables when researchers are unable to manipulate a cause. Additionally, secondary analysis of data is useful to answer research questions not previously anticipated by researchers.

Setting

The secondary data were part of a research project funded by the Competency & Credentialing Institute (CCI) from October 2020 to December 2021. The research project was particularly interested in the ergonomic risk factor of ORNs. Survey data was initially collected from October 2020 to February 2021 at a large healthcare system in the southeastern United States. The large healthcare system includes five hospitals, three of which operate freestanding surgical centers. The hospitals and surgical centers serve both rural and urban areas across 12 counties.

Participants were recruited via email and face-to-face methods to enhance participation (Polit & Beck, 2021). Participants completed an online survey, which utilized Dillman et al. (2014) Tailored Design Method for online surveys. The survey included the Physical Workload Index Questionnaire (PWIQ) and the TeamSTEPPS^{TM} Teamwork Attitudes Questionnaire (T-TAQ). Additionally, the data collected demographics, musculoskeletal pain and injury information, work schedule information, ergonomic risk factors, and adherence to ergonomic safety practices information. This data was particularly useful in answering the research questions because it collected responses from both ORNs and STs and included the variables of interest related to AORN safety guidelines and musculoskeletal health.

Population and Sample

The survey originally invited all perioperative personnel within the health system to participate in the survey, which included 283 ORNs and 103 STs. Of the ORNs invited to participate, 155 responded to the survey for a 54.8% response rate. Forty surgical technologists responded to the survey for a 38.8% response rate. As part of a secondary analysis, sample size for this study was pre-determined. The original research included any registered nurse working in the perioperative setting (i.e., administration, nurse anesthetists, and staff nurses). This study investigated only ORNs who identified themselves as staff nurses and STs whose role includes daily duties within the operating room during surgical procedures to answer the research questions. This data was important in answering the research questions and aligned with the chosen theoretical framework for hypothesis testing.

Ethical Considerations

According to 45 C.F.R 46.102(e), human subjects research includes “living individuals about whom an investigator (whether professional or student) conducting research… obtains, uses, studies, analyzes, or generates identifiable private information or identifiable biospecimens” (Protection of Human Subjects, 2018). For transfer of secondary data, all identifiers from the primary study were removed before analysis. As such, when identifiers are removed this does not constitute human subjects research and does not require approval from an Institutional Review Board.

Measures

The tools and instruments in the survey used to collect data are broken down into concepts of interest consistent with the SEIPS odel and include personal, organizational, and task variables and outcomes of interest (Carayon et al., 2006). Personal variables included age, gender, and years of experience. Organizational variables included hours worked during shift, shifts worked in a row, and teamwork. Task variables included the AORN seven high-risk tasks, physical workload, and adherence to AORN safety guidelines. The outcomes of interest were occupational injury, musculoskeletal pain, and days of work missed related to injury.

Personal Variables

Personal variables included age, gender, and years of experience in the surgical setting and the healthcare settings. Age and years of experience were measured numerically. Gender was measured by asking participants if they identified as male, female, or nonbinary. These personal variables are consistent with research in ergonomics and the nursing workforce (Lee & Lee, 2017; Smiley et al., 2018) and are consistent with examples provided by Carayon et al. (2006) in the presentation of the SEIPS model (i.e. physical characteristics and education, skills and knowledge).

Organizational Variables

Organizational variables included hours worked during shift, shifts worked in a row, and teamwork and are consistent with examples provided by Carayon et al. (2006) in the presentation of the SEIPS model (i.e., work schedules and teamwork). Hours worked during shift were measured numerically in hours. Shifts worked in a row were measured numerically by asking how many days in a row are typically worked. Teamwork was measured utilizing the Team Works Attitude Questionnaire (T-TAQ), which is provided in Appendix B. T-TAQ was developed through the TeamSTEPPS program by the Agency for Healthcare Research and Quality to measure attitudes about teamwork (Baker et al., 2008). T-TAQ measures the constructs of team structure (6-items, Cronbach's Alpha .70), leadership (6-items, Cronbach's alpha .80), situation monitoring (6 items: Cronbach's Alpha .83), mutual support (6-items, Cronbach's Alpha .70), and communication (Cronbach's Alpha .74). The T-TAQ includes a total of 30 5-point Likert type questions that ask for a level of agreement. Levels of agreement were coded with Strongly Disagree coded as 1 to Strongly Agree coded as 5. Among the 30 items, four are reverse coded. After recording, a total score was computed for each construct by summing the item responses across the six items to derive a total construct score, or an average score can be derived for each construct. Total scores for each construct can range from 6 – 30, where higher scores indicate a more positive attitude towards teamwork.

Task Variables

Task variables included the AORN seven high-risk tasks, adherence to AORN safety guidelines, and physical workload and are consistent with examples provided by Carayon et al. (2006) in the presentation of the SEIPS model (i.e., job demands). The AORN seven high-risk tasks were measured by asking participants to self-report how many times they engaged in the seven ergonomic risks identified by AORN in a 14-day timeframe. Adherence to AORN safety guidelines was measured by a self-report of the percent of time over the past 14 days the respondent adhered to each of the seven safety measures for prevention of MSDs as described by AORN.

Physical workload was measured by a self-report survey using the 19-item Physical Workload Index Questionnaire (PWIQ), which is provided in Appendix C (Hollmann et al., 1999). According to the PWIQ developers, the most important factors contributing to physical workload, especially when occupational work conditions are being studied, are unfavorable postures of the body or the extremities, like bending, twisting, kneeling, or squatting, as well as the handling of heavy workloads required during work (Bot et al., 2004). The PWIQ consists of 19 items describing these work situations. Five items describe trunk postures, including straight upright, slightly inclined, strongly inclined, twisted, and laterally bent backwards. Eight additional items describe postures include sitting, standing, squatting, walking/moving, and arms at shoulder height and above. Six questions included lifting and carrying weight of 22 – 44 pounds or more than 44 pounds with trunk upright and trunk inclined. For each question, the respondent was asked how often they used each body position or lifted weight upright or bent on a 5-point response ranging from never (coded 0) to very often (coded 5). For the derivation of an index of physical workload, the authors provided the relative compressive forces acting at the lumbar spine for 15 of the postures and the handling of weights with the most compressive force. The four with the lowest compressive force that were not involved in the derivation of the index included trunk upright, both arms below the shoulder, standing without lifting weights, and sitting without lifting weights. The index of physical workload for each person is derived by multiplying each position/weight compressive force by the frequency that each position/weight is performed during work and summing the scores across the 15 items. The index can range from 0 to 56.168. Cronbach alpha's of general population studies have been as high as .93 (Bot et al., 2004) and found to be 0.82 for nurses (Lee et al., 2013).

Outcome Variables

The outcomes of interest for this study were occupational injury, musculoskeletal pain, and days of work missed related to injury. Occupational injury was dichotomized as a yes/no question for the presence of an injury. Musculoskeletal pain questions asked about pain, aching, stiffness, burning, numbness or tingling to the a) back, b) neck, c) shoulders, or d) hands/wrists in the past 12 months on a pain severity scale of 1 (lowest) to 10 (highest). For those experiencing an occupational injury, days of work missed due to injury was measured numerically.

