Identification, Evaluation and Control of Physically Demanding Patient-Handling Tasks in an Acute Care Facility

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Abstract

Work-related musculoskeletal disorders (WMSDs) are prevalent among health care workers worldwide and underreporting among nurses may mask the true impact of these injuries. Nursing staff are consistently among the top 10 occupations at risk for experiencing WMSDs and patient-handling tasks are the precipitating event in the majority of back injuries experienced among nursing staff.

Existing research has focused on patient-handling issues within long-term care facilities, and identifying physically demanding patient-handling tasks. The first study in this dissertation (Chapter 3) was conducted to determine whether nurses in acute care facilities are exposed to the same hazards as their cohorts in long-term care. The aim was to identify the top 10 patient-handling tasks being conducted and to rank these tasks by perceived physical demand. This two-phase study consisted of a procedural task analysis of patient-handling activities, and a questionnaire to identify the characteristics of the study population and obtain a ranking of physically demanding patient-handling tasks. All nurses providing direct inpatient care were recruited to participate in both phases of this study. Compared to long-term care facilities, in which the majority of tasks have been shown to be associated with performance of ADL tasks, the most frequently observed tasks in the acute care facility were repositioning tasks. Therefore, it is important to determine the patient-handling demands and needs that are unique to each type of healthcare facility. Generalizing across facilities or units may lead to incorrect assumptions and conclusions about physical demands being placed on nurses.

A laboratory simulation was used for the second study (Chapter 4). The top four physically demanding patient-handling tasks (taken from Chapter 3) were simulated to determine the effect of an assistive device and assistance from another person. Sixteen nurse volunteers were recruited and provided perceptual responses regarding exertion and injury risk. Nurses perceived that assistance decreased their physical exertion and injury risk; however they consistently perceived exertion to be relatively higher than their injury risk.

The aim of the third study (Chapter 5) was to determine the level of agreement between and within different expert groups. Three groups of participants were involved, with different levels of ergonomics expertise (i.e. researchers, consultants, and graduate students). These groups viewed digitized video clips from the laboratory simulation (Chapter 4) and provided ratings of perceived exertion, perceived injury risk and common WMSD risk factors (effort, posture, and speed). The major finding from this study was that poor agreement existed between nurses and the other expert groups (researchers, consultants and students).

The current research laid the groundwork for measuring the magnitude of physical exposure to injury risk in the patient-handling environment. The research supports earlier evidence that suggests nurses underreport their discomfort and injury, which, in turn, contributes to increased exposure and risk. This knowledge will enable practitioners to focus interventions and designs on those factors in the work environment that contribute significantly to increased exposure and thereby more effectively reduce WMSD risk.

Dedication

This work is dedicated to the memory of my parents, Regino and Mary Sagadraca, who passed on the values of hard work, respect for education and respect for life. This is also dedicated to the memory of Mr. Greg Wells, whose faith in people will always be remembered. I miss all of you very much.

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1.0 Introduction

Nurses perform many different activities during the course of their workday. These tasks include lifting loads in a variety of twisted, bent or non-neutral postures; handling heavy, unbalanced or shifting loads; carrying loads a substantial distance; and performing these activities in restricted spaces. Patient handling—moving or transferring a patient from one location to another—is particularly problematic for nursing personnel. Patients may move unexpectedly and can become uncooperative or even combative, which changes the load demands and greatly alters the physical challenge associated with the activity. Even the smallest adult patient can place an unsafe load on the health care worker. The cumulative exposure to the forceful exertions required by patient-handling tasks results in an increased risk for a variety of work-related injuries among nursing personnel.

Musculoskeletal disorders account for the majority of occupational injuries and illnesses resulting in lost work time and compensation expenditures. In the United States in 2002, 12.6 occupational injuries or illnesses occurred per 100 full-time employees in long-term care facilities (Bureau of Labor Statistics, 2003). In acute care facilities, the rate was 9.7 per 100 full-time employees, and approximately one-third of these injuries resulted in absence from work (Bureau of Labor Statistics, 2004). Nursing staff are consistently among the top 10 occupations in terms of the risk of experiencing work-related musculoskeletal disorders (WMSDs). Incidence rates were found to be 8.8 per 100 in acute care hospitals and 13.5 per 100 in long-term care facilities (Nelson & Baptiste, 2006). These are considered to be low estimates because underreporting of injuries in nursing is common. Among all occupations, nursing aides (NAs), orderlies and licensed practical nurses/licensed vocational nurses (LPNs/LVNs) had the second highest number of injuries and illnesses requiring time off (U.S. Department of Health and Human Services, 2001a), with notably high rates of back injuries (U.S. Department of Labor, 2002). Retsas and Pinikahana (2000) found that approximately 68% of manual-handling injuries were associated with direct patient care tasks and 34.4% of occupational injuries were attributed to patient handling (Heck, 2002). Garg (1995) indicated that manual lifting and transferring of patients accounted for 84% of all documented injuries among nursing home personnel at three nursing homes over a 3-year period, resulting in 86% of all lost and restricted workdays and 81 to 93% of workers' compensation claims.

The majority of patient-handling research has been conducted in long-term care or extended care facilities. Patients in these facilities typically have higher levels of dependency and present more challenges in patient-handling activities. Although there are a wide variety of nursing tasks, Garg et al. (1992) identified a set of the most physically demanding tasks for long-term care facility nurses based on nurses' self-reports. This list has allowed safety, health and engineering personnel to investigate nursing activities and identify potential solutions, redesigns and assistive devices for the high-risk tasks. Long-term care facilities are often constructed or structurally modified to accommodate patient-handling equipment such as ceiling lifts and horizontal track systems. A main limitation of current research on injuries to nursing personnel is that the investigations have been primarily limited to long-term care facilities. Care provided in acute care facilities also presents patient-handling challenges; however, very few studies have been conducted in these facilities. The extent of exposure to physically demanding tasks and associated injury risk among acute care facility nursing personnel is unknown. Patient-handling assistive devices in acute care facilities are typically limited to portable, low-cost devices since the patient census and dependency levels do not justify the capital expense required to install ceiling lifts and track systems. The effect of patient-handling assistive devices in acute care facilities on personnel physical demands and injury risk exposure is unknown.

The research leading to this dissertation: (1) identified the most frequently occurring patient-handling tasks in an acute care facility; (2) determined the rank order of these tasks based on perceived physical demands; (3) described the self-reported prevalence of physical symptoms and discomfort among acute care nursing personnel; (4) defined and ranked the specific task elements within a subset of frequent patient-handling tasks based on perceived exertion; (5) described the moderating effect of assistive devices or an additional person on the physical demands and performance; (6) analyzed subjective evaluations of each task element; and (7) evaluated the agreement on risk exposure assessment among ergonomists (experts) and the association between expert evaluations and nursing staff ratings. As a whole, this research expands the knowledge of patient-handling tasks and risks in acute care facilities, and the potential for risk reduction using common engineering and administrative controls. This research also offers contributions to nursing practice and training programs by providing information to serve as the basis for standards of practice and nursing procedures.

2.0 Literature Review

2.1 Background

In *Concept of Work*, Applebaum (1992) argues that work is basic to the human condition, that, like the spine, it structures the way people live, how they make contact with material and social reality and how they achieve status and self-esteem. On a less philosophical or metaphorical note, the *Merriam-Webster Dictionary* defines work as: "an activity in which one exerts strength of faculties to do or perform something," or "a sustained physical or mental effort to overcome obstacles and achieve an objective or result." Work relates to all human activities and proves vital to satisfying basic human needs and wants, such as gathering food or building shelter.

Fossil records show that humans organized themselves for hunting—a most basic form of "work" hundreds of thousands of years ago (Donkin, 2001). During the Stone Age, two central aspects of work emerged: organization and reward. Survival depended on the individual's (or group's) ability to meet the basic demands of human existence: shelter, food and warmth. All work focused on such survival. As communities formed, populations grew, time passed and conceptions of work began to encompass more than the mere meeting of physical needs. In fact, "work" began to include intellectual and professionalized endeavors, and people began to specialize in their occupations. Over time, work became an increasingly tiered system with intellectual and professional endeavors assuming the top tiers, while physical, even skilled labor, was relegated to the bottom tier.

Regardless of how conceptions of work have changed over time, one element of it remains constant: its physical nature. Even the most intellectual of work endeavors places demands on the human body, but physical labor carries its own special demands and risks. In ancient Greece, Socrates first documented the physical effects of work. He stated “those arts that are called mechanical are spoken against everywhere and have quite plausibly come by a very bad reputation in the city. For they utterly ruin the bodies of those who work at them and those who are concerned with them, compelling them to sit still and remain indoors, or in some cases even spend the whole day by the fire” (Applebaum, 1992).

Ramazzini’s eighteenth-century study *De Morbis Artificum* (Diseases of Workers) outlines his work and findings in what would come to be known as occupational medicine (Ramazzini, 1964). In 1713, Ramazzini recorded the first medical documentation of the physical effects of work: “The first and most potential is the harmful character of the materials that they handle for these omit noxious vapors and very fine particles inimical to human beings and induce particular diseases. The second cause I ascribe to certain violent and unnatural postures of the body, by reason of which the nature structure of the vital machines is so impaired that serious diseases gradually develop” (Ramazzini, 1964).

As early as the eighteenth century, doctors noticed that workers whose jobs required them to maintain certain body positions for long periods of time developed musculoskeletal problems. In the past 20 years, research has established strong connections between job tasks and the resulting adverse physical effects otherwise known as WMSDs (Bernacki et al., 1999). WMSDs develop, in part, as a result of repeated forceful exertions with minimal recovery time between repetitions. The cumulative effect of these repeated forceful movements affects muscles, tendons and ligaments and potentially leads to WMSDs.

2.2 Statement of the Problem

WMSDs affect 1.7 million workers every year and account for one-third of all reportable injuries, 60,000 of which result in permanent disability (Frymoyer, 1997). In the United States, WMSDs account for a substantial portion of the cost associated with workplace injuries and illnesses. While the exact cost of WMSDs remains unknown, researchers estimate $20 billion per year in direct workers' compensation costs and up to $60 billion in indirect costs.

Back pain is one of the most common musculoskeletal problems. Frymoyer (1983) stated that approximately 60 to 80% of the general population will experience low back pain (LBP) at some point in their lives. In 1993, in the United States alone, back disorders accounted for 27% of all nonfatal occupational injuries and illnesses involving days away from work (NORA, 2002). In 2002, the Bureau of Labor Statistics reported 1.4 million injuries and illnesses requiring time off from work. Additionally, a 2002 study found that the cost of a workers' compensation claim for a low back disorder averaged $8,300, more than twice the average cost ($4,075) of all other compensable claims combined (NORA, 2002). Among health care personnel, nurses have the highest rate of back pain, with an annual prevalence of 40-50% (Edlich et al., 2004). Financial costs are evident to both the worker and the employer.

Patient handling precipitates the majority of back injuries in nursing personnel, a factor that indicates the need for ergonomic interventions (Goldman et al., 2000). Typical patient-handling tasks include transferring patients from the bed to the wheelchair, repositioning them in bed and transferring them laterally from the bed to the gurney. Depending on the configuration in the patient's room, nursing personnel often must adopt and maintain extreme postures, such as sustained trunk flexion. Unlike the act of lifting a box with handles, moving or transferring a patient from one location to another involves more physical exertion, which can translate to increased risk. Not only is the patient's weight unevenly distributed, but the mass itself is asymmetric, bulky and cannot be held close to the body. Additionally, when patients become confused, combative or shift their weight unexpectedly, the lifting task becomes further complicated. Moreover, the amount of assistance a patient can offer varies, making the task different each time it is performed. Finally, patient care requirements, high-demand schedules, urgent situations and patient falls may require rapid responses and nursing personnel may attempt a single perform lift rather than waiting for assistance.

2.3 Factors Contributing to the Problem

Workplace injuries occur as a result of a complex interaction of factors in three primary domains (Figure 1): the physical work environment (including work procedures), organizational factors and the social context of the workplace. Individual physical and psychological factors act as moderators for these factors in symptom development or adaptive response to risk exposures.

The National Research Council conceptual model (Figure 1) is particularly relevant for the nursing profession. Nursing personnel are required to perform physically demanding tasks, often in stressful situations. Nursing shortages, lower staffing levels, limited management support and health care industry trends such as managed care create significant organizational stresses. Finally, shift work requirements interfere with the nurses' social and family support.

The physical work environment and the internal loads required in nursing tasks offer important opportunities in injury prevention. Controlling risk exposure through the identification and analysis of physical risk factors and subsequent task redesign may assist in decreasing injury rates and lost work time outcomes.