Data Collection & Management Methods

Data for this study is owned by the University of North Carolina Greensboro (UNCG). A data use agreement was initiated between UNCG and East Carolina University (ECU). The data use agreement requested access to deidentified, and raw data collected to ensure no prior analysis will affect the conclusions of this study. Once the data use agreement was finalized, data was exported from Qualtrics Software and converted to an Excel file. The Excel file was then imported to a secure storage drive accessible to approved members of the study. The secure drive is approved for storage of research data (ECU Enterprise Service Management System, n.d.). Data was shared only with members of the dissertation committee as part of this study. Data was assessed for a match to the proposed hypotheses and tested to ensure all relevant constructs are present within the data (Pienta et al., 2011).

Data Analysis

Data was analyzed using the International Business Machines Statistical Package for the Social Sciences (IBM SPSS) software, version 27.0. All data was examined for out-of-range values and missing values. Descriptive statistics were used for all categorical variables (frequency distributions) and quantitative variables (frequency distributions, means, and standard deviations). Tests of statistical significance included independent samples t-tests, Pearson correlations, and chi-square tests. For all tests of significance, $p < .05$ was considered statistically significant. Effect sizes were derived for all tests of significance. Specific data analysis strategies for each research question are presented below.

> RQ1: What is the adherence rate to AORN safety guidelines when performing seven high-risk physical tasks in the operating room and the frequency of performing each task without adherence to the safety guidelines in ORNs and STs?

For RQ1, descriptive statistics were computed for the frequency of high-risk tasks performed incorrectly and percentage of adherence to the safety guidelines for each task. A comparison of mean frequency and adherence percentage between ORNs and STs were performed using independent t-tests.

RQ2: What is the frequency of unfavorable postures (bending, twisting, kneeling, or squatting) of the trunk, arms, and legs, frequency of lifting/carrying light, medium, and heavy loads in upright and inclined body positions, and physical workload based on the frequency of unfavorable postures and lifting/carrying of light to heavy loads in upright and inclined positions for ORNs and STs?

For RQ2, mean and standard deviation of the frequency of unfavorable postures and frequency of lifting/carrying of light to heavy loads were computed for each of the 13 body postures and the six lifting/carrying of items. For postures and lifting/carrying items, proportions were computed for participants who responded often/very often on the Likert scale of the physical workload questionnaire. Chi-square was used to compare proportions between ORNs and STs. Differences in mean workload index scores between ORNs and STs was tested with the independent t-test.

RQ3: What is the correlation of frequency of AORN tasks performed without following AORN guidelines and proportion of time safety guidelines were followed with frequency of unfavorable postures and handling of heavy loads and workload associated with the postures and lifting of heavy loads during work in ORNs and STs?

For RQ3, Pearson correlations was used to examine relationships between task adherence and non-adherence of the safety guidelines and physical workload. In addition, frequency of improper task performance and adherence rate were categorized, and mean workload were compared between categories with the independent t-test in the ORNs and STs.

RQ4: What is the relationship of frequency of task non-adherence to AORN safety practices, percent of time adhering to AORN safety practices, and workload on age, surgical experience, and teamwork?

For RQ4, Pearson correlations were used to examine relationships between task adherence and non-adherence of the safety guidelines and physical workload on age, experience in a surgical setting, and attitudes toward teamwork in ORNs and STs.

RQ5: Over a twelve-month period, what is the prevalence of pain/discomfort experienced in the body areas of back, neck, shoulders, hands/wrists, and feet, severity of pain in each body area, prevalence of an occupational injury, and days of missed work because of the injury in ORNs and STs?

For RQ5, percentages were computed for prevalence of pain in each body area and those reporting occupational injury. Mean and standard deviation were computed for pain severity in each body area and days missed due to occupational injury. For comparisons between groups involving proportions (presence of pain in each body part and occupational injury), the chi-square test statistic was used. For a comparison between groups in mean pain severity, independent t-test was used.

RQ6: What is the relationship between the physical workload on severity of pain in any of the body areas and occurrence of an occupational injury?

For RQ6, Relationships were analyzed using Pearson's correlation coefficient. Physical workload was categorized by position and means were computed. Additionally, a comparison of workload between those with and without occupational injury were computed using independent t-test.

RQ7: What is the relationship between severity of pain in any of the body areas and occurrence of an occupational injury with age, experience in a surgical setting, and attitudes toward teamwork?

For RQ7, relationships were analyzed using Pearson's correlation coefficient. Independent-samples t-test was used to compare mean age and teamwork attitude scale scores between those with and without pain/discomfort in body parts in ORNs and STs. Experience in a surgical setting was categorized and difference in mean age and teamwork attitude scale scores were compared between categories with independent t-test or one-way analysis of variance depending on the number of categories formed in ORNs and STs.

Limitations

Secondary data analysis has several advantages and limitations to consider. During secondary analysis, the researcher is often working with data collected for a different purpose or with a different research question as the foundation (Johnston, 2014). This data was well suited for secondary analysis because the original research explored similar phenomena of interest. Another common limitation for secondary analysis is that researchers are frequently not part of the original data collection and may not know all the procedures used (Johnston, 2014). This was not the case with this secondary analysis, as this researcher was part of the original research and data collection and can speak to data collection methods and procedures.

The non-experimental correlational design of this study can only indicate a relationship among variables and cannot prove causation (Polit & Beck, 2021). Although correlational studies do not provide as strong of evidence as experimental designs, nurse scientists are often unable to manipulate an independent variable and frequently utilize correlational designs. Correlational studies are well suited to understand phenomena as they occur in the real world.

The cross-sectional nature of the data provided a view of the phenomenon and relationships at one point in time (Polit & Beck, 2021). As such, cross-sectional designs are not well suited to explore a phenomenon over time. Generalization of findings from this study should be used with caution when considering the temporal order of MSD pain and injury and associated variables of interest.

Finally, the data was collected using a self-reported survey questionnaire. According to Polit and Beck (2021), self-reports may involve the tendency of participants to answer questions in a way consistent with social norms. The data was collected through anonymous online survey, where anonymity may decrease the social desirability response bias. Additionally, response rates from the original study were moderate and cannot rule out response bias.

Summary

The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. This study was a secondary analysis of data using a cross-sectional descriptive correlational design. ORNs and STs from a large healthcare system in the southeastern U.S. were included in the sample. Descriptive and correlational test statistics were used to analyze relationships among personal, organizational, task, and outcome variables.

CHAPTER 4: FINDINGS

The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. This chapter includes findings from the secondary analysis of data on ORNs and STs who participated in a previous study. Demographic and descriptive statistics of the sample are provided along with reliability coefficients for selected instruments from this study. Additionally, an analysis of findings is further organized by research question and a final summary is provided.

Demographic and Descriptive Statistics

Personal Variables

Personal variables collected in the study included categorical and continuous variables. For the categorical variable (gender), frequencies and percentages were used to describe ORN and ST participants. For continuous variables (age, years of experience in healthcare, and years of experience in surgery), mean and standard deviations were computed for ORN and ST participants. Total sample size for the study was N = 156, with 117 ORNs and 39 STs.

Table 2 presents the characteristics of the ORNs and STs. The ORNs were significantly older and had more healthcare and surgery experience than the STs. The average hours worked per shift and the average number of consecutive days worked were similar for the ORNs and STs. Almost all the study subjects were women, with only two ORN males and two ST males.