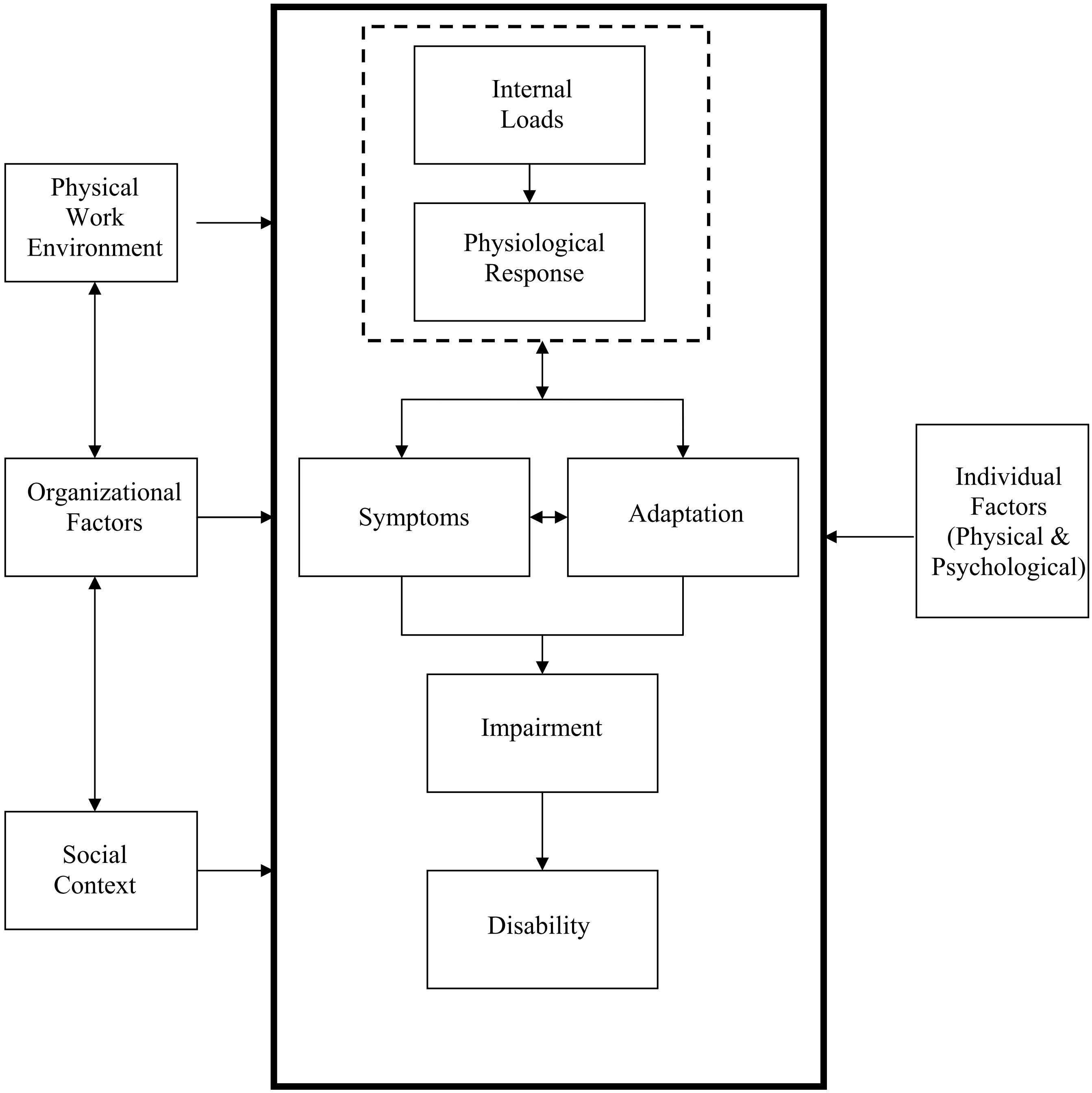


Figure 1: Injury Conceptual Model (adapted from National Research Council, 2001)

2.3.1 Identification and Analysis of Physical Risk Factors

Physical risk factors associated with injuries fall into three main categories: personal risk factors, work methods and job demands. Personal risk factors include specific human characteristics that either increase or decrease the likelihood that an injury will occur. Human characteristics that directly affect physical task demands include age, gender, physical conditioning, anthropometric measures and medical condition (Chaffin & Andersson, 1991; Waters & Putz-Anderson, 1997). Work methods and job demands are directly related to the physical hazards workers encounter on a daily basis. These physical hazards include non-neutral postures, forceful exertions, whole body and hand-arm vibration, mechanical compression, repetition and the frequency and duration of work tasks. Nursing tasks, especially patient-handling activities, involve repeated exposures to non-neutral postures and forceful exertions.

Patient handling is essentially a type of material-handling task, and presents the same risk factors seen in typical industrial material-handling tasks. The National Institute for Occupational Safety and Health (NIOSH) Work Practices Guideline (Waters et al., 1993) is an accepted tool for identifying exposure to known risk factors in manual material handling and provides a concrete assessment tool to assist industry in the analysis of lifting tasks and, ultimately, in the prevention of WMSDs. The NIOSH guideline assumes several task conditions: smooth, continuous and unobstructed lifting motion; moderate object dimensions and stable load; favorable climatic environment; and unrestricted standing posture with solid footing.

Unfortunately, the majority of these assumed conditions are not present in patient-handling tasks. Moreover, the NIOSH guideline limits the maximum weight allowed under “ideal” conditions to 23 kilograms, which is well below normal “loads” encountered during patient handling. Patients requiring assistance present with a wide variety of body dimensions, weight and levels of cognitive functioning. Nursing staff may encounter sudden and unpredictable changes in the patient’s weight distribution and potentially combative situations while performing a patient transfer. Although the NIOSH lifting guideline cannot be applied directly to a human "load," the components of the analysis are relevant in the analysis of the patient-handling task.

2.3.2 Health Care Industry Trends

Another factor contributing to nursing injuries are the trends taking place in the health care industry. The United States health care system is the most technologically advanced system in the world. As a result, Americans may hold greater expectations for their health care than the population of any other nation. Patients expect a high quality of care and access to specialized, technologically advanced assessments and treatments. The health care industry has expanded and developed, in part, as a response to these expectations and has become a major force in the U.S. economy. In 1960, health care expenditures accounted for just 5% of the gross domestic product (GDP), but by 2003 this number had increased to 15% (Appleby, 2004). Health care spending increased 9.3% in 2002, the largest increase in 11 years, to a total of $1.55 trillion, representing an average of $5,440 for each person in the United States (Pear, 2004).

As the demographics of the U.S. population change, the demands on the health care system are expected to increase and its role in the nation's economy will grow exponentially. Members of the "baby boomer" generation (i.e., those born from 1945 to 1960) are reaching retirement age and are placing an increasing demand on the health care system. In 2011, 77 million baby boomers will reach 65 years old, and the number of Medicare beneficiaries is expected to reach 69.3 million by 2025. The "elderly" segment of the U.S. population – those over 80 years of age – currently comprise the fastest-growing segment of the population (Agency on Health Care Research and Quality, 2003). At the same time, recent workplace changes, increased employment opportunities for women and rising divorce rates have affected families' ability to care for older relatives in the home. This situation has resulted in an increasing demand for long-term care and assisted living programs.

The health care industry is one of the largest employers in the United States. In 1988, 8.8 million people worked in the health care industry. Hospitals employed 4.2 million workers, while nursing homes and other long-term care facilities employed about 1.4 million workers. According to the Bureau of Labor Statistics, in September 2003, hospitals employed 4.2 million people, an increase of about 1.6% over the previous year (American Hospital Association, 2003). The problem that the health care industry faces is the dramatic increased demand for services at a time of record nursing staff shortages.

2.3.3 Nursing Shortage

One of the biggest challenges facing the health care industry is the shortage of nurses in the United States and around the world. A 20% shortfall of nursing professionals in the United States is projected by the year 2020 (Buerhaus, 2001). It is also estimated that each year, 12% of nursing personnel will consider a job transfer to decrease risk and another 12 to 18% will leave the profession due to chronic back pain (Nelson & Baptiste, 2006). Factors contributing to the current and projected shortage include the increasing number of professional work alternatives without the physical demands of nursing, decreasing enrollment of students in current nursing programs and decreasing retention of the workforce due to injury (AONE, 2002).

2.3.3.1 Staffing Levels and Trends

In a survey conducted by the American Organization of Nurse Executives, nurses reported feeling overworked and unable to provide adequate nursing care (AONE, 2002). Nurses listed inadequate nursing staffing levels as one of the primary reasons for stress and dissatisfaction. Decreased staffing levels lead to a change in work distribution and increased patient-to-nurse ratios. In the early 1990s, nurses testified before Congress regarding their increasing concerns about managed care agencies' attempts to reduce costs by replacing skilled nursing staff with less-skilled and lower-paid workers (Needleman et al., 2002; U.S. Department of Health and Human Services, 2001a)

2.3.3.2 Retention Rates

Decreasing retention rates among nurses continue to be of concern to both health care advocates and industry administrators. More than 40% of the current working registered nurses (RNs) plan to leave their positions within the next 3 years (Steinbrook, 2002). Reasons frequently cited for decreased retention include increased patient to nurse ratios, increased overtime or double shifts and the nurses' frequent exposure to physical stress and subsequent injuries (AONE, 2002). A reduction in the supply of nurses, along with increasing demand, clearly suggests potential future threats to health care access and the quality of care. The nation's nursing workforce is aging, nursing school enrollments have been dropping and nearly 2.7 million RNs are not actively practicing (Buerhaus et al., 2000). If current trends continue, by 2020 the nation will face a shortage of half a million nurses (CBSNEWS, 2002; Lapp, 2004).

2.3.3.3 Increasing Options

Many women born during the "baby boom" graduated from high school and proceeded directly into nursing school. At that time, women faced limited career choices and the nursing profession provided a viable opportunity for employment. Recent technological advances and the successes of the Women's Movement have expanded career choices for women, and the popularity of nursing as a profession has decreased. Women who graduated from high school in the 1980s and 1990s were 35% less likely to enter nursing school than women who graduated in the 1970s (Buerhaus, 2001). The expanded employment opportunities available to women today include positions without the workload challenges and physical stresses faced by nurses on a daily basis. As a result, women are choosing to pursue other professional options.

2.3.3.4 Aging Workforce

The Current Population Survey of the U.S. Bureau of the Census reported that between 1983 and 1998 the average age of working RNs increased from 37.4 to 41.9 years (Buerhaus et al., 2000). During this 15-year span, the percentage of the RN workforce younger than 30 years decreased from 30.3% to 12.1%, and the actual number of working nurses younger than 30 years decreased by 41% (Buerhaus, 2001). The Health Resource and Service Administration found that in 1980, 40.5% of RNs were under the age of 35 compared to 18.3% in 2000 (AONE, 2002). The average age of the RN population was 45.2 in 2000 compared to 44.3 in 1996. In 2006, according to the American Nursing Association, the mean nursing age is 47 years.

A survey of nurse executives projected that the aging RN workforce will result in serious shortages in the next 10 to 15 years (AONE, 2002). Due to the aging nurse workforce, a large percentage of nurses are approaching retirement and there are not enough experienced nurses available to replace these retiring nurses. Unfortunately, demand for nurses is expected to grow dramatically as the general population ages, further complicating a serious staffing gap.

2.3.4 Patient Characteristics Affecting Patient-Handling

Patients' dependency level, cognitive functioning, medical condition, weight and weight distribution define key load characteristics and determine the physical demands and staff injury risk. Nursing staff routinely assess these characteristics during the admission assessment, and can tailor the nursing care provided to meet the patient's needs and the staff's capacities. Based on the information gathered in the nursing intake assessment, health care workers can make informed decisions regarding staffing levels, the use of assistive devices and the overall level of care. Managing physically dependent patients challenges health care professionals who are already busy performing general patient care tasks. The difficulty of the movement task will vary relative to the dependency level of the patient. For example, when assisting a totally dependent patient, staff members may need to reach across the bed to access the person they need to assist and a physical lift is often involved. Movement into a chair involves moving the patient to a different height level, and there is usually some carrying involved. Physical risk factor exposures during these tasks may involve reaching, forceful exertions, assuming non-neutral postures and carrying loads a substantial distance. Higher patient dependency levels may expose the workers to increased injury risks and require workers to make decisions about what type(s) of assistive devices to use.

2.3.5 Critical Interpretation

Nursing injuries result from a complex interaction of factors: the physical work environment, organizational factors, social context and the individual's physical and psychological characteristics (Figure 1). Along with components in this conceptual model, demographic, technologic and economic changes across the U.S. health care industry contribute to the increasing injury trend among nurses.

The single most important demographic trend is the aging of the largest segment of the population. As this large cohort ages, there will be a dramatic increase in health care demands. Currently, this increased demand can be seen with increasing emphasis and treatments addressing common age-related conditions that affect lifestyles (e.g., arthritis, strength, endurance, sexual function). In the next 10 to 20 years, this demand will shift to care for conditions that traditionally require more intensive nursing support. The availability of nurses will become a critical factor in the health care industry's ability to respond to this changing demand. Converging individual, work, organizational, social, demographic, economic and technologic factors will determine the future availability of nursing personnel and, ultimately, the future structure of the health care industry. Preventing nursing injuries will have a long-term impact on the future availability of nursing personnel. The physical work environment plays a major role in nursing injuries and offers one of the most realistic and effective approaches to nursing injury prevention. This research focuses on the physical environment, specifically related to patient transfers. Results of this work will lead to the development of specific injury prevention recommendations and guidelines for equipment, design, layout and lifting procedures.

2.4 Ergonomic Assessment Methods

In order to improve the interface and relationship between workers and their environment, human factors and ergonomics professionals routinely evaluate, redesign and/or seek to optimize work systems. There are a variety of assessment methods to evaluate jobs and tasks that expose workers to ergonomic stresses. Some of the more common methods include: checklists (Hildebrant et al., 2001; Killough & Crumpton, 1996); assessment scales such as the Strain Index, Rapid Upper Limb Assessment (RULA) Tool and Ovako Working Posture Analysis System (McAtamney & Corlett, 1993; Scott & Lambea, 1996); and expert ratings (Keyserling & Wittig, 1988; Latko et al., 1997). Ergonomists use these assessment methods to evaluate the worker's exposure to risk factors such as posture and force. An acceptable score in these assessments does not guarantee that the workplace is free of ergonomic hazards, nor does an unacceptable score assure that a severe problem exists. The final output and measurement methods differ for most of the tools, but scores give the ergonomists and employer an opportunity to detect the presence of work postures or other risk factors requiring further attention.

A number of studies have been conducted to evaluate nursing procedures in patient handling. Nursing consists of complex activities and numerous methods have been presented to evaluate the risk of WMSDs including checklists (Feldstein et al., 1990); surveys (Garg & Owen, 1992; Garg et al., 1992; Owen et al., 2000); task analyses (Nelson, 2002; Owen, 1999); biomechanical modeling (Garg et al., 1991; Nussbaum & Torres, 2001) and expert ratings. Unfortunately, the nursing environment is highly variable, and it is difficult to find an assessment method that captures and identifies all known risk factors. The next sections provide descriptions of some of the most commonly used assessment methods and their applications to patient-handling tasks.

2.4.1 Checklists and Surveys

A variety of checklists and surveys, ranging from simple questionnaires to open-ended questions, have been developed to help ergonomists and employers identify the jobs or tasks that pose higher risks for developing WMSDs. Some checklists serve as screening tools for ascertaining the demands of an individual task or its various elements.

Checklists or surveys have certain distinct advantages: they screen jobs rapidly for harmful exposures to risk factors, are structured to organize the investigator's observations of specific items and can be used as an indicator for further analysis. Disadvantages of checklists include their organization, with items typically grouped into very broad categories; the lack of specificity in the questions; the inclusion of items that might not be applicable in a given situation; the lack of quantitative information; and the limited ability to lead to specific interventions.

Ergonomists use checklists and surveys to obtain information about the various tasks and patient-handling activities that nurses perform during the course of their day. However, with many different factors contributing to repeated risk factor exposures, it is difficult to obtain a precise or detailed understanding of which elements of a task expose the worker to increased risks of injury.

2.4.1.1 Rating Scales

Different checklists and surveys incorporate rating scales to obtain information about workload and perceived exertion, and rating scales vary in their structure and complexity. They can involve such simple tasks as rating perceived grip force on a continuous scale from 0 to 10 (Armstrong et al., 1989) or they can involve the use of a complex, multifaceted scale such as the Strain Index (Moore & Garg, 1995). Psychophysical methods estimate physical exertion/demand based on the participant's subjective perception.

Researchers have used perceived exertion ratings to determine the physical effort required for task completion. Psychophysical methods have been applied in the assessment of NAs' tasks, both to investigate the perceived physical effects of transferring patients and to identify which methods minimize psychophysical stress (Zhuang et al., 2000).

2.4.1.2 Borg Rating of Perceived Exertion

One of the most widely used psychophysical methods is the Borg Rating of Perceived Exertion (RPE) Scale (Borg, 1970). The Borg RPE is a categorical rating scale that conveys the individual's perceived intensity of exertion based on a ratio scale with values ranging from 6 to

20 and descriptive anchors (Borg, 1985). Several studies (Borg, 1977; Borg & Ottoson, 1986; Pandolf et al., 1978) have validated this scale by showing an association between heart rate and perceived exertion. The Borg Scale range of ratings from 6 to 20 was originally intended to designate physical exertion levels corresponding to heart rates ranging from 60 to 200 beats per minute. Each value on the Borg Scale represented .10 of the projected corresponding heart rate value (e.g., a rating of 10 would correspond to a heart rate of 100 beats per minute).

Borg's original scale did not include descriptive anchors attached to the numerical rating scale (Borg, 1982). Descriptive anchors improve the rater's understanding and accuracy of the responses. The modified Borg Scale includes values ranging from 0 to 10 with descriptive anchors equating 0 to "nothing at all" and 10 to "extremely strong." Moreover, since a worker/participant may perceive an intensity or maximal exertion stronger than 10, another category was provided beyond "10." The modified Borg Scale also allows workers or participants to use decimals. The scale can be used for whole-body exertions or can be applied to specific body segments. Several patient-handling studies have used both the Borg RPE Scale and the Borg CR-10 Scale to evaluate the perceived exertion of the nursing workload (Garg et al., 1991; Winkelmolen et al., 1994). Garg et al. (1991) found that nurses identified the lower back as the body part experiencing the greatest exertion during patient-handling tasks. In a subsequent study, Garg and Owen (1992) found the ratings of perceived exertion substantially decreased after the incorporation of assistive devices in the work environment. These studies demonstrate the effect of ergonomic interventions by using rating scales as a quantitative measure.

2.4.1.3 Visual Analogue Scales

Visual Analogue Scales (VAS) are simplified rating scales that have been used to determine levels of discomfort, perceived exertion or pain. These scales normally consist of a 10-centimeter line with two anchors, usually minimal and maximal (Figure 2). Participants specify the level of their perception by marking a place on the scale.

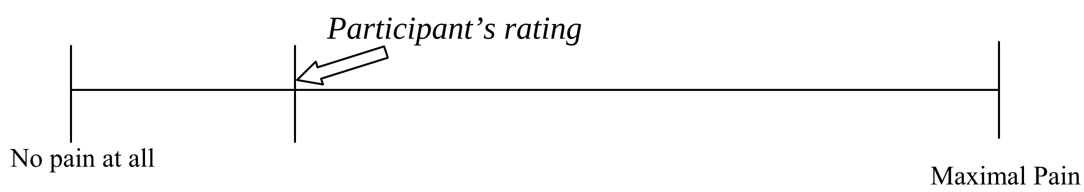


Figure 2: Example of Visual Analogue Scale (Describing Pain)

A VAS can be applied to many different environments and situations. For example, in a study conducted by Latko et al. (1997), experts used a VAS to indicate level of repetitive hand activity (where 0 = hands idle most of the time and 10 = rapid steady motion/exertion). Interestingly, Latko et al. found less than a one-point average difference in the experts' repetition ratings among the sessions.

2.4.2 Task Analysis

Task analysis breaks down a system into detailed components. Information retrieved from using this process includes task requirements, evaluations and decisions that must be made, task times, operator actions and environmental conditions. This method can be used later to estimate the time and effort required to perform tasks; determine staffing, skill and training requirements; determine human-system interface requirements; and provide input to reviews and specifications.

Task analysis methods used in patient-handling research have performed the same primary function: breaking down complex tasks into simpler individual components. While performing these task analyses, researchers can gather a variety of supplemental data, but the interpretation may vary from investigator to investigator.

Garg and Owen (1992) employed task analysis methods to examine work performed by NAs in a long-term care facility. As part of this project, the team of researchers conducted ergonomic evaluations of 10 tasks perceived as most stressful. The researchers observed nurses performing high-risk tasks, and collected information on task frequency, timing, environmental aspects and the frequency of flexion, rotation and lateral bending movements. Characteristics of the NAs and clients were also obtained, and they videotaped the tasks in order to corroborate data gathered by the observers.

In a study conducted by the Patient Safety Center of Inquiry, Veterans Health Administration, Nelson (2002) applied the task analysis method to gather information on task type and frequency, and performed a crude two-dimensional postural analysis from videotaped activities. Postural analysis was performed at 15-second intervals; however, the investigators indicated that the postural analysis was lengthy and time-consuming. Methodological problems were encountered with the videotape analysis, specifically the frequently obstructed view of the nurse performing the activities created by a poor camera angle.

Task analyses possess distinct advantages in that the information retrieved from this method includes an accurate description of elements involved in the movements, frequency of movement, adopted postures, completion time and equipment used during performance of the task. Although videotaping can assist in evaluating items such as posture and force, evaluation of these videotapes can be time and resource intensive.

2.4.3 Expert Ratings

Ergonomists conduct worksite assessments in order to evaluate and rate ergonomic stressors that may lead to fatigue, discomfort and eventual injury. The ergonomics expert must not only identify those jobs, tasks or task elements that can lead to discomfort or injury, but must also determine methods to reduce the workers' exposure to risk factors. Experts employ a number of assessment methods when conducting worksite or task evaluations. Some methods include detailed time motion studies, video task analysis, naturalistic observations and the use of risk factor checklists. Time and resource constraints often limit the experts' thorough job evaluation, thus hampering their ability to provide detailed quantitative measures of the findings. Experts often limit hazard evaluations to on-site observations, information gathered from the workers and personal experience.

Expert observational assessments have been shown to be a relatively efficient and accurate approach to evaluating job hazards. For example, Keyserling and Wittig (1988) used a panel of 5 experts to observe 10 jobs in manufacturing and warehouse facilities. The study was designed to determine the extent of agreement among the experts' ratings in four different areas of ergonomic stress. This particular study used a simple scoring scheme with three categories, which allowed the researchers to compare the expert ratings to a quantitative measure—the NIOSH lift equation. Consistent agreement (i.e., identical ratings for all experts) was found for 30% of the expert rating scores and consensus (i.e., identical ratings by three or more experts) was found for 87.5% of the scores, findings that indicated the experts' ratings generally agreed with NIOSH ratings.

In a second example, Latko et al.(1997) had a group of trained job analysis experts rate 33 jobs individually, followed by a group discussion to reach a consensus on the ratings. Experts rated repetitive hand activity for the overall task using a series of 10-centimeter VAS, with verbal anchors ranging from 0 (“hands idle most of the time”) to 10 (“rapid steady motion / exertion”). An average difference of one-point was found in the participants’ repetition ratings among the sessions. However, compared to the three category rating scheme in the Keyserling and Wittig study (1988), the VAS scoring scheme appears more complicated and thus could introduce more variability into rating scores.

Other studies of expert ratings have examined the accuracy and stability of the ratings. These studies include expert ratings of exposures in the occupational environment (Fritschi et al., 2003), postures associated with task performance (Lowe, 2004a), and work-related musculoskeletal risk factors (Winnemuller et al., 2004). Fritschi (2003) found high accuracy in experts’ ratings of exposure to occupational hazards, with raters demonstrating an average sensitivity of 90% with accurate ratings of hazard concentration and frequency of exposures. However, Lowe (2004a; Lowe, 2004b) found rater accuracy decreased with increased frequency of observation of worker postures. Winnemuller et al. (2004) compared ergonomic risk factor assessments of supervisors and workers to detailed ergonomist job analyses at four work sites in four different industries. Although supervisors and workers appeared to recognize hazards within the occupational environment, they exhibited a tendency to overestimate the presence of risk factors.

2.4.4 Biomechanical Modeling

Biomechanical modeling provides quantitative measures or estimates of physical stresses. Biomechanical models are often used to estimate forces and moments exerted on specific musculoskeletal tissue (Ayoub et al., 1997), and ergonomists and employers can use biomechanical models to evaluate job tasks that may expose workers to WMSD risks. Biomechanical models assist in defining exertion limits so that excessive stress on the different components of the musculoskeletal system can be avoided. These models can also be used to predict the risk of injury during performance of tasks (Chaffin et al., 1997).

Several studies have been conducted using biomechanical models to assess patient-handling practices (Garg & Owen, 1992; Garg et al., 1991; Kumar et al., 2003; Marras et al., 1999; Nussbaum & Torres, 2001; Ulin et al., 1997). These studies used static biomechanical models to measure the physical stresses on the body while workers are performing patient-handling tasks. Garg et al. (1991) not only described the biomechanical stresses on the body during patient handling, but also quantified decreases in biomechanical stresses (spine compressive and shear forces) while using a patient-handling assistive device. Garg et al. (1992) also investigated the effect of the use of lifting devices and room modifications on the biomechanical stresses associated with patient handling. They found decreases in compressive forces from approximately 4,800 N to 2,000 N and decreased strength requirements from 83% to 41% with the patient-handling task modifications.

Kumar et al. (2003) evaluated biomechanical loads for x-ray technologists during patient-handling tasks. The x-ray technologists were videotaped while performing patient-handling movements, and the magnitude of the hand load was measured and recorded. Model input included joint angles, height and weight of the technologist and load on the hands. The compression and shear loads were calculated for 16 commonly performed patient-handling tasks. Tasks such as repositioning of the patient and transferring the patient from a wheelchair to the treatment table exceeded the maximum permissible limit for the spine compressive loads set by NIOSH.

The effect of different patient transfer techniques and mechanical devices was examined in a study conducted by Ulin et al. (1997). Six different patient transfer techniques were performed by two nurses on totally dependent patients, and each transfer was videotaped to record the postures of the nurses during the transfer. A biomechanical model was used to compute the peak compressive force on L5/S1 as well as the percentage of the population with sufficient strength capability to perform the patient transfers. Peak compression forces of approximately 9,000 to 13,000 N were estimated while transferring patients using the manual transfer methods, though these forces decreased substantially (to 1,700 N) when assistive devices were used.

Daynard (2001) used a quasi-dynamic biomechanical model to assess peak and cumulative compressive and shear loads at L4/L5 during a series of patient-handling tasks. This study found that, although worker compliance increased with use of assistive devices and overall compressive and shear forces were decreased, patient-handling tasks performed with the use of these devices took longer to complete and, in some cases, led to an actual increase in cumulative spinal loading. The increase in spinal loading was attributed to the variations in transfer techniques and the increased exposure time to non-neutral postures and spinal loading.

In the study conducted by Zhuang et al. (1999), a four camera motion analysis system and two force platforms were used in combination with a static biomechanical model. The objective of this study was to evaluate the effect of patient weight, patient transfer technique and use of an assistive device on the biomechanical stresses among NAs. Use of assistive devices reduced the back compressive forces during the preparation phase of the patient-handling task and use of specific devices further decreased the frequency and magnitude of lifting stress exposure.