Table 2

Sample Characteristics (N=156)

	ORN		ST				
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*	η^2
Age	45.5	12.5	38.5	9.9	3.20	.002	.064
Healthcare exp.	19.9	12.6	12.7	7.6	3.36	.001	.068
Surgery exp.	15.8	12.2	11.0	7.5	2.33	.021	.034
Shift hours	9.4	2.0	9.5	1.7	0.22	.827	.000
Days in a Row	3.6	1.2	3.7	1.1	0.33	.743	.001

Note: ORNs = Operating Room Nurses; STs = Surgical Technicians; Healthcare exp. = years of experience in healthcare setting; Surgery exp. = years of experience in healthcare setting; Shift hours = Average total hours per shift worked; Days in a row = number of consecutive days worked in a row.

Organizational Variables

Teamwork was measured using the five constructs of the T-TAQ, which include team structure, leadership, situation monitoring, mutual support, and communication. T-TAQ scores were lowest among both groups for communication and highest for leadership. No statistically significant differences were found between groups for any construct. See Table 3.

Table 3

Organizational Variables Among Operating Room Nurses and Surgical Technicians

	ORN		ST		
	M	*SD*	*M*	*SD*	*p*
Teamwork					
Team Structure	4.3	0.4	4.4	0.5	.364
Leadership	4.5	0.4	4.6	0.5	.212
Situation Monitoring	4.4	0.5	4.5	0.5	.532
Mutual Support	4.3	0.5	4.2	0.5	.194
Communication	4.2	0.4	4.1	0.5	.300

Instruments

Table 4 presents the internal consistency reliability of the study instruments using Cronbach's alpha. Low reliability estimates were observed for mutual support and communications domains of the T-TAQ in both the ORNs and STs.

Table 4

Cronbach's Alpha for T-TAQ and Questionnaire for Physical Workload

Variable	ORNs	STs	Total Group
T-TAQ			
Team Structure	.71	.83	.75
Leadership	.78	.86	.81
Situation Monitoring	.84	.89	.85
Mutual Support	.69	.52	.64
Communication	.66	.74	.69
Questionnaire for Physical Workload	.89	.94	.91

Note: T-TAQ = TeamSTEPPS Teamwork Attitudes Questionnaire

Analysis of Research Questions

Research Question 1

What is the adherence rate to AORN safety guidelines when performing seven high-risk physical tasks in the operating room and the frequency of performing each task without adherence to the safety guidelines in ORNs and STs?

The seven AORN safety guidelines measured include patient transfer, patient positioning/repositioning, lifting body parts of the patient, standing duration, retractor use, lifting equipment, and pushing or pulling objects/equipment. Table 5 summarizes the average percent of time ORNs and STs adhered to the AORN safety guidelines over a two-week period. In the ORN group, safety adherence ranged from 51% on retractor use to a high of 60% on positioning/repositioning of patients. In the ST group, adherence was over 60% on the first four tasks. The lowest adherence for the STs was reported for pushing/pulling heavy objects and retractor use. There were no significant differences in adherence rate between ORNs and STs.

Table 5

Mean Percentage of Time Adhering to Safety Guidelines of Seven AORN Work Tasks

	ORN		ST				
Task	*M*	*SD*	*M*	*SD*	*t*	*p*	η^2
1. Patient transfer	55.27	39.34	62.39	39.99	0.75	.453	.006
2. Position/re-position	59.94	36.86	64.17	39.22	0.47	.641	.002
3. Lift body part	52.51	36.48	63.54	39.11	1.21	.230	.017
4. Standing duration	55.40	38.69	64.78	38.13	1.02	.311	.011
5. Retractor use	51.16	38.90	49.95	42.42	0.52	.620	.003
6. Lifting equipment trays	57.34	38.95	58.87	40.90	0.16	.875	.000
7. Push/Pull heavy objects	52.83	35.17	48.52	38.73	0.48	.629	.003

Note. AORN = Association of periOperative Nurses

Table 6 summarizes the average frequency of times each task was performed without adhering to safety guidelines over a two-week period. The average non-adherence frequency was similar between ORNs and STs on the first three tasks which involved transferring patients, positioning/repositioning of patients, and lifting body parts of patients. On the tasks related to standing duration, retractor use, and lifting equipment trays, the average number of times they were performed outside of the safety guidelines was significantly higher for the STs compared to the ORNs.

Table 6

Mean Task Frequency of Non-adherence to AORN Safety Guidelines

	ORN		ST				
Task	*M*	*SD*	*M*	*SD*	*t*	*p*	η^2
1. Patient transfer	7.95	13.56	7.30	11.36	0.21	.833	.000
2. Position/re-position	8.56	13.23	9.53	11.25	0.28	.779	.001
3. Lift body part	8.39	13.30	9.68	10.70	0.39	.695	.002
4. Standing duration	11.53	12.55	23.03	26.97	3.16	.002	.078
5. Retractor use	4.32	6.78	11.76	19.08	2.81	.006	.078
6. Lifting equipment trays	5.59	6.08	13.58	14.36	3.85	<.001	.135
7. Push/Pull heavy objects	10.94	12.65	15.52	16.72	1.49	.139	.021

Research Question 2

What is the frequency of unfavorable postures (bending, twisting, kneeling, or squatting) of the trunk, arms, and legs, frequency of lifting/carrying light, medium, and heavy loads in upright and inclined body positions, and physical workload based on the frequency of unfavorable postures and lifting/carrying of light to heavy loads in upright and inclined positions for ORNs and STs?

Table 7 shows the frequency of nine unfavorable body positions and six weightlifting situations that were used during work by the ORNs and STs. Operating room nurses spent significantly more time kneeling than the STs, although the percentage of time spent in this position was low. The STs spent significantly more time in unfavorable trunk postures than the ORNs, as well as significantly more time in all the weightlifting situations. The largest percentage differences involved STs lifting less than 22 pounds in an upright position, lifting 22-24 pounds in an upright position, and lifting less than 22 pounds in an inclined position.

Table 7

Mean Frequency of Occurrence and Percentage of Time Used Often or Very Often of Body Positions and the Handling of Loads During Daily Work

	ORN			ST					
Positions and Loads	*M*	*SD*	%	*M*	*SD*	%	*t*	*p*	η^2
Trunk									
Slight incline	2.08	1.07	35	2.74	1.09	63	2.84	.005	.064
Strong incline	1.38	1.01	13	2.11	1.25	41	3.15	.002	.077
Twist	1.37	0.90	11	2.00	1.39	37	2.79	.008	.062
Lateral bend	0.52	0.74	1	1.33	1.44	22	3.95	<.001	.116
Arms									
One above shoulder	1.28	1.00	10	1.33	1.21	15	0.23	.816	.000
Two above shoulder	1.02	0.98	10	1.22	1.19	11	0.89	.373	.007
Legs									
Squatting	1.40	0.97	79	1.30	1.20	100	0.45	.651	.002
Kneeling	1.40	0.99	14	0.67	1.14	11	3.30	.001	.084
Walking	3.48	0.76	90	3.37	0.74	85	0.69	.494	.004
Lifting upright									
< 22 pounds	2.22	1.09	42	3.12	0.82	81	3.90	<.001	.115
22 – 44 pounds	1.54	1.10	21	2.52	1.16	52	4.01	<.001	.119
> 44 pounds	0.86	0.98	6	1.67	1.30	22	3.48	.001	.093
Lifting inclined									
< 22 pounds	1.14	1.03	9	2.15	1.26	41	4.23	<.001	.132
22 – 44 pounds	0.66	0.88	4	1.58	1.47	27	3.96	<.001	.120
> 44 pounds	0.52	0.88	5	1.33	1.52	22	3.50	.001	.095

Note. Mean frequency based on Likert responses of 0 = never to 4 = very often. Non-missing data for ORNs = 94 and for STs = 27.

Table 8 presents the average of the relative contribution of compressive forces on the spine caused by the nine body postures and six weightlifting situations. The sum of these compressive forces across the 15 items for each person is the physical workload index for each person. STs had significantly higher compressive forces from all the trunk positions and all the weightlifting situations as well as the overall workload index compared to the nurses.

Table 8

Mean Workload Estimate of Body Positions and Handling of Loads During Work

	ORN		ST				
Positions and Loads	*M*	*SD*	*M*	*SD*	*t*	*p*	η^2
Trunk							
Slight incline	2.00	1.05	2.67	1.07	2.90	.004	.066
Strong incline	1.50	1.12	2.33	1.38	3.21	.002	.080
Twist	0.09	0.06	0.14	0.09	2.79	.006	.092
Lateral bend	0.09	0.13	0.23	0.25	3.95	<.001	.116
Arms							
One above shoulder	0.20	0.16	0.21	0.19	0.29	.770	.001
Two above shoulder	0.32	0.31	0.38	0.37	0.94	.348	.007
Legs							
Squatting	0.56	0.39	0.53	0.49	0.39	.700	.001
Kneeling	0.21	0.15	0.10	0.17	3.30	.001	.084
Walking	0.52	0.13	0.51	0.11	0.46	.645	.002
Lifting upright							
< 22 pounds	1.20	0.61	1.65	0.55	3.41	.001	.089
22 – 44 pounds	1.69	1.21	2.77	1.27	4.01	<.001	.119
> 44 pounds	1.42	1.61	2.75	2.14	3.48	.001	.093
Lifting inclined							
< 22 pounds	1.98	1.84	3.82	2.24	4.34	<.001	.136
22 – 44 pounds	1.54	2.12	3.67	3.57	3.88	<.001	.112
> 44 pounds	1.56	2.68	4.07	4.64	3.56	<.001	.097
Workload index	14.90	10.11	25.82	15.02	4.40	<.001	.140

Note. Non-missing data for ORNs = 94 and for STs = 27.

Research Question 3

What is the correlation of frequency of AORN tasks performed without following AORN guidelines and proportion of time safety guidelines were followed with frequency of unfavorable postures and handling of heavy loads and workload associated with the postures and lifting of heavy loads during work in ORNs and STs?

For both groups, relationships between proportion of time safety guidelines were followed with physical workload were small and non-significant. In the ORN group, there was not any association of workload with frequency of unsafe patient transfers. Trunk posture workload was associated with increased frequency of unsafe standing duration, and arm positioning workload had medium correlations with frequency of unsafe practices related to positioning/repositioning of patients, lifting body parts, and standing duration. Leg positioning workload had a medium correlation with frequency of unsafe pushing/pulling of objects. Workload estimates for upright lifting of weights, inclined lifting of weights, and total workload had medium associations with unsafe frequencies of lifting body parts, standing duration, retractor use, and pushing/pulling objects. There were large associations of workload for upright lifting of weights, inclined lifting of weights, and total workload with unsafe frequency related to lifting of equipment. See Table 9.

In the ST group there was no association of workload with arm and leg positioning associated with frequency of any unsafe task practices. Trunk load had medium to large associations with frequency of unsafe practices related to all the tasks except for standing duration. Upright weightlifting had large correlations with unsafe practices related to patient transfer and lifting of body parts, and a moderate correlation with frequency of unsafe practices related to pushing/pulling of objects. Workload associated with lifting of weights in an inclined position and total workload had large correlations with frequencies of unsafe practices related to patient transfer, patient positioning, and lifting of patient body parts as well as medium correlations with frequencies of unsafe practices related to lifting of equipment and pushing/pulling of objects. See Table 9.

Table 9

Correlations of Non-adherence Frequency to AORN Safety Guidelines with Workload Estimates for Body Postures and Weightlifting Situations and Total Workload

Task	*n*	Trunk	Arms	Legs	Weight upright	Weight inclined	Total workload
ORN							
T1	75	.03	.20	.08	.23	.23	.18
T2	75	.15	.34**	.15	.33	.33	.30**
T3	71	.17	.46***	.29*	.41***	.41***	.40**
T4	83	.39***	.45***	.22	.31**	.31**	.35**
T5	65	.21	.12	.03	.43***	.43***	.41**
T6	67	.12	.21	.19	.51***	.51***	.50***
T7	73	.08	.19	.34**	.44***	.44***	.42***
ST							
T1	20	.55*	.30	.27	.59**	.62**	.67**
T2	15	.65**	.27	.35	.44	.62*	.65**
T3	17	.59*	.29	.37	.56*	.61**	.66**
T4	27	.33	-.03	-.22	.08	.21	.20
T5	22	.46*	.14	-.11	.21	.31	.34
T6	21	.63**	.01	-.12	.30	.48*	.46*
T7	25	.45*	.07	.16	.41*	.45*	.46*

Note. T1 = patient transfer; T2 = position/reposition; T3 = lifting body part; T4 = standing duration; T5 = retractor use; T6 = lifting equipment; T7 = push/pull objects.

**p* < .05. ***p* < .01. ****p* < .001.

Research Question 4

What is the relationship of frequency of task non-adherence to AORN safety practices, percent of time adhering to AORN safety practices, and workload on age, surgical experience, and teamwork?

All correlations between age and surgical experience with non-adherence frequency to safety practices, percent of time adhering to safety practices, and workload were small and not significant for both ORNs and STs. In the ORNs there were only small and non-significant correlations between teamwork constructs and non-adherence frequency to safety practices and percent of time adhering to safety practices.

Table 10 presents correlations of teamwork constructs with frequencies of non-adherence to AORN safety guidelines of seven operating room tasks and with percent of time adhering to safety guidelines on the tasks for the ST group. There were only small to negligible correlations of leadership, situational monitoring, and communication with all the non-adherence frequency tasks. Medium negative correlations were observed between team structure and retractor use and between mutual support and patient transfer, patient positioning/repositioning, lifting body parts, and pushing/pulling objects.

For the percent of task time complying with safety guidelines, only the communication construct did not have any medium or large correlations with any of the tasks. Team structure had medium correlations with patient transfer and positioning tasks, and leadership had medium correlations with patient transfer, positioning, and lifting body parts tasks. Situation monitoring had a large correlation with patient transfer and medium correlations with positioning/repositioning and lifting of body parts. Mutual support had medium correlations with positioning/repositioning, lifting of body parts, and pushing/pulling objects and a large correlation with percent of time complying with retractor use.