Biomechanical studies of patient handling have used several different models to measure stresses affecting different body parts such as the low back. These studies have evaluated the effects of using different methods of moving patients, the effects of assistive devices and the effects of different patient characteristics on the biomechanical stresses from patient handling. Static models, although easier to use, do not consider the effect of movement on the internal loads. Work by Marras and Sommerich (1991) and Granata and Marras (1995), for example, has indicated that static models may underestimate compressive loads by 45% and shear loads by 70% due to task dynamics, multiple muscle activity and the coactivity of the muscle system.

2.4.5 Assessment Applications

Assessments of nursing care tasks and patient-handling activities have employed a variety of analysis tools. Garg and Owen (1992) conducted a study in a long-term care facility where they identified the top 16 tasks on the basis of perceived physical demands. Nursing Aides were observed using a work sampling method during 79 four-hour work shifts at different time intervals, along with 14 four-hour periods of videotaping. These methods were used to describe a typical nurse's workday and to determine the number of patient-handling tasks conducted per shift, use (or lack of use) of assistive devices and the biomechanical stresses to the low back. From the observations, a list of 16 patient-handling tasks was compiled. Nurses were asked to rank these 16 tasks according to perceived exertion. This list was used in a follow-up study (Garg & Owen, 1992) where assistive devices and modification of the work space (i.e., toilet and shower areas) were used as interventions. This study demonstrated a decrease in low-back injuries (post-intervention). By identifying the perceived physically demanding tasks, decisions can be made about specific interventions that may decrease the worker's exposure to ergonomic risk factors.

A pilot study at Walter Reed Army Medical Center, conducted by the U.S. Army Center for Health Promotion and Preventive Medicine Ergonomics Program (McCoskey, 2007), employed a combination of perceived exertion ratings, task frequency and duration observations, and self-report of physical symptoms. The study was designed to describe the type, frequency and physical demands of the patient-handling tasks in an acute care facility. The researchers found that over 50% of all lateral transfers, including repositioning-in-bed and bed-to-stretcher, required moderate or greater physical exertion. Further, 20% of all other transfer types combined required moderate or greater physical exertion (McCoskey, 2007). These findings were consistent with the results of a study by Owen et al. (2002), who found that nurses experience the greatest amount of physical stress when lifting patients up in bed and transferring patients from bed to stretcher.

2.4.6 Critical Interpretation

Many different assessment methods, ranging from simple measures to complex analytical techniques, are available to ergonomists to evaluate a worker's exposure to job-related hazards. However, each method of assessment relies on a different method of scoring. Even when raters evaluate the same task, the assessment methods involving more complex rating schemes result in higher variability among the ratings. In addition, experts often vary in the manner in which they assess jobs even though their training is essentially equivalent. Expert ratings are often only the first step in recognizing and reducing ergonomic stressors. Follow-up analyses are necessary to classify and quantify specific causes of stresses receiving "moderate" or "high" hazard level ratings.

Due to the multiple factors contributing to WMSDs, it is difficult to identify a single "optimal" tool to assess a worker's exposure to ergonomic risk factors in the workplace. Ideally, a gold standard assessment would validly quantify the magnitude of the exposure(s). This gold standard tool should also provide output that correlates with actual injuries, physical symptoms or discomfort rating by body part and worker perception of exposure. The proposed research is not a long-term epidemiological study and, therefore, it is beyond the scope to validate exposure magnitude and predict injury. However, one explicit aim is to indirectly validate these outcome measures by agreement with other methods such as perceived exertion, biomechanical output and discomfort ratings.

A number of studies have used a variety of assessment tools to evaluate the risks associated with patient-handling tasks. Much of the data has been collected in long-term care facilities as the patient population and patient handling demands are relatively stable; however, some preliminary research has focused on acute care facilities. Thus, it is important to understand the tasks nurses are performing in acute care facilities and whether physical demands may differ from long-term care facilities.

2.5 Interventions in Patient Handling

Due to the magnitude of the risks associated with patient-handling activities and increasing injury rates, health care organizations have instituted a variety of workplace interventions to address the problem of WMSDs. Engineering controls are the preferred method to control and prevent WMSDs (NIOSH, 1997). Examples of engineering controls include design of the workstation layout, selection of tools and placement of barriers between worker and risk exposure. Administrative controls are management-directed work practices and policies to reduce or prevent exposures to ergonomic risk factors. Examples of administrative controls include personnel selection and training. Patient-handling intervention strategies include both engineering and administrative controls. Specifically, health care facilities have implemented assistive lifting devices (engineering control), training in proper body mechanics and proper lifting techniques (administrative controls) and the introduction of lift teams (Charney, 1997).

As an example, the Veterans Administration Patient Safety Center of Inquiry developed a multi-faceted intervention program consisting of an Ergonomic Assessment Protocol, Patient Assessment Criteria, Movement Algorithms, Back Injury Resource Nurses, Equipment Selection and the implementation of a No-Lift Policy. Results from this project included a 31% decrease in injuries, an 88% decrease in modified workdays and an overall savings after one year of over $120,000 (Nelson et al., 2003).

The use of engineering controls such as patient lifting devices have resulted in some decrease in injuries, lost work time and related costs (Evanoff et al., 2003; Fragala, 1996; Villeneuve, 1998). Research has been conducted primarily on high-cost devices such as ceiling and stand assist lifts, but these devices may be cost-prohibitive for some facilities. Therefore, more work is needed to evaluate low-cost manual devices and their effect on patient-handling tasks.

2.5.1 Assistive Devices

Traditional engineering controls such as automation or barriers cannot be applied to patient-handling tasks. One feasible engineering control involves the use of patient-handling devices to decrease the physical demands placed on nurses during transferring and movement tasks. Current technology has increased the availability and types of different devices for patient-handling tasks including overhead ceiling lifts (portable and fixed), stand assists, lateral transfer devices, friction reducing devices and gait belts. The Veterans Administration Patient Safety Center of Inquiry categorized these devices by type of transfer (Table 1).

Table 1: Equipment Categories for Safe Patient Handling and Movement*

Device	Approximate Cost	Use
Sliding Boards	Basic Board: $50 "Beasy Board" with Sliding Disc: $300 (Sammons Preston)	• Seated bed to chair or toilet transfer • Serves as supporting bridge during seated transfers
Air-Assisted Lateral Sliding Aids	$4500 (Hovermatt)	• Lateral transfers involving patients with special medical conditions • Portable air supply inflates the mattress • Air flows through perforations in the mattress; the patient is moved on a cushioned film of air allowing staff members to perform the task with much less effort
Friction-Reducing Lateral Sliding Aids	Lateral Transfer Aid: $580 Slide-Matt: $400 (Phil-E-Slid)	• Bed-to-stretcher type transfers • Positioned beneath the patient and provides a surface for the patient to be slid over more easily due to the friction reducing properties
Mechanical Lateral Transfer Aids	Independent of Bed: $9000 (Hill Rom On3)	• Mechanizes the lateral transfer • Eliminates the need to manually slide the patient, minimizing the risk to the caregiver
Transfer chairs	$1500-4000 (Hill Rom)	• Chairs that convert into stretchers where the back of the chair pulls down and the leg supports come up to form a flat stretcher • Facilitates lateral transfer of the patient and eliminates the need to perform lift transfers in and out of the wheelchair
Gait Belts with Handles	$20 (Alimed/Sammons Preston)	• Thick belt with handles • Used to assist or transfer a partially dependent patient • Improves the grasp ability for the health care provider; gait/transfer belts are installed on patients, usually around the area of the waist providing handles for a worker to grasp
Powered Full Body Sling Lifts	Floor Based: $3000 Ceiling Based: $3000 H-track: $6000 (Barrier Free/Arjo)	• Most common lifting device • Moves patients in/out of beds, in/out of chairs, toileting tasks, bathing tasks and any type of lift transfer
Powered Standing Assist and Repositioning Lifts	Stand Assist: $3900-5600 (Barrier Free/Arjo)	• Used where patients are partially dependent and have some weight bearing capabilities. • Moves patients in/out of chairs and for toileting tasks • Easily maneuvered in restricted areas, such as small bathrooms
Standing Assist and Repositioning Aids	Bed Rail Assist: $240 Trapeze Bar: $130 Transfer Pole: $110 (Sammons Preston)	• Provides assistance to a patient when moving from a seated to standing position • May be freestanding or attached to beds

*Source: VA Patient Safety Center of Inquiry, 2001.

Villeneuve (1998) conducted an analysis of the outcomes associated with patient-handling assistive devices in a large field study. The study compared a traditional free-standing mobile patient lift with an overhead ceiling lift. Five health care facilities participated in the study: four long-term care facilities and one rehabilitation center for people with multiple disabilities. Outcome measures included the level of satisfaction of direct users (nursing staff and patients) and management, the impact on the staff posture, effort and operation time, and employee accidents. The study included multiple data collection methods: questionnaires; interviews with nursing staff, patients and managers; and observations and videotape recordings of the tasks. Nursing staff, patients and management preferred the ceiling lift due to the stability of the device, ease of use, patient stated comfort and safety, availability of the device and elimination of the physical effort. An overall reduction in the number of employment accidents was found (24 to 0 in one institution in 8 years and 21 to 5 over 4 years in another institution), and a savings of over $600,000 in workers' compensation costs.

Garg et al. (1992) conducted a prospective study in two units of a long-term care facility. The total program consisted of determining patient-handling tasks perceived to be stressful by nursing staff, and conducting a laboratory study using select assistive devices. The intervention included training nursing staff in the use of lifting devices, modifying room configurations and application of the training techniques. Overall results were that spine compressive forces decreased from 4,700 to 2,000 N and required hand peak forces decreased from 300 to 120 N.

In another example, Fragala and Santamaria (1997) identified the characteristics from the patient population on two different high-risk units in an acute care hospital. From this information, two different devices—a stand assist and an overhead lift—were selected to move patients. A training program was also implemented for management staff and direct patient care staff. After 6 months of data collection, the number of lost workdays decreased from 69 to 0 and restricted workdays decreased from 122 to 2. Improvements were seen in occupational injuries in the orthopedic unit (83%) and medical/surgical unit (75%).

A biomechanical evaluation was performed on the manual lift followed by use of the devices. Garg et al. (1991) demonstrated decreases in compressive and shear forces when using assistive devices. During performance of the lift, trunk flexion angles remained unchanged with both the manual lift and use of the device; however, spine compressive forces decreased from 4,300 to 1,900 N and shear forces decreased from 700 to 400 N.

Evanoff et al. (2003) implemented mechanical lifts in 31 intervention units in 4 acute care hospitals and 5 long-term care facilities. Devices included 25 full-body lifts and 22 stand-up assist lifts. All members of the nursing staff were required to attend an instructional course prior to full implementation of the devices. Frequency of use (of devices) was monitored intermittently by a researcher. Short interviews were conducted, and questions included the number of times the worker used the equipment for transfer activities, the number of times the worker observed other nurses using the devices and why they did not use the lifts more often. Reductions in injuries and lost workdays were demonstrated in both types of facilities; however, greater reductions were seen in the long-term care facility. This may have been due to several factors: a policy of mandatory lift usage, management support, and care activities and patient characteristics are more stable in long-term care facilities, which may make it easier to prepare and plan the movements.

Different reports (Bell, 1987; Bell et al., 1979; Nelson et al., 1997; Owen, 1988; Pheasant, 1993) agree that lifting devices assist nurses in decreasing the physical demands of their job and the biomechanical results support this conclusion. Although patient-handling devices decrease stress on the back, the previously summarized studies strongly support that devices alone are not the solution. To be more efficient, patient-handling devices should be part of a multi-faceted program (Fragala & Santamaria, 1997; Nelson, 2002; Owen, 2000).

2.5.2 Training

Training is commonly used as an administrative solution intended to minimize worker exposure to occupational hazards by increasing awareness and skill levels. Patient-handling training is frequently employed in response to patient-handling concerns. Many facilities and educational programs use body mechanics and training in proper lifting techniques to prevent job-related injuries; however, the results remain debatable. Some studies suggest that training can have an effect on workers' lifting behaviors (Nussbaum & Torres, 2001), while others show controversial results (Fragala, 1993; Nelson et al., 1997). Although some studies show clear reductions in injury rates following training (Troup & Rauhala, 1987; Videman et al., 1989; Wood, 1987), other studies show that these efforts have failed to reduce job-related injuries in patient-handling tasks (Harber et al., 1985; Hayne, 1994; Owen & Garg, 1991; Snook et al., 1978; Stubbs et al., 1983; Venning et al., 1987)

New staff and the implementation of new programs require training. However, a number of investigators (Dehlin et al., 1976; Owen & Garg, 1991; Stubbs et al., 1983; Venning, 1988; Wood, 1987) emphasize that training should not be the sole solution, but should be included as part of a comprehensive program that addresses ergonomic concerns. Traditional material-handling training based on body mechanics and load positioning cannot be applied to the nursing profession and patient handling. Experts do not agree on which lifting techniques are optimal for nursing tasks (Owen & Garg, 1991; Venning, 1988).

2.5.3 Team Lifting

Most team lifting studies assess lifting performance by quantifying psychophysical variables. This approach uses self-based estimates of maximum lifting capacity, which in turn are intended to reflect the ability of one person or team to safely lift a load. Most psychophysical team lifting studies (Karwowski, 1988; Karwowski & Pongpatanasuegsa, 1988; Rice et al., 1995) have found that the lifting capacity of the team is less than the combined total lifting capacity of individual members.

Contrasting results have been found by Johnson and Lewis (1989) and Mital and Motorwala (1995). They indicated that a two-person team has a greater lifting capacity than the combined sum of the individual lifting capacities of the team members. A subsequent study by Rice et al. (1995) found that the lifting capacity of a team is limited by the weaker members of the team. This was further supported by Sharp et al. (1997), who found that the lifting capacity for a team of mixed gender was significantly less than for single gender teams.