Table 10

Correlations of Teamwork Constructs with Frequency of Tasks with Non-adherence to Safety Guidelines and Percent Adherence of Tasks with Safety Guidelines of STs

Construct	T1	T2	T3	T4	T5	T6	T7
Non-adherence							
Team Structure	.09	-.07	.08	-.25	**-.33**	-.05	-.04
Leadership	.11	-.19	-.09	.01	-.24	-.22	-.05
Situation Monitoring	.05	-.13	-.02	-.07	-.13	-.19	.02
Mutual Support	**-.38**	**-.42**	**-.40**	-.09	-.11	-.24	**-.31**
Communication	.07	-.17	.09	-.11	-.12	.01	-.02
Adherence							
Team Structure	**.36**	**.35**	.28	.28	.14	.17	.01
Leadership	**.48***	**.40**	**.32**	.23	.15	.06	-.02
Situation Monitoring	**.51***	**.41**	**.37**	.25	.12	.19	-.02
Mutual Support	.17*	**.35**	**.38**	.05	**.55****	.30	**.43***
Communication	.20	.24	.27	.05	.06	.13	.02

Note. T1 = patient transfer; T2 = position/reposition; T3 = lifting body part; T4 = standing duration; T5 = retractor use; T6 = lifting equipment; T7 = push/pull objects. Correlations with bold type are medium correlations $r < .50$ or large correlations $r \geq .50$. Sample size ranged from 17 to 26 for the non-adherence correlations, and $n = 22$ for the adherence correlations.
*$p < .05$. **$p < .01$.

Research Question 5

Over a twelve-month period, what is the prevalence of pain/discomfort experienced in the body areas of back, neck, shoulders, hands/wrists, and feet, severity of pain in each body area, prevalence of an occupational injury, and days of missed work because of the injury in ORNs and STs?

Table 11 presents the prevalence of body part pain for ORN and ST participants with an injury, those with no injuries, and for the total group. For total prevalence in both groups, the largest pain prevalence was in the back and feet and the lowest prevalence occurred in the hand/wrist. For those reporting an injury, the biggest difference between ORNs and STs in pain prevalence was in the hand/wrist area with 25% of the ORNs reporting pain compared to 77.8% of STs. There were no significant differences in total group prevalence between ORNs and STs.

Table 11

Prevalence of Body Part Pain for Injury, Non-injury, and Total for ORNs and STs

	ORN			ST		
	Injury			Injury		
	Yes	No	Total	Yes	No	Total
Body part	%	%	%	%	%	%
Back	100	72.5	74.4	77.8	73.3	74.4
Neck	87.5	59.6	61.5	55.6	60.0	59.0
Shoulder	87.5	62.4	64.1	55.6	66.7	64.1
Hand/Wrist	25.0	48.6	47.0	77.8	46.7	53.8
Feet	87.5	67.9	69.2	77.8	80.0	79.5

Note. ORN: injury n = 8, non-injury n = 109, ST: injury n = 9, non-injury n = 30.

Table 12 presents the number of body areas with pain and the prevalence of ORNs and STs with injuries, no injuries, and for the total with those number of body areas. In the ORN group, no injuries were reported in those with fewer than three painful body areas, while in the ST group one subject reported an injury and had no painful areas. For the other 8 injuries in the ST group, all injuries were associated with three or more painful body areas. There were no significant differences in the number of painful body areas between ORNs and STs.

Table 12

Prevalence of ORNs and STs with Number of Pain Areas in those with Injury and No Injury

	ORN			ST		
	Injury			Injury		
	Yes	No	Total	Yes	No	Total
Number of areas	%	%	%	%	%	%
0	0.0	10.1	9.4	11.1	10.0	10.3
1	0.0	9.2	8.5	0.0	6.7	5.1
2	0.0	11.0	10.3	0.0	10.0	7.7
3	25.0	20.2	20.5	44.4	16.7	23.1
4	62.5	28.4	30.8	11.1	33.3	28.2
5	12.5	21.1	20.5	33.3	23.9	25.6

Note. ORN: injury $n = 8$, non-injury $n = 109$, ST: injury $n = 9$, non-injury $n = 30$.

Mean pain level for each body part is summarized in Table 13. Mean pain levels ranged from 4.84 to 5.36 for ORNs, and from 4.61 to 6.05 for STs. For both ORNs and STs, highest mean pain levels were reported in the feet and lowest mean pain levels were in the neck. No statistically significant differences were found between groups for pain levels in any area of the body.

Table 13

Mean Pain Level of Body Parts for ORNs and STs

	ORN		ST			
	M	*SD*	*M*	*SD*	*t*	*p*
Back Pain Level	5.31	2.03	5.5	2.26	-.36	.717
Neck Pain Level	4.84	1.99	4.61	1.91	.44	.663
Shoulder Pain Level	5.12	2.02	4.78	2.05	.62	.535
Hand/Wrist Pain Level	4.85	2.36	5.27	2.58	-.57	.574
Feet Pain Level	5.36	2.37	6.05	2.21	-1.18	.240

The prevalence of self-reported MSD injury for ORNs was 8.5% ($n = 8$), compared to 25.9% ($n = 7$) for STs. A chi-square test for independence indicated a significant difference between ORNs with injury and STs with injury, $\chi 2$ (1) = 7.94, *p* = .005, phi = .226. Of the ORNs who reported an injury, body parts included back, shoulder, ankle, and hand. Of the STs who reported an injury, body parts included arm, knee, back, and elbow. Days of work missed due to injury for ORNs ranged from 1 to 5 days, compared to STs who ranged from 1 to 30 days.

Research Question 6

What is the relationship between the physical workload on severity of pain in any of the body areas and occurrence of an occupational injury?

All the correlations of physical workload with body part pain levels for the ORNs were small and not significant. In the ST group, there was a large positive correlation between workload and hand/wrist pain levels, *r* = .57, *n* = 15, *p* = .027 and between workload and feet pain, *r* = .54, *n* = 22, *p* = .009.

Table 14 shows the mean workload for body postures, lifting of weights in an upright position, lifting of weights in an inclined position, and total workload on the spine. There is no association between workload and injury in the ORN group. In the ST group, there are significant differences in workload on all variables except for workload related to the use of legs. The biggest contributor to the total workload differences in the injured and non-injured STs is the workload associated with lifting of weight while in an inclined body position.

Table 14

Means, Standard Deviations, and Independent Samples t-Test of Workload

	Injury						
	Yes		No				
Postures/weights	*M*	*SD*	*M*	*SD*	*t*	*p*	η^2
ORN							
Trunk	4.41	1.95	3.62	2.07	1.03	.303	.012
Arms	0.57	0.51	0.51	0.44	0.35	.724	.001
Legs	1.13	0.49	1.30	0.55	0.85	.399	.008
Weight upright	3.43	2.11	4.40	3.21	0.83	.408	.007
Weight inclined	4.88	4.49	5.11	6.30	0.10	.920	.000
Total workload	14.42	7.74	14.95	10.33	0.14	.888	.000
ST							
Trunk	8.00	1.57	4.44	2.17	3.96	.001	.386
Arms	1.01	0.70	0.45	0.42	2.56	.017	.207
Legs	1.50	0.88	1.01	0.59	1.68	.106	.101
Weight upright	9.65	3.48	6.29	3.19	2.35	.027	.180
Weight inclined	18.96	7.79	8.97	8.40	2.79	.011	.233
Total workload	39.13	13.61	21.16	12.73	3.16	.004	.286

Note. ORN: injury n = 8, non-injury n = 86. ST: injury n = 7, non-injury n = 20.

Research Question 7

What is the relationship between severity of pain in any of the body areas and occurrence of an occupational injury with age, experience in a surgical setting, and attitudes toward teamwork?