Psychophysical assessment criteria were also used by Lee and Lee (2001) to compare the lifting capacity of two-person teams performing lifting tasks with team members of matched and unmatched standing height. Although the standing height difference among team members of unmatched height teams was only 4 centimeters, Lee and Lee (2001) reported substantial increases in the maximum acceptable weight lifted by height matched teams compared to unmatched height teams. These findings were supported by Dennis and Barrett (2003) who compared spinal loads during two-person lift activities performed with team members of matched versus unmatched standing height. Dennis and Barrett (2003) concluded that matching the standing height of lifting team members may reduce the cumulative effects of spinal loading for taller lift team members.

Charney conducted extensive research on hospital lift teams. In one study (Charney, 1997), 10 facilities employed trained lift teams, resulting in reductions in injuries (70%), lost days (90%) and incidence rates (63%). Lift teams have also led to a reduction in associated injury-related costs and increased patient satisfaction (Charney, 1993). As a result, several institutions have created special lift teams dedicated to performing the majority of lifting tasks and patient transfers. In these facilities, lift teams coordinate with the nursing staff and other medical personnel and determine which lifting devices to use when moving the patient. The team is responsible for all scheduled and unscheduled patient transfers. The team lifting approach is effective because it reduces injury risk by relying on a single group of trained employees; however, this approach transfers all of the injury risk to the lift team and can potentially result in more severe injuries among lift team members.

2.5.4 United States Legislation

Despite evidence that the use of patient-handling equipment reduces injury and discomfort to health care workers, the United States has not kept pace with other countries in the use of modern technology for prevention of back injuries related to manual patient lifting. With the passage of Senate Bill 1525 (June, 2005), Texas led the nation in addressing the issue of back injury from manual patient-handling with the first safe patient-handling legislation in the United States. This bill is noted for including both hospitals and nursing homes, encompassing facilities employing the majority of nurses, NAs and other healthcare workers.

The state of Washington passed House Bill 1672 in March, 2006. This bill mandated that hospitals provide mechanical lifting equipment and provide staff-development training sessions regarding appropriate lifting techniques. Other states are following with similar legislation. California introduced a bill that addressed lift teams. Although this passed the state House and

Senate, the bill was vetoed by the Governor. California has recently re-introduced safe patient-handling legislation. The Governor of Ohio signed a law creating a program that provided interest free loans to long-term care facilities that implemented a no-manual lift program. Other states such as Massachusetts and New York have also introduced legislation, but these are still pending.

2.5.5 Critical Interpretation

Patient handling is a complex activity with recognized injury risks. Numerous administrative and engineering patient-handling interventions have been recommended, yet nursing staff injuries persist. Despite increased evidence and the growing number of states who have adopted legislation to address patient-handling issues, health care facilities have responded slowly. Facilities are concerned with the costs associated with implementing assistive devices, potential modification and restructuring of the facility and the implementation of training activities or programs. At the high-cost end, powered lifting devices range from $3,000 to $10,000. The initial monetary investment for such devices leads some health care administrators to decide against these interventions. It is important to identify low-cost interventions or devices that effectively reduce the workers' exposures to risk factors during patient-handling tasks without costly facility modifications or restructuring.

2.6 Summary

2.6.1 Gaps in the Research

Patient-handling activities are associated with increased injury rates among nursing staff. Nurses are among the workers most at-risk for developing WMSDs (U.S. Department of Health and Human Services, 2001a). The major gaps in patient-handling research are in the identification of physically demanding tasks in acute care facilities, evaluation of the effects of low-cost manual devices on the performance of patient-handling tasks and validation of expert ratings of patient-handling tasks.

Much of the existing research in patient handling has been performed in identified high-risk units, such as spinal cord injury and long-term care facilities. The patient population and patient-handling demands are relatively stable in these facilities; however, very little research has focused on acute care facilities. Acute care nursing tasks are similar to those in long-term care facilities, and the same patient-handling risk factors are likely to be present. Specialty units in acute care facilities such as cardiac care, medical/surgical and pediatric care present unique patient care requirements and may pose a higher injury risk to nurses.

Research on the effectiveness of low-cost manual assistive devices is limited. Assistive devices broadly range from $700 to $10,000, and acute care facilities may find the capital investment for the equipment and facility modifications cost prohibitive. Investigations of the effectiveness of low-cost interventions in reducing the workers' exposures to risk factors during patient-handling tasks will assist in resolving health care administrators' fiscal reluctance.

Ergonomists use a variety of assessment methods to evaluate potentially high-risk jobs and tasks. Various studies have been conducted that employ expert evaluations as a technique to quantify the magnitude of the exposure(s). Unfortunately, since multiple factors contribute to WMSDs, researchers have found it difficult to identify a single "optimal" tool to assess a worker's exposure to ergonomic risk factors. Currently, there are no validated tools that provide quantitative injury risk estimates in the context of nursing tasks. This research proposes evaluating the level of agreement on risk exposure assessment among experts, and the association between expert evaluations, nurses' ratings and biomechanical analyses.

2.6.2 Goals and Objectives

Data released by the Bureau of Labor Statistics for 1999 indicated that 271,000 occupational injuries were documented for hospital workers and, of that number, 188,600 occupational injuries were recorded by workers in nursing and personal care facilities. Further, nurses experience the third highest injury rate of all private sector industries (U.S. Department of Labor, 2002). The aim of this research was to contribute to the field with regard to injury prevention. To that end, physically demanding patient-handling tasks performed in acute care hospitals were identified, and the effects of different levels of assistance and use of equipment were determined.

The research involved three different studies. The first study consisted of two sequential phases: a procedural task analysis and questionnaire. The procedural task analysis was conducted on inpatient units in an acute care hospital in Southwest Virginia. Nurses were observed while performing patient-handling tasks and elements of their movement and task completion times were recorded. A list of patient-handling tasks was compiled based on these observations, and was used during the questionnaire phase of this study. The goal of the first study was to identify and rank physically demanding patient-handling tasks acute care facility nurses perform during the course of their day.

A laboratory task simulation of the top four physically demanding patient-handling tasks identified in study one was conducted in the second study. This simulation assessed the effects of an assistive device and another person on outcome measures such as performance and risk factor exposure. Patient-handling tasks were categorized by the type of lift and the appropriate patient-handling device used for that transfer. Participants performed each transfer with and without an assistive device and with and without another person. The patient-handling task was divided into three main task elements: the preparation of task, the actual movement and the completion of task. Subjective measures, including perceived exertion and perceived injury risk, were obtained from the participants upon completion of each task element. Specific aims of this study were to identify the most physically demanding element(s) of the patient-handling task, describe the effect of low-cost manual devices on the patient-handling task, and describe the effect of the addition of another staff member on several outcome measures including performance, risk factor exposure and perceived exertion.

The third study employed three groups of ergonomists with different levels of expertise: university professors, consultants and graduate students. These groups analyzed videotape segments taken during the second study and rated the magnitude of the observed risk factors. Objectives of this experiment were to assess the level of inter-rater agreement among ergonomists with different levels of expertise and evaluate the association between the expert ratings and the nurses' subjective ratings.

Health care employers must find interventions that maximize their limited financial resources while simultaneously providing efficient and safe patient care. Although this research focuses primarily on nurses, the findings that will arise from it can be generalized to other health care providers involved in patient-handling tasks such as radiology technicians, operating room personnel, occupational therapists and physical therapists.

3.0 Identification of Physically Demanding Patient-Handling Tasks in an Acute Care Hospital: Task Analysis and Questionnaire Results

Abstract

Background: Work-related musculoskeletal disorders are prevalent among healthcare workers worldwide and injury underreporting among nurses may mask the true impact of injuries. Patient-handling tasks are the precipitating event in the majority of back injuries among nursing staff. Existing research has focused on patient-handling issues within long-term care facilities and has further identified physically demanding patient-handling tasks within long-term care. It is not known whether nurses in acute care facilities are exposed to the same hazards as their cohorts in long-term care.

Methods: This two-phase study was designed to identify, describe and rank the physically demanding patient-handling tasks in an acute care facility. Phase one consisted of an exploratory on-site task analysis of patient-handling activities, whereas phase two used a questionnaire to identify the characteristics of the study population and to obtain a ranking of physically demanding patient-handling tasks.

Results: Two major findings were obtained. First, the top 10 most frequent patient-handling tasks were identified in an acute care facility. Second, transfers performed in acute care facilities differ from those in long-term care facilities. This difference is likely due to a different focus on patient care. Long-term care facilities are primarily focused on custodial care, and have a defined population with similar dependency levels. Because patients are fairly stable and the dependencies are fairly similar, it is easier to plan daily movements and tasks, and also easier to plan and implement interventions. In contrast, acute care involves a variety of patients, changing dependency levels, differing equipment needs and diverse settings in which the patients are being transferred.

Conclusions: Differences in the types of transfers being performed across types of healthcare facilities, as well as across units within acute care facilities, highlight the importance of determining the patient-handling demands and needs that are unique to each type of healthcare facility. Generalizing across facilities or units may lead to incorrect assumptions and conclusions about physical demands being placed on nurses.

3.1 Introduction

Work-related musculoskeletal disorders (WMSDs) remain prevalent in healthcare workers (Bureau of Labor Statistics, 2006). Nursing Aides (NAs) and Licensed Practical Nurses/Licensed Vocational Nurses (LPNs/LVNs) have the highest risk of developing a WMSD when compared to other U.S. workers who required time off from work (U.S. Department of Health and Human Services, 2001b). The Bureau of Labor Statistics (2002) identified NAs as the highest ranked occupation at risk for developing WMSDs. Additionally, nurses have one of the highest workers' compensation claim rates for back-related injuries of any occupation (U.S. Department of Health and Human Services, 2001b).

Injury underreporting among nurses may mask the true impact of nursing injuries, especially back injuries. Among nurses who have experienced some form of back pain, 92% stated they have never reported this to their employers (French et al., 1997). Nursing organizations, such as the London Royal College of Nursing' Work-Injured Nurses Group, have suggested that many nurses do not report back injuries because they feel "if they start complaining or reporting accidents they will be letting their patients down" (Bulaitis, 1992). Nurses also believe that back pain is an inevitable part of their work, resulting in even greater underreporting (Malone, 2000).

Patient-handling tasks are the precipitating event in the majority of back injuries among nursing staff (Goldman et al., 2000). These tasks include but are not limited to transferring patients out of bed, repositioning patients in bed and lateral transfers from bed to gurney. Nurses perform these tasks frequently, often dealing with other task factors such as the limited space in the patient's room that forces nursing staff to adopt and maintain non-neutral postures and lift heavy loads repeatedly throughout the day.

A majority of studies on patient handling have been conducted in long-term care facilities. Patients in these types of facilities possess increased dependence levels, and require more assistance from nursing staff for mobilization and performance of activities of daily living (McAtamney & Corlett, 1993; Stubbs et al., 1983). Physically demanding tasks have been identified in long-term facilities in order to understand which tasks expose nurses to ergonomic stresses (Garg et al., 1992; Nelson et al., 2003; Owen & Garg, 1991).

The primary focus in an acute care hospital is to stabilize the patient, treat the illness or condition and discharge the patient home or to another type of facility such as long-term care. During a patient's stay in an acute care hospital, various medical procedures are performed and the patient's condition may be the limiting factor in their mobilization activities. Unlike a long-term care facility, where the population is relatively stable and workers can plan movements, the population in an acute care hospital may be unpredictable. Therefore, it is important to identify patient-handling tasks taking place in acute care and, subsequently, recommend interventions that decrease the workers' exposure to ergonomic risk factors.

In order to improve the interface and relationship between workers and their environment, different methods have been used to evaluate workers' exposure to ergonomic risk factors. Some common assessment methods include work sampling, surveys and questionnaires, risk and exposure assessment tools and expert ratings. Work sampling is a measurement technique used to quantitatively analyze non repetitive or intermittently occurring activity (Niebel & Freivalds, 1999). This technique is based on the theory that the percentage of observations on a particular activity is a reliable measure of the percentage of total actual time spent on that activity. When properly used, work sampling can help determine areas that should be analyzed in further detail (Niebel & Freivalds, 1999).

Surveys are another common approach to identify jobs or tasks that pose higher risks for developing WMSDs. Some surveys serve as screening tools for ascertaining the demands of an individual task or its various elements and range from simple questionnaires to open-ended questions. In the nursing domain, ergonomists have used surveys to obtain information on the different tasks and transfers that workers perform during a typical workday. The current study used both work sampling and survey methods to describe conditions within an acute care facility, to gather demographic information about the nursing population, and to determine which tasks nurses perceive to be physically demanding in an acute care setting.

3.2 Methods and Materials

3.2.1 Overview

This study was designed to identify, describe and rank the physically demanding patient-handling tasks performed by nursing staff in an acute care facility, and consisted of two phases: (I) an exploratory on-site procedural task analysis of patient-handling activities, and (II) a questionnaire to identify the characteristics of the study population and allow nurses to rank physically demanding patient-handling tasks. A procedural task analysis breaks down the steps that the workers must perform so that the task can be successfully achieved. This type of task analysis is developed sequentially with a start and an end (Kirwan & Ainsworth, 1992). The task analysis was conducted on inpatient units in an acute care hospital wherein nurse participants were observed performing patient-handling tasks. A list of patient-handling tasks, rank ordered by frequency, were compiled from the on-site observations and served as the basis for the questionnaire of nursing staff in Phase II. Several aspects of the tasks were captured, including patient dependency and cooperation level, number of nurses involved, etc.

The questionnaire phase provided information on the demographics of the nursing population, body part discomfort levels and a ranking of the 10 most physically demanding patient-handling tasks from Phase I. In addition, there was interest in whether differences existed in self-reported symptoms and nurse demographics. All nurses working on inpatient units who routinely perform patient-handling tasks were recruited to participate. The rank-ordered list was used to identify the patient-handling tasks for later lab-based task simulation (Chapter 4) as well as a study on expert ratings (Chapter 5).

3.2.2 Goals

The primary goal of the Phase I exploratory study was to identify patient-handling tasks that nurses perform during the course of their workday. The secondary goal was to describe several aspects of the patient-handling tasks, which included patient dependency level, cooperation level, number of nurses assisting in the movement, completion time, use of assistive devices and methods used to achieve preparation, movement and completion of the task. The third goal was to compare the task aspects of the most frequently occurring tasks and determine if there were significant differences between tasks.

The primary goal of Phase II was to identify the most physically demanding tasks based on nurses' perception. Tasks were based on the top 10 list identified in Phase I. The secondary goal was to evaluate the association between self-reported symptoms and demographic characteristics.

3.2.3 Facility

Both phases of the study were conducted at a non-federal, Joint Commission on Accreditation of Healthcare Organizations accredited, acute care community hospital that is representative of hospitals located in Southwest Virginia. This facility has a capacity of 565 beds and as of June 2005 employed 4,083 personnel, including 1,016 full-time Registered Nurses (RNs) and 139 full-time LPNs/LVNs. Services provided to the community by this facility include a 24-hour emergency department, rehabilitation, imaging, behavioral health, ambulatory care, home health care and inpatient units (to include cardiac care, medical/surgical services, pediatrics, cardiac care, oncology, neurology, obstetrics and orthopedics). During the past several years, the census appears to have remained stable (Figure 3).

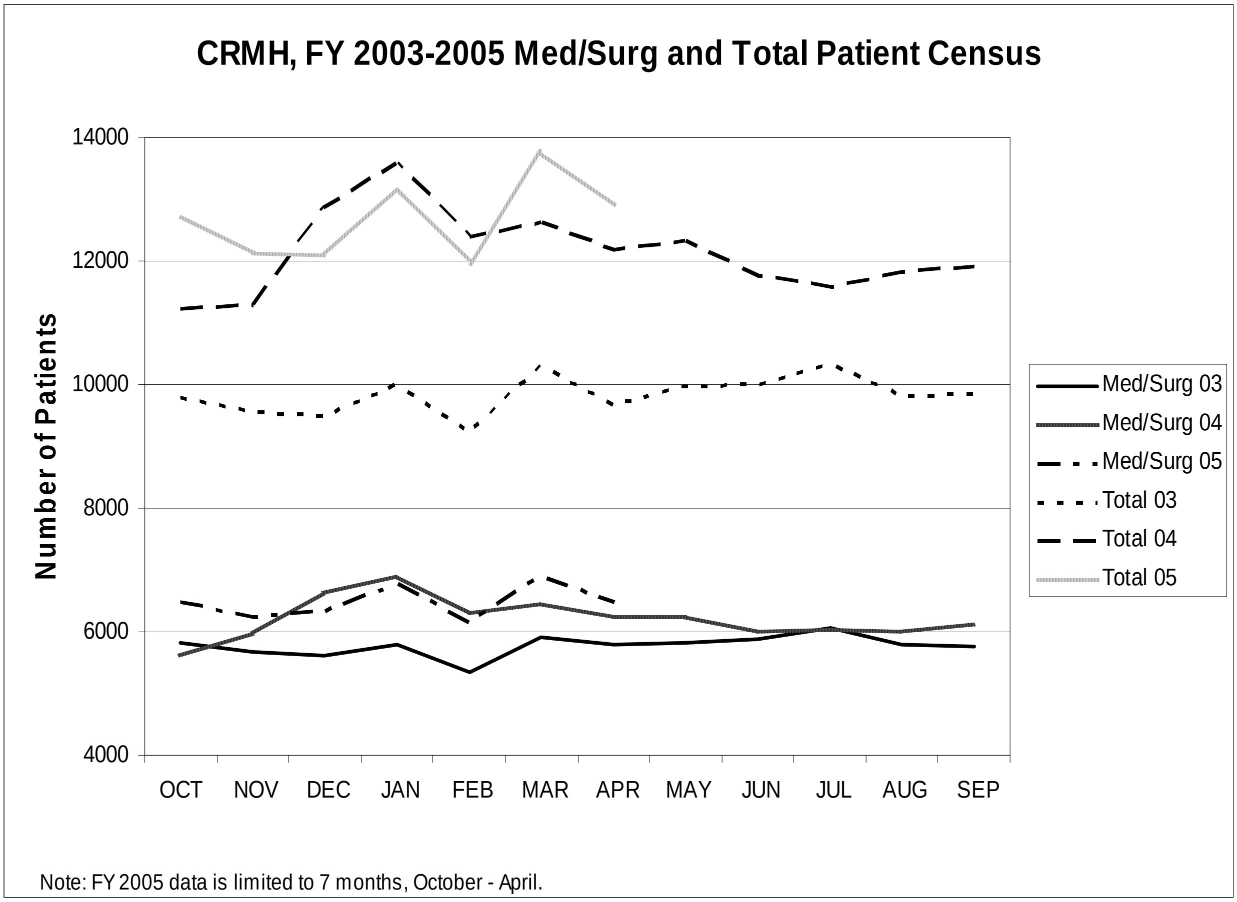


Figure 3: Hospital Census, FY 2003-2005

Observations were conducted on two intensive care units (ICUs), two progressive care units (PCUs) and two medical/surgical units. ICUs are primarily responsible for providing life support services to patients are who critically ill. Patients admitted to the ICU not requiring life support services are usually admitted for intensive monitoring, such as the crucial hours after major surgery when they are deemed to be unstable for transfer to a less intensively monitored unit. A PCU is one where the patient does not require intensive monitoring, but is still determined to be unstable for a general medical/surgical unit. According to the nursing administration in this facility, the patient-to-nurse ratio in the ICU is one-to-one. On a PCU, the ratio is two-to-one and on a general medical/surgical unit, the ratio is five-to-eight patients to one nurse.

3.2.4 Participants

All RNs, LPNs/LVNs and Nursing Aides (NAs) providing direct inpatient care were recruited to participate in both phases of this study. Participants included both male and female nursing staff. Nurses not involved in patient-handling activities were excluded from this study.

3.2.5 Procedures

3.2.5.1 Phase I: Procedural Task Analysis

Seven university undergraduate students formed teams to assist with data collection. Team members received verbal and written instruction regarding the experiment, were informed about data collection (Appendix A) and documentation procedures and practiced and received feedback on the data collection methods in a laboratory setting. Two three-person observation teams were formed, since existing evidence suggests that three people are sufficient to observe patient-handling activities on a nursing unit (McCoskey, 2007; Nelson, 2002). Observations were conducted Monday through Friday, and each unit was observed on two separate days for three two-hour intervals per day. A random number generator provided the start and stops times (e.g., 3:00 to 5:00 p.m.) for the observations and ensured that a representative work sample was collected. Data from a pilot study conducted by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) showed that patient-handling movements are primarily performed during the morning and evening shifts (McCoskey, 2007; Nelson, 2002). All units were scheduled randomly for observations and each unit was observed for two non-repeating days (Table 2).

Table 2: Schedule for Unit Observations

Day of the Week	Team	Unit	Description
(1) Monday	Team 1	5 West	Medical/Surgical Unit
(1) Monday	Team 2	10 Mountain ICU	Medical/Surgical Intensive Care Unit
(2) Tuesday	Team 1	9 Mountain ICU	Neuro Trauma Intensive Care Unit
(2) Tuesday	Team 2	10 Mountain PCU	Medical/Surgical Progressive Care Unit
(3) Wednesday	Team 1	9 Mountain ICU	Neuro Trauma Intensive Care Unit
(3) Wednesday	Team 2	9 West	Medical/Surgical Unit (Orthopedic)
(4) Thursday	Team 1	9 Mountain PCU	Neuro Trauma Progressive Care Unit
(4) Thursday	Team 2	10 Mountain ICU	Medical/Surgical Intensive Care Unit
(5) Friday	Team 1	9 West	Medical/Surgical Unit (Orthopedic)
(5) Friday	Team 2	5 West	Medical/Surgical Unit
(6) Monday	Team 1	9 Mountain PCU	Neuro Trauma Progressive Care Unit
(6) Monday	Team 2	10 Mountain PCU	Medical/Surgical Progressive Care Unit

Potential nurse participants on the assigned units received verbal and written information concerning the purpose, methods and intent of the experimental procedures using a standardized set of instructions. All who agreed to continue completed an informed consent process approved by the Virginia Polytechnic Institute and State University Institutional Review Board (IRB).

Following completion of the informed consent, participants were introduced to their observers and provided with the information the observers would record. Data collection teams were assigned to a specific unit for a day and conducted observations during three randomly defined two-hour blocks of time. Nursing staff informed the observation team when a patient transfer or movement was conducted and provided information such as patient dependency and cooperation levels. One member of the team observed the transfer and other members of the observation team were available to conduct another observation in the event multiple patient-handling activities occurred simultaneously. The observation team attempted to capture all patient-handling movements on each unit. When additional or emergency activity made the observation impossible, unit nurses provided as much information as possible about any missed transfers.

Information collected from the nurses included transfer type, patient dependency and cooperation level, number of staff involved in the transfer, assistive device used, and start and end times. Transfers were divided into lateral and non-lateral movements. Lateral transfers included repositioning in bed (side-to-side), moving the patient to the head of the bed and transferring patients from bed to bed or from the bed to a gurney. Non-lateral transfers included all other transfers such as bed to chair, bed to wheelchair, wheelchair to commode or shower to wheelchair.

Dependency and cooperation levels were categorized by using definitions from the Patient Safety Center of Inquiry (2001). For example, categories of dependency ranged from "total assistance" (the patient requires 100% assistance by one or more persons to perform all physical activities) to "independent" (the patient requires no physical or cognitive assistance to perform functional activities. Patients were categorized as cooperative (may need prompting and able to follow simple commands) or unpredictable or variable (behavior may change frequently, is considered unpredictable, not cooperative, or unable to follow simple commands).

3.2.5.2 Phase II: Nurse's Questionnaire

The objectives of this phase were twofold: (1) identify the most physically demanding patient-handling tasks based on the perceptions of all nurses, and (2) evaluate the association between self-reported symptoms and demographic characteristics. A questionnaire (Appendix B) was developed addressing patient-handling training, work organization, and musculoskeletal symptoms in four body parts (neck, back, upper extremity and lower extremity). Questions regarding work organization were taken from those presented by Huang and Feuerstein (2004) and covered time management, decision making and management style. Musculoskeletal symptom questions were based on the common Nordic Questionnaire (Kuorinka et al., 1987), and addressed occurrences within the prior year. Questions were added regarding specific symptoms for each body part, current ratings of the problems resulting from those symptoms and related lost time and medical treatment.

Participants were given the questionnaire along with a list of patient-handling tasks compiled from the observational task analysis phase. They were asked to rank order the patient-handling tasks from high to low in terms of overall physical demands (where 1 = most physically demanding to 10 = least physically demanding). This ranking was done using material from the Patient Safety Center of Inquiry (Appendix C) for identifying and prioritizing physically demanding patient-handling tasks, which in turn was adapted from earlier material generated by the Veteran's Administration Patient Safety Center of Inquiry.

All nurses involved in patient-handling activities on an inpatient unit were invited to complete the questionnaire. Personnel from nursing administration distributed the questionnaires to the nurse unit managers on each inpatient unit. Standardized instructions were provided to the unit managers. All nurses received verbal and written information concerning the purpose, methods and intent of the experimental procedures using these instructions. Nurses agreeing to participate completed an approved informed consent process and received monetary compensation upon completion.

3.2.6 Data Analysis

In Phase I, the observed patient-handling tasks were tabulated and rank ordered by frequency. Patient dependency level, cooperation level, number of nurses assisting in the movement, completion time, and use of assistive devices were tabulated across all tasks.

Additional analyses were done to determine if there were differences in several tasks aspects – such as completion time, time of day, unit, job title, dependency level, cooperation level, number of staff, self-report of discomfort and symptoms – between tasks identified as among the "top 10" in terms of frequency. Analysis of variance (ANOVA) was used for continuous measurements (e.g., time to complete transfer), with post-hoc (Tukey's HSD pair wise comparison used where relevant. Chi-square analyses were used for categorical measurements (i.e., time of day, day of week).

In Phase II, the most frequent patient-handling tasks were identified and rank ordered by perceived physical demand. The relationship between the type of patient-handling task and perceived physical demand was compared using a one-way analysis of variance (ANOVA), and using Tukey's HSD for post-hoc comparisons.

Differences in self-reports of discomfort and total symptoms with respect to demographic characteristics (i.e., age, shift, job title, unit and years of experience) were examined by Chi-square tests or ANOVA. As the participant sample was extremely unbalanced across titles (104 RNs, 11 LPNs/LVNs and 27 NAs), comparisons between job titles are limited. Hence such analyses were conducted using all nurses and only RNs. Comparisons between shifts, units and age groups were made using only the RNs, to focus on one specific job title that represented a large portion of the sample.

Both age and years of experience were considered as potential covariates in analyses comparing job titles, units and shifts, with respect to transfers per day and transfer times. Age and years of experience among the nurses were not surprisingly correlated in this population ($r = 0.80$). Because of this high correlation, distinct effects of age and years of experience cannot be separated. Age was captured in categories and years of experience as a continuous variable. It was thus considered more appropriate to use years of experience as a covariate.