In the ORN group, all correlations between age, surgical experience, and teamwork constructs with body part pain levels were small (.10 to .29) or negligible. There was one small correlation that was significant between age and feet pain, r = .23, n = 76, p = .048. No additional relationships were statistically significant for ORNs regarding age, surgical experience, mutual support with injury or pain intensity. In the ST group, there were some medium non-significant correlations and one large significant correlation. Medium non-significant relationships include age and back pain (r = .34, n = 29, p = .072); surgical experience and feet pain (r = .33, n = 3), p = .061); leadership and back pain (r = .33, n = 27, p = .091); mutual support and hand/wrist pain (r = -.31, n = 19, p = .189); and situation monitoring and feet pain (r = .36, n = 28, p = .061). A large significant negative correlation was found with mutual support and shoulder pain (r = -.50, n = 23, p = .016).

Summary

This chapter provided a summary of demographics, descriptive, and correlational statistics among variables of this study. Findings from the study were summarized by research question. Answers to research questions were presented using written summaries and tables to provide more detailed findings. Most notable findings include pain prevalence and physical workload relationships. Back pain was highly prevalent for both groups. Additionally, pain prevalence in one or more body areas was significant for both ORNs (90.6%) and STs (89.7%). The mean physical workload was significantly higher for STs compared to ORNs. Additionally, a significant positive relationship was found with physical workload and the presence of injury for STs. For both ORNs and STs, physical workload was significantly correlated with the frequency of non-adherence to the majority of AORN tasks. A discussion of findings is presented in the following chapter.

CHAPTER 5: DISCUSSION

The purpose of this study was to examine the effects of physical workload, prevalence of AORN high-risk tasks, and adherence to AORN guidelines in performing physical tasks with outcomes of musculoskeletal pain, occupational injury, and days of work missed in operating room nurses and surgical technologists. This chapter will provide interpretations for the major findings of the study. Additionally, study strengths and limitations, recommendations for further research, and implications for nursing are also provided.

Instruments

The Cronbach's alpha for T-TAQ in this study was found to be below acceptable in the constructs of mutual support and communication. Acceptable levels for Cronbach's alpha are generally above .70 to be considered reliable (Hatcher, 2013). For ORNs, Cronbach's alpha for mutual support was found to be .69, and .66 for communication. For STs, a Cronbach's alpha of .54 was found for mutual support. During development of the T-TAQ, Baker and colleagues (2008) found Cronbach's alpha to be .70 for mutual support and .74 for communication. It should be noted that the mutual support construct included three negatively worded items and the communication construct included one negatively worded item. Even after correctly recoding the negative items, Cronbach's alpha tends to be smaller in scales with negatively worded items compared to scales without such items. In this study, there were a small number of individuals who responded with agree and strongly agree on the positively worded items but responded with an inconsistent agree or strongly agree on the negatively worded items. Although T-TAQ has been used in operating room personnel (Kawaguchi & Kao, 2021; Vertino, 2014), samples are often mixed with nurses outside the operative setting and not comparable to this study sample. Although two constructs were below acceptable, the T-TAQ could be considered for additional research in ORNs and STs for measurement of teamwork attitudes with a larger sample size to see if Cronbach's alpha levels reach acceptability for all constructs. Alternatively, different instruments measuring the constructs of mutual support and communication could also be used for a comparison in future studies.

Characteristics of the Study Sample

For ORNs, the sample demographics are similar to the demographics reported by AORN for average age and years of experience in surgery (Bacon & Stewart, 2020). Our sample differs from the AORN report for gender where males account for 11% of members, where our study sample included only 1.7% male participants. For STs, the sample demographics were similar in age and gender to a previous study by Shahijani and colleagues (2019). This study found the average age and experience level of ORNs to be significantly higher than STs. One possible explanation for this may be the typical entry-level educational training differences between groups. For ORNs in the U.S., an associate or bachelor's degree is considered entry-level. For STs, a nondegree certificate is considered entry level. This indicates earlier entry into the profession for STs compared to ORNs, which could impact averages for age and experience.

Interpretation of the Findings

Adherence rates to AORN guidelines were similar between groups. Adherence rates ranged from 50% to 65% for all tasks performed. Study findings indicate ORNs and STs adhere to the safety guidelines the majority of the time, but only slightly over the 50% threshold for adherence. To our knowledge, no studies have explored adherence rates to AORN safety guidelines. The operating room can be a stressful and demanding work environment (Jeyakumar et al., 2018; Sheikhzadeh et al., 2009). The stress and demand of the operating room may contribute to the lower rates of adherence to safety measures. Productivity and turnover times may contribute to the stressful environment and could impact the ability of ORNs and STs to follow AORN safety guidelines that may increase operative or turnover times. The lowest adherence rate for both groups was found with retractor use. AORN recommends the use of self-retaining retractors rather than manual retraction, but this is often a decision based on the preference of the surgeon, which could result in lower adherence rates for those personnel who did not have a choice in retractor selection.

The frequency of non-adherence to AORN guidelines for the seven high-risk perioperative tasks was high for both groups related to standing duration. It is well known that nurses, in general, spend a great deal of time on their feet during typical working days. Similarly, STs must maintain a standing position for long periods of time to maintain sterility of the surgical field. Not surprisingly, mean frequency of non-adherence was greater with STs for standing duration when compared to ORNs. ORNs have more flexibility to take short breaks from standing and often spend time sitting for documentation of the surgical case. Similarly, prolonged standing was found by other researchers exploring MSD in operative personnel (Chomem & Motter, 2021; Meijsen & Knibbe, 2007a). Additionally, STs had higher frequency of non-adherence for guidelines involving retractor use and lifting equipment trays. This could be due to the differences among groups with the frequency of which these tasks are performed in general. STs spend most of their time inside the sterile field, while ORNs fulfill roles both within the sterile field and outside the field. These differences could result in less frequent retractor use for ORNs, and more opportunities for ORNs to use assistive devices, such as rolling carts, when lifting equipment trays.

The physical workload of STs was found to be significantly higher than that of the ORNs. Study findings indicated that STs worked in awkward positions more frequently than ORNs, resulting in higher mean physical workload and greater risk of MSD pain or injury. These findings are supported by Clari et al. (2019) who found nurses working in the scrub role more frequently doubled their risk of upper limb MSDs. Our findings differ from Shahijani et al. (2019), who used the REBA checklist for observed postures and found overall risk of MSD injury was higher for those circulating than those in the scrub role. Shahijani et al. conducted their study in Iran, where participants in circulating and scrub roles were all considered STs. This is different from our study setting, where STs do not perform the role of a circulator and are solely in the role of the scrub person. Additionally, Yu et al. (2016) also explored differences in workloads of ORNs and STs using the SURG-TLX survey and found no difference between groups. However, the SURG-TLX measures workload through both physical and cognitive load indexes. These mixed findings indicate a need for consistency in measuring workload and further research.

Prevalence of MSD pain was significant for both groups and pain in at least one area was reported by 91.3% of ORNs and 92.5% of STs. These findings were similar to studies where prevalence of MSD pain was found to be 92.5% (Asghari et al., 2019) for ORNs and 96.7% (Shahijanie et al., 2020) for STs. Additionally, our study found the highest prevalence of pain for ORNs and STs to be in the back at 74.4% for both groups. For ORNs, back pain prevalence was higher in our study than previous studies, which ranged from 50 to 61.9 % (Asghari et al., 2019; Bakola et al., 2017; Mahmoudifar & Seyedamini, 2017; Meijsen & Knibbe, 2007a; Nasiri-Ziba et al., 2017; Nützi et al., 2015; Rypicz et al., 2020). Previous studies were not conducted in the U.S. and variations in the population of surgical patients, such as weight of the patients or type of surgical procedure, may play a role in back pain differences. Additionally, our study asked participants about the presence of back pain, where previous studies asked specifically about low back pain, which could account for the higher prevalence found in ORNs for this study.