Associations between work organization factors and total number of symptoms for each body part (neck, upper extremity, lower extremity and back) were determined using bivariate correlations. Comparisons between age groups, shifts, job titles and units with respect to the number of reported training classes were determined using Chi-square analyses. A Friedman's test was conducted to compare rank scores among transfer types, followed by Dunn's test to compare all pairs of transfer types. A Cronbach's Alpha was determined to assess the reliability of the subscales of the work organization questions. In all statistical analyses, significance was concluded when $p < 0.05$.

3.2.7 Results

3.2.7.1 Phase I: Procedural Task Analysis

A total of 114 patient transfers were observed, documented and analyzed. Of the 114 observed transfers, 57% were conducted by RNs, 40.4% by NAs and 2.6% by LPNs/LVNs. The mean transfer time was 3.04 minutes and the mean number of staff was 2.2. All transfers were tabulated and ranked by counts (Table 3).

Table 3: Transfer Types and Associated Count and Percentage

Transfer Type	Count	Percentage
Up in Bed	22	19.4
Side to Side	17	14.9
Side to Side/Up in Bed	15	13.2
Chair to Bed	11	9.7
Bed to Chair	7	6.2
Commode to Bed	5	4.4
Chair to Commode	5	4.4
Gurney to Bed	4	3.6
Bed to Gurney	4	3.6
Bed to Commode	4	3.6
Bed to Bed	2	1.6
Bed to X-ray Table	2	1.6
Lift Leg onto CPM	2	1.6
Walker to Chair	2	1.6
X-ray Table to Bed	2	1.6
Bed to Bed	1	0.9
Bed to Walker	1	0.9
Chair to Rolling Chair	1	0.9
Chair to Standing Position	1	0.9
Chair to Walker	1	0.9
Floor to Bed	1	0.9
Gurney to X-ray Table	1	0.9
Supine to Sitting in Bed	1	0.9
Walker to Bed	1	0.9
X-ray Table to Gurney	1	0.9

In the observed transfers, a majority (91.2%) of the patients was cooperative and was transferred without the use of any assistive device (87.7%). Over half (57%) of the patients required minimal to moderate assistance, with 75.4% requiring two or more people to conduct the transfer. Nearly half of all transfers (47.5%) were lateral, including up in bed (19.4%), side-to-side (28.1%) and a combination of both movements (13.2%).

Observations were performed on two consecutive Mondays, but were treated as independent days and involved respectively percentages of 14.9% and 14%. The majority of the transfers (24.6%) occurred on Tuesday, followed by Wednesday and Friday both with 17.5%.

The fewest transfers occurred on Thursday (11.5%). The percentage of transfers by unit were evenly divided, with 35.1% performed on both the intensive care units (ICUs) and medical/surgical units and 29.8% on the progressive care units (PCUs).

RNs conducted the majority (57%) of the transfers, followed by NAs (40.4%), and with the remainder (2.6%) done by LPN/LVNs. With respect to transfer time, 56.1% of the transfers took less than two minutes to complete and 80% took less than four minutes. Nearly half (47.3%) of the transfers were performed between 8:00 a.m. and 12:00 p.m., followed by 33.3% between 12:01 p.m. and 4:00 p.m. A substantial percentage of transfers (25%) were conducted between 10:01 a.m. and 12:00 p.m.

There were 25 different types of observed transfers, with the 10 most frequent accounting for 82.4% of the total (Figure 4). The top 10 transfer types occurred a minimum of four times in the observations. Transfers that occurred fewer than four times were not included in further analyses.

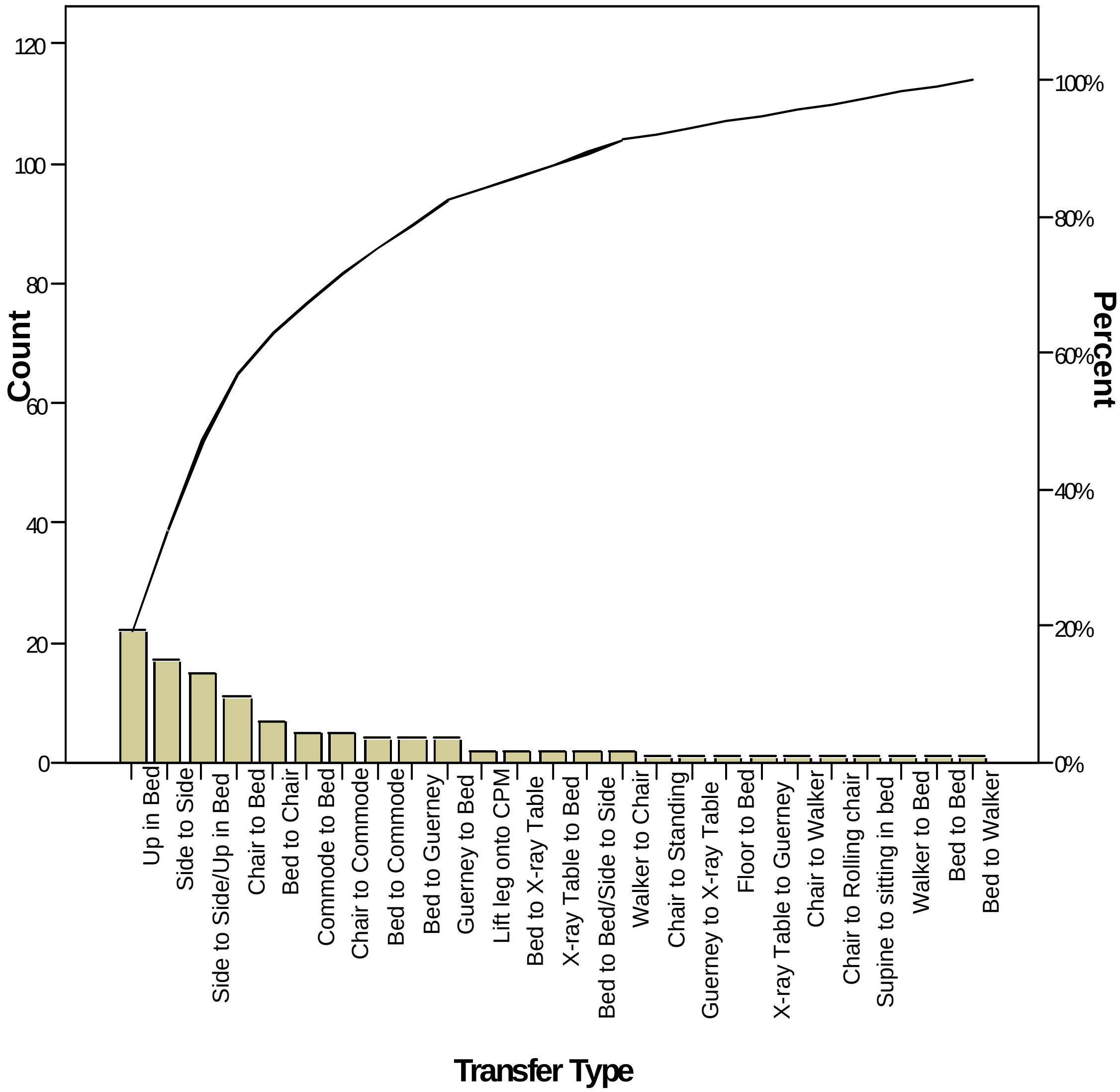


Figure 4: Pareto Distribution of all Transfer Types

No significant differences between transfer types were observed with respect to total time ($p = .286$), yet significant differences between transfer types were observed between the different units ($p = .005$). Transfers in ICUs involved a large percentage of repositioning transfers (i.e., movements up in bed or side-to-side). PCUs had a variety of transfers that included movements out of bed, into bed and repositioning in bed. This distribution of transfers for the PCUs was significantly different from the ICUs (p = .024) and the medical/surgical units (p = .034). A significant difference (p = .002) in the number of staff per transfer was found between tasks. The majority of transfers (73.4%) were conducted with two or more people. In the repositioning transfers, 87% were performed by two or more nurses.

3.2.7.2 Phase II: Questionnaire Results

Six hundred questionnaires were distributed, with a response rate of 24.7% (n = 148). Respondents were primarily female (93.1%), though 12% did not indicate their gender. Over half the respondents (56.8%) worked the day shift, 30.2% were on the evening shift and 13% worked on other shifts. More than half of the nurses (54.6%) had 0.5-10 years of experience, nearly one-fourth (24%) had 11-20 years, 15.8% had 21-30 years and 5.6% had 31 or more years. RNs represented 73.2% of the sample, 19.1% were NAs and 7.7% were LPNs/LVNs. The majority of the participants were 41+ years of age (45.6%), followed by 30.3% in the 20-30 age range and 24.1% in the 31-40 age range.

Significant differences in years of experience were found between job titles (p = .033), units (p = .025), and shifts (p = .019). RNs and LPNs/LVNs had more years of experience than NAs (14.0 and 16.3 vs. 6.6 years). Nurses working on medical/surgical units had more years of experience than nurses working in the PCUs (16.1 vs. 9.9 years). Nurses working day or evening shifts had fewer years of experience than nurses working other shifts (9.9 vs. 19.1 years).

Percentages of all nurses reporting one or more neck, back, upper extremity, or lower extremity symptoms in the past year were 49, 68, 11.6 and 47.9%, respectively (Table 4). Comparable trends were found between all nurses and RNs only, in terms of number of symptoms and body parts affected. Among RNs, age-related differences were observed for upper extremity ($p = .013$), and lower extremity ($p = .041$) symptoms. Overall, a higher percentage of older RNs (41-50 and 51+) reported symptoms than those in the younger age groups (20-30 and 31-40).

Table 4: Number and Percentage of Reported Symptoms by Body Part

	Number of Reported Symptoms									
Body Part	**0**		**1**		**2**		**3**		**4+**	
	All Nurses	RNs	All Nurses	RNs	All Nurses	RNs	All Nurses	RNs	All Nurses	RNs
Neck	75 51%	47 45.2%	24 16.3%	20 19.2%	27 18.4%	22 21.2%	10 6.8%	9 8.7%	11 7.5%	6 5.7%
Back	46 32%	36 34.6%	53 37%	40 38.5%	18 12.4%	13 12.5%	14 9.6%	11 10.6%	13 9%	4 3.8%
Upper Ext.	130 88.4%	96 92.3%	7 4.8%	6 5.8%	4 2.7%	2 1.9%	5 3.4%	0 0%	1 .7%	0 0%
Lower Ext.	76 52.1%	51 49%	21 14.4%	18 17.3%	20 13.7%	16 15.4%	15 10.3%	10 9.6%	14 9.5%	9 8.7%

All nurse responses: neck n=147, back n=144, upper extremity n=147 and lower extremity n=146.
RNs only responses: all body parts n=104.

Among all nurses, age-related differences were found for neck ($p = .004$) and upper extremity ($p = .005$) discomfort. Nurses 41-50 years of age reported significantly more neck discomfort than those 20-30 ($p = .001$) and 51+ ($p = .003$) years old; nurses 31-40 years of age reported significantly less upper extremity discomfort than those in the 41-50 ($p = .002$) and 51+ age groups ($p = .004$). Similar results were found in the RN group where the older age groups, 41-50 ($p = .010$) and 51+ ($p = .009$) years of age reported significantly more upper extremity discomfort than younger nurses (31-40).

RNs (69.2%) reported significantly (p = .036) more training classes than LPNs/LVNs (45.5%) and NAs (40.7%). The most frequently reported training topics were transfer techniques (24.3%) and body mechanics (23.0%).

Responses to the work organization questions are summarized in Table 5. Regarding time management, approximately 50-70% of all nurses agreed that there is constant pressure to keep working throughout the shifts with a great sense of urgency and no time to relax. No significant differences were observed between shifts, units, age groups or job titles regarding time management. However, age and shift-related differences were observed in responses to decision making and management style questions for both groups. In terms of decision making, over 70% of all nurses agreed that they have some part in making decisions that affect them and the way things are done on the job. A higher percentage of older nurses (age 51+) agreed that they have an active part in determining how tasks are performed than younger nurses (p = .016). Roughly 8% of all nurses agreed that supervisors and co-workers provide at least some feedback on how well they are doing their job. Only 15.5% of the nurses agreed that supervisors and co-workers provided a lot of feedback. A higher percentage of nurses on the day shift stated they were given feedback than the nurses on the evening shift (p = .022). Among RNs, shift and age-related differences were observed on decision making questions. A significantly greater percentage of RNs on the evening shift (p = .049) or other shifts (p = .032) agreed with the statement that they take an active part in determining the way things are done on the job. A greater percentage of RNs in the older age group (51+) agreed that they have the ability to determine which parts of a task will be performed and completed than the younger age groups 20-30 years (p = .002) and 31-40 years (p = .05).