Our mean pain ranges were moderate for both groups in all body parts measured. On a 0 to 10 pain scale, mean pain ranges were reported from 4.61 to 6.05 for ORNs and STs in the areas of the back, neck, shoulder, hand/wrist, and feet. Similarly, Asghari et al. (2019) found moderate pain ratings between 3.1 and 3.5 on a 0 to 5 pain scale for the neck, shoulders, upper back, elbows, low back, wrists/hands, hips/thighs/buttocks, knees, and ankles/feet. Our findings of high pain prevalence and moderate pain levels suggest MSD pain may be a significant problem for ORNs and STs. Additionally, MSD rates of injury were significantly higher for STs (25.9%) when compared to ORNs (8.5%). This is supported by our previously mentioned finding where STs had higher physical workload means, increasing their risk of MSD injury.

For ORNs, significant relationships were found between frequency of unsafe lifting equipment with upright and inclined lifting of weight, as well as total workload. The more frequently ORNs did not adhere to AORN safety guidelines when lifting equipment, the higher their workload scores were for positions of upright and inclined weightlifting and for total workload. These findings support the perceptions of increased risk for MSD related to moving heavy equipment and lifting found in previous studies (Meijsen & Knibbe, 2007a; Sheikhzadeh et al., 2009).

For STs, lifting of weights in an inclined position and total workload were significantly correlated with the frequency of unsafe patient transfer, patient positioning, and lifting body parts. As the number of times STs performed transfers, positioning, and lifting activities without following safety guidelines increased, total workload and inclined position workload scores increased. These findings are supported by qualitative findings of Sheikhzadeh and colleagues (2009) where perioperative personnel reported perceptions of high workloads. Additionally, this study found significant relationships of trunk positions and frequency of unsafe practices related to all tasks except standing duration for STs. Trunk workload scores increased with the number of times STs performed unsafe patient transfer, positioning, lifting body parts, retractor use, lifting equipment, and pushing/pulling objects. Similarly, researchers using the REBA tool found high scores indicating increased risk for MSDs during patient relocation, retracting, transferring instruments, and equipment relocation (Abdollahzade et al., 2016; Asghari et al., 2019; Shahijani et al., 2019).

In the ST group, workload was significantly correlated with pain levels of the hand/wrist and feet. As total workload increased, pain in the hand/wrist and feet increased. These findings are supported by Shahijani and colleagues (2020), who found high prevalence of pain reported by STs at similar levels in the hand/wrist (40.9%) and ankle/feet (44.1%). Additionally, all workload positions except those with the use of legs were associated with injury in the ST group. Most notably, handling weight in the inclined position was the biggest contributor to the total workload differences of those STs injured versus non-injured. Unfavorable positions of the trunk, arms, and when handling weight by the ST are often out of necessity to maintain sterility while scrubbed into the surgical field. When removing sterile instruments from their processing tray, STs must handle the weight of the tray while in the inclined position to maintain sterility of themselves and the instruments. It is not surprising that the workload resulting from this task contributed to injury for the STs.

Attitudes on teamwork were positive and similar among both groups for all constructs. Our findings support the work of Bakola and colleagues (2017), who found 97.7% of participants agreed that teamwork facilitated effective delivery of care in the operating room. However, only STs were found to have several significant relationships between adherence rates to safety guidelines and teamwork constructs. As attitudes toward leadership increased, adherence to patient transfer safety guidelines increased. This study also found an increase in mutual support with increased adherence to retractor use and push/pulling objects. To our knowledge, there is no literature related to adherence rates and correlates of teamwork attitudes. Our findings suggest teamwork may be an important factor in increasing adherence to safety guidelines, but more research is needed.

Strengths and Limitations

This study had several strengths and limitations for consideration. An important strength for this study was addressing significant gaps in the literature. Importantly, this study found low to moderate adherence to AORN safety guidelines in operative personnel. Additionally, this study found a relationship between physical workload and frequency of non-adherence to the AORN safety guidelines. These finding are a significant step towards understanding adherence to safety guidelines and the development of MSDs in operative personnel. This study also addressed the limited research exploring MSDs in STs, as well as differences among ORNs and STs. Further, this study adds to the paucity of research on MSDs for ORNs and STs in the U.S., enhancing generalizability of findings.

The use of secondary data created limitations for this study. First, although adherence rates and frequency of non-adherence to AORN safety guidelines were measured, there was no way to know how much time was spent on each task and the potentially related MSD risk. Also, there were several different time references for participants to consider throughout the survey. For the AORN adherence and non-adherence to guidelines, a 14-day recall was utilized, while a

12-month recall was used for pain and injury data. For pain severity, physical workload, and organizational variables, no time frame was specified. The variety of time references creates temporal order limitations and generalization should be considered with caution. Finally, the possibility of response bias cannot be ruled out given the self-report nature of the initial questionnaire.

Recommendations for Further Research

This study indicated that adherence rates to AORN safety guidelines among ORNs and STs were low to moderate. Future research is needed to assess the knowledge level of operative personnel related to the AORN guidelines. It is unclear if participants were familiar with the guidelines or recommendations prior to the study, or if any formal ergonomic training had been provided. Further observational research would also be beneficial to support findings of this study related to adherence rates. Additionally, future research is needed to explore factors contributing to and hindering adherence to the guidelines. Use of qualitative methodologies to explore these factors with ORNs and STs could illuminate areas for possible intervention.

The role of the ORN may vary significantly depending on the state or type of facility. Nurses found in the operating room may be circulators, scrub nurses, or first assistants, and each role has different demands on the musculoskeletal system. Our study found STs to have higher physical workloads and more significant rates of injury than ORNs, however, ORNs who spend most of their workday in the role of scrub nurse may have similar outcomes. Further research would be indicated to differentiate MSD risk for the different roles performed in the operating room in order to target possible interventions to reduce risk.

While this study explored days of work missed due to injury, the high prevalence of MSD pain and moderate pain levels found with participants warrant further exploration related to absenteeism due to MSD pain. In a recent meta-analysis, researchers exploring predictors of sickness absenteeism in nursing found experiencing musculoskeletal pain significantly increased the odds of sickness absence (Gohar et al., in press). Specifically, for operative personnel, Sheikhzadeh and colleagues (2009) found lower back pain and ankle/knee pain as primary causes of absenteeism. Given these correlations, further research is needed to explore the impacts of absenteeism on patient safety in the operating room. High rates of absenteeism affect staffing, which can in turn affect quality of care for patients. Further research exploring relationships between absenteeism and OR specific outcomes, such as surgical site infection rates, is needed.

Implications for Practice

Adherence to the guidelines during high-risk activities contribute to an ergonomically safe work environment for operating room personnel and contribute to the prevention of MSDs (Ogg, 2011). Because our study showed low to moderate adherence rates, leadership within the operating room should consider strategies to improve adherence to AORN safety guidelines. Increasing levels of ergonomic knowledge through education has been found to improve ergonomic practices in the operating room (Abdollahi et al., 2020; Ali et al., 2018; Moazzami et al., 2016), however, researchers also found operative personnel perceived educational activities as inadequate for protection against occupational injury (Bakola et al., 2017; Çelikkalp & Sayilan, 2020). Annual educational activities grounded in adult learning theories may be beneficial to increase knowledge of and adherence to the AORN safety guidelines.

Physical workload was measured by asking about time spent in unfavorable positions of the trunk, arms, legs, and when handling weight. The significantly higher physical workload and rates of injury found for STs indicate a need for change in current practice. In our study, the highest mean workloads were found during lifting weight while inclined for STs. It is common among operating rooms to have limits on the weight of instrument trays to decrease workload when moving and lifting the trays and AORN recommends not exceeding 25 pounds (Association of periOperative Registered Nurses, 2019). Our study found STs and ORNs frequently lifted weights exceeding these guidelines. It is important to have a quality control measure in place to monitor the weight of instrument trays on a continual basis. The instruments within trays may change over time and weight may fluctuate. Frequent monitoring of the tray weights to keep them within guidelines would decrease workloads of all personnel who handle the trays.

This study found STs adhered to retractor use guidelines only 42% of the time and had significantly higher levels of hand/wrist pain. Manual retraction of human tissue is physically demanding for the musculoskeletal system. Additionally, manual retraction often creates a need to put the individual performing retraction in awkward positions, creating more stress on the musculoskeletal system and increasing the risk for injury. As previously mentioned, AORN recommends the use of self-retaining retractors, when possible, but this is often the decision of the surgeon rather than the individual performing retraction. Additional considerations for the use of self-retaining retractors may be budgetary considerations of administrators. If the cost of a self-retaining retractor is high, it may be difficult for administrators to justify the purchase. However, given the low adherence to AORN safety guidelines for retractor use and the high prevalence of hand/wrist pain for STs, administration should consider fund allocation for self-retaining retractors. Further, offering surgeons instrument trial periods for self-retaining retractors and education on the MSD impact to the surgical team may result in increased use and adherence for operative personnel.

Summary

This chapter provided a discussion of findings for this study. Adherence rates to AORN safety guidelines were low to moderate for both ORNs and STs, and more research is needed to explore possible related factors. It is recommended that annual continuing education is provided to operative personnel to keep up to date with AORN ergonomic safety guidelines. Additionally, there were some significant differences among ORNs and STs related to measures of workload and rates of injury, which may be explained by the differences in roles and tasks performed by the groups. Further research is needed to explore MSD risk related to role differences in ORNs. Because of the increased physical workload found in this study in STs handling heavy loads, it is recommended that a quality control process be in place to limit the weights of instrument trays.

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APPENDIX A: AORN ERGONOMIC TOOLS AND BRIEF DESCRIPTION

AORN Ergonomic Tool	Brief Descriptor of Safety Guideline
1. Lateral Transfer of a Patient from a Stretcher to an OR Bed	Provides an algorithm for deciding on number of OR personnel needed or use of assistive mechanical devices for transfer
2. Positioning and Repositioning the Supine Patient on the OR Bed	Provides an algorithm for number of OR personnel needed or assistive mechanical devices when repositioning
3. Lifting and Holding the Patient's Legs, Arm, and Head While Prepping	Provides a table of weight-based risk for lifting and holding legs, arms, and head during prepping as well as time limit recommendations
4. Solutions for Prolonged Standing	Provides an algorithm for standing fatigue solutions
5. Tissue Retraction During Surgery	Provides an algorithm for self-retaining and manual retraction decisions
6. Lifting and Carrying Supplies and Equipment in the Perioperative Setting	Provides lifting index and risk levels for common equipment carried by OR personnel
7. Pushing, Pulling, and Moving Equipment on Wheels	Provides weight and distance restrictions for moving common surgical equipment

APPENDIX B: TEAMSTEPPS TEAMWORK ATTITUDES QUESTIONNAIRE (T-TAQ)

TeamSTEPPS Teamwork Attitudes Questionnaire (T-TAQ)

Instructions: Please respond to the questions below by placing a check mark (√) in the box that corresponds to your level of agreement from *Strongly* *Disagree* to *Strongly* *Agree*. Please select only one response for each question.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Team Structure					
1. It is important to ask patients and their families for feedback regarding patient care.					
2. Patients are a critical component of the care team.					
3. This facility's administration influences the success of direct care teams.					
4. A team's mission is of greater value than the goals of individual team members.					
5. Effective team members can anticipate the needs of other team members.					
6. High performing teams in health care share common characteristics with high performing teams in other industries.					
Leadership					
7. It is important for leaders to share information with team members.					
8. Leaders should create informal opportunities for team					

members to share information.					
9. Effective leaders view honest mistakes as meaningful learning opportunities.					
10. It is a leader's responsibility to model appropriate team behavior.					
11. It is important for leaders to take time to discuss with their team members plans for each patient.					
12. Team leaders should ensure that team members help each other out when necessary.					

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Situation Monitoring					
13. Individuals can be taught how to scan the environment for important situational cues.					
14. Monitoring patients provides an important contribution to effective team performance.					
15. Even individuals who are not part of the direct care team should be encouraged to scan for and report changes in patient status.					
16. It is important to monitor the emotional and physical status of other team members.					

17. It is appropriate for one team member to offer assistance to another who may be too tired or stressed to perform a task.					
18. Team members who monitor their emotional and physical status on the job are more effective.					
Mutual Support					
19. To be effective, team members should understand the work of their fellow team members.					
20. Asking for assistance from a team member is a sign that an individual does not know how to do his/her job effectively.					
21. Providing assistance to team members is a sign that an individual does not have enough work to do.					
22. Offering to help a fellow team member with his/her individual work tasks is an effective tool for improving team performance.					
23. It is appropriate to continue to assert a patient safety concern until you are certain that it has been heard.					
24. Personal conflicts between team members do not affect patient safety.					

TeamSTEPPS® 2.0

Strongly Agree
Agree
Neutral
Disagree

		Strongly Disagree				
Communication						
25.	Teams that do not communicate effectively significantly increase their risk of committing errors.					
26.	Poor communication is the most common cause of reported errors.					
27.	Adverse events may be reduced by maintaining an information exchange with patients and their families.					
28.	I prefer to work with team members who ask questions about information I provide.					
29.	It is important to have a standardized method for sharing information when handing off patients.					
30.	It is nearly impossible to train individuals how to be better communicators.					

Please provide any additional comments in the space below.

Thank you for your participation!

APPENDIX C: PHYSICAL WORKLOAD INDEX QUESTIONNAIRE (PWIQ)

Appendix I

Musculoskeletal load due to body posture and strenuous effort during work

Please estimate, how often you have to work with the body postures displayed below, and how often you have to lift or to carry the weights mentioned below.
Please fill up **all** lines!

Trunk	never	seldom	sometimes	often	very often
straight, upright					
slightly inclined					
strongly inclined					
twisted					
laterally bent					

Arms	never	seldom	sometimes	often	very often
both arms below shoulder height					
one arm above shoulder height					
both arms above shoulder height					

Legs	never	seldom	sometimes	often	very often
sitting					
standing					
squatting					
kneeling with one knee or with both					
walking, moving					

Weight, lifted / carried with upright trunk	never	seldom	sometimes	often	very often
light (up to 10 kg)					
medium (10 - 20 kg)					
heavy (more than 20 kg)					

Weight, lifted / carried with inclined trunk	never	seldom	sometimes	often	very often
light (up to 10 kg)					
medium (10 - 20 kg)					
heavy (more than 20 kg)					