Table 5: Work Organization Questions and Responses by Frequency

Questions	All Nurses	RNs Only	All Nurses	RNs Only	All Nurses	RNs Only
Time Management	**Agree**		**Neutral**		**Disagree**	
1. In my group, people cannot afford to relax.	74 49.9%	52 50%	34 23%	22 21.2%	40 27.1%	30 28.8%
2. In our group, there is constant pressure to keep working.	103 69.7%	68 65.4%	20 13.5%	16 15.4%	25 16.8%	20 19.2%
3. In my group, there is a sense of urgency about everything.	79 53.4%	51 49%	39 26.5%	29 27.9%	30 20.1%	24 23.1%
Decision Making	**Very Little**		**Some**		**A Lot**	
4. To what extent do you take an active part in making decisions that affect you?	25 16.8%	14 13.5%	46 31.2%	31 29.8%	77 52%	59 56.7%
5. To what extent do you take an active part in determining the way things are done on the job?	37 24.9%	21 20.2%	54 36.4%	36 34.6%	57 38.7%	47 45.2%
6. To what extent do you determine which part of the task you will do?	33 22.2%	19 18.3%	52 35.2%	37 35.5%	63 42.6%	48 46.2%
Management Style	**Little**		**Some**		**Much**	
7. To what extent do supervisors or co-workers let you know how well you are doing on the job?	24 16.2%	18 17.3%	80 54.1%	51 49%	44 29.7%	35 33.7%
	Accurate		**Neutral**		**Inaccurate**	
8. The supervisors and co-workers on this job almost never give me any "feedback" about how well I am doing in my work.	79 53.6%	55 52.9%	57 38.4%	39 37.5%	12 8%	10 9.6%
9. Supervisors often let me know how well they think I am performing on the job.	23 15.5%	13 12.5%	74 50%	52 50%	51 34.5%	39 37.5%

Several significant correlations were observed between the responses to work organization questions and the total number of symptoms for the neck, back and lower extremity (Table 6). With increasing time pressure there was an increase in reported neck and lower extremity symptoms ($r \sim 0.18 – 0.20$). Perceptions of having less input into decisions being made on the unit were associated ($r = 0.19$) with increased lower extremity symptoms. Increased numbers of back symptoms correlated ($r = 0.18$) with decreased feedback from supervisors and co-workers. The Cronbach's Alpha for each subscale was as follows: Time Management (0.82), Decision Making, (0.83) and Management Style (0.53).

Table 6: Correlations Between Work Organization Factors and Total Symptoms

	Upper Extremity	Lower Extremity	Neck	Back
Time Management				
1. In my group, people cannot afford to relax.	-.104	-.183*	-.207*	-.160
2. In our group, there is constant pressure to keep working.	-.110	-.189*	-.180	-.116
3. In my group, there is a sense of urgency about everything.	-.071	-.178*	-.190*	-.138
Decision Making				
4. To what extent do you take an active part in making decisions that affect you?	-.122	-.191*	.001	-.110
Management Style				
7. To what extent do supervisors or co-workers let you know how well you are doing on the job?	-.115	-.140	-.116	-.175*

*Significant correlation ($p < 0.05$).

The final part of Phase II had nurses rank order the top 10 patient transfer tasks by physical demand (1 = highest physical demand to 10 = least physical demand) with results summarized in Figure 5. The four most physically demanding tasks were bed to chair (mean score = 4.16), chair to bed (4.26), bedside commode to bed (4.29) and bed to bedside commode (4.34). The least physically demanding transfer was side to side (7.5), which had a significantly higher mean score versus all other tasks.

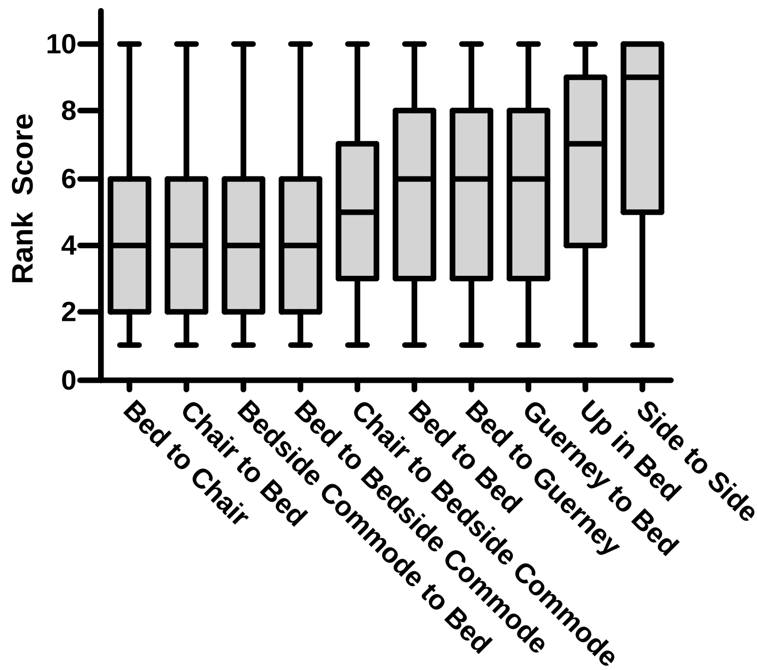


Figure 5: Box and Whisker Plot of Physical Demand Ratings in the Top 10 Tasks (Interquartile Range and Median)

3.2.8 Discussion

The primary purpose of this study was to identify and assess the specific patient-handling tasks that take place within an acute care facility. Many authors have identified tasks that take place in long-term care facilities; however, these tasks are less defined in acute care facilities. The goals of Phase I were, through a task analysis, to identify the patient-handling tasks nurses perform in these settings, describe different aspects of these tasks and compare the different characteristics between the tasks. The goals of Phase II were to identify, using a questionnaire, the most physically demanding tasks based on acute care nurses' perceptions and to evaluate the association between self reports of discomfort and symptoms with respect to demographic characteristics.

Overall, 25 different transfer types were identified from 114 observed transfers. The list of top 10 transfer types from this study in an acute care facility is roughly comparable to the list derived from the Garg et al. (1992) study in a long-term care facility (Table 7). Several differences are apparent, however, in the tasks conducted in each type of facility. Repositioning tasks such as movements up in bed or side-to-side were included in both lists; however, they were more frequent in the acute care facility. The majority of movements observed in the long-term care facility are associated with performance of activities of daily living (ADL) such as feeding, dressing or bathing patients or tying restraints and movements in and out of the wheelchair.

Table 7: Task Comparison by Frequency

	Acute Care Facility	Long-Term Care Facility
Most Frequent	Up in Bed	Activities of Daily Living
↑	Side to Side	Change Attends
	Side to Side/Up in Bed	Toilet to Wheelchair
	Chair to Bed	Wheelchair to Toilet
	Bed to Chair	Repositioning Patient in Wheelchair
	Commode to Bed	Bed to Wheelchair
	Chair to Commode	Wheelchair to Bed
↓	Bed to Commode	Repositioning Patients in Bed
Least Frequent	Bed to Gurney	Chairlift to Wheelchair
	Gurney to Bed	Weighing Patient

When reviewing the differences in the most frequent patient-handling tasks between the two types of facilities, it is important to note the differences in scope of practice between these environments. Long-term care facilities provide 24-hour care to people who can no longer care for themselves due to physical, emotional or mental conditions. For people who are losing their ability to function independently due to chronic disease and increasing frailty, custodial care may be a long-term need. This would explain why the most frequent types of transfers in a long-term care facility are those associated with ADL tasks.

In contrast, in an acute care facility the focus is on stabilizing patients medically and discharging them home or to another facility, such as skilled nursing or a rehabilitation unit. . Patients in acute care facilities are often too sick to complete ADLs or are able to complete them independently, which explains why this category of transfers, and other transfers which are not directly linked to clinical goals (elective movements), are not commonly seen in these environments. Rather, transfers aimed at preventing health complications (pressure sores from lack of movement) and promoting patient recovery from acute illnesses or injuries are more common in these facilities.

Within the acute care facility, an important difference was observed in the distribution of transfer types between units. The ICU had a large percentage of repositioning transfers while the PCU had a variety of transfers that included movements out of bed, into bed and repositioning in bed. Also, the distribution of transfers for the PCU was significantly different from the ICU and the medical/surgical units. These differences can be explained by considering the purpose of each unit. In the ICU, the patient spends the majority of the time in bed attached to different monitors and equipment. The main focus in this type of unit is to stabilize the patient medically. Nurses are also concerned with frequently repositioning the patient to prevent the development of pressure areas. This explains why the majority of the movements in ICUs are repositioning transfers.

The PCU, however, is the step down unit for the ICU. Patients are transferred to the PCU when they have improved to a point where they do not require constant monitoring. The patient-to-nurse ratio is higher on the PCU (i.e., three or four patients to one nurse) and the patients are allowed to spend more time out of bed. Thus, movements in and out of bed are more frequent. On a medical/surgical unit, the patient does not require the intense monitoring provided on the ICU and PCU and the nurse-to-patient ratio is even higher (i.e., approximately seven patients to one nurse). The patient is also allowed to spend more time out of bed. This supports the finding in this study where the majority of transfers (52.7%) were conducted in and out of bed on the medical/surgical units.

These findings are consistent with earlier evidence. McCoskey's study (2007) was designed to describe the type, frequency and physical demands of the patient-handling tasks in an acute care facility. They determined that the units with the highest number of reported transfers were the Cardiac Care Unit (CCU), Surgical Intensive Care Unit (SICU), Medical Intensive Care Unit (MICU) and General Medicine. Transfers were categorized into lateral and non-lateral transfers. Lateral transfers included repositioning in bed, rolling in bed, moving the patient to the head of the bed and transferring patients from bed to bed. Non-lateral transfers included all other transfers such as bed to chair, bed to wheelchair and wheelchair to commode. Repositioning transfers accounted for 47% of all transfers. They further reported that over 50% of all lateral transfers, including repositioning transfers, required moderate or greater physical exertion. McCoskey's findings (2007) were also consistent with the results of Owen et al. (2002), who found that nurses experience the greatest amount of physical stress when repositioning patients.

Garg et al. (1992) found that manual lifting accounted for 98% of observed transfers in long-term care facilities. In the current study, a majority (~90%) of the transfers were conducted without lifting devices. Use of equipment was noted, specifically when nurses elected to use any type of assistive device. However, the availability of equipment on each unit was not captured. Although use of equipment can help decrease physical demands and lost workdays (Daynard et al., 2001; Garg & Owen, 1992; Nelson et al., 2006; Ulin et al., 1997; Zhuang et al., 1999), it appears that in the majority of cases, nurses do not use equipment in acute care. Reliance on manual methods may be due to several influences (Nelson & Fragala, 2003): nurses may perceive that using equipment takes more time; equipment may not be available; equipment may be difficult to use; there may be space constraints within the room; or the patient may prefer to have staff perform the transfer instead of using equipment.

In Phase II, less than 50% of the nurses reported at least one symptom for the neck and lower extremity and less than 20% reported at least one symptom for the upper extremity within the past year. However, the percentage of nurses reporting at least one back symptom within the past year was higher (69%). Several studies have shown that a large percentage of nurses report LBP due to work-related activity, primarily from manual patient handling (Harber et al., 1985; McGill & Kavcic, 2005; Nelson & Baptiste, 2006).

Further, the questionnaire results revealed age-related differences on the neck, lower and upper extremity symptoms. Overall, the older age groups (41-50 and 51+) reported higher numbers of symptoms than the younger age groups (20-30 and 31-40). However, no significant age related differences were found with respect to the number of back symptoms. This may be due to the large majority (68%) of nurses reporting at least one back symptom within the last year.

Responses regarding training revealed that nurses received little patient-handling related instruction within the past year. Transfer techniques and body mechanics accounted for over half (55%) of the training topics cited (n = 128). Of note, only 5% of the nurses responded that they had received training on equipment, despite the fact that patient-handling equipment was observed on the units. Nurses were given to opportunity to provide three training topics they received within the last year; however, there was a 70% no response to this question. It may be that there were no training requirements in this hospital, however researchers did not have access to this information.

Another focus of the questionnaire was on work organization. Hagberg et al. (1995) defined work organization as the way in which work is organized, supervised and carried out and depends on many factors including management style, time management, decision making, type of product or service, characteristics of the workforce, level and type of technology and market conditions. Existing studies indicate potential links among work organization, job stress and WMSD risks (Michael, 2001; NIOSH, 2007).

Huang et al. (2003) found that time pressure was associated with low back and upper extremity symptoms while higher biomechanical exposures were risk factors for low back symptoms and concurrent low back/upper extremity symptoms. In the present study, nurses agreed that constant work pressure and a sense of urgency afforded them no opportunity to relax. However, no significant work organization related differences were found with respect to body part symptoms.

Age and shift related differences were observed in the decision making portion of this survey. Over 70% of the nurses agreed that they had a part in active decision making. This may be attributed to the fact that RNs represented 70% of the sample size, and the hierarchy within a hospital dictates that RNs are expected to make more decisions than those with other job titles. The scope of practice for an RN is wider than that of an LPN/LVN based on the Nurse Practice Act’s definition of their respective roles and the RNs’ higher level of education. In the hospital setting, RNs are ultimately responsible for the safety and care of the patient and, to that end, they often supervise tasks performed by LPNs/LVNs and unlicensed assistive personnel such as NAs.

Responses regarding management style showed a significant difference among shifts for all nurses. A greater percentage of nurses on the day shift agreed that they are provided more feedback about how well they are performing their job. Existing evidence shows that supervisory/management style and autonomy are important from the occupational health perspective (Bongers et al., 1993; Kalimo et al., 1997). An authoritative management style has been found to have a negative effect, whereas a participatory style has been found to be advantageous (Smith & Carayon, 1996). Among nurses, management support was an important predictor of job satisfaction and autonomy of work in decreasing anxiety (McIntosh, 1990). This implies that nurses perceive communication between management and staff as important and that a participatory management style is vital in their daily activities.

It is also noted that significant but weak correlations were observed between the work organization questions and self-reported body part symptoms. These weak correlations ($r = 0.18$-0.20) are likely a result of other factors, that were not monitored, contributing to the injury process. As seen in Figure 1, there are a number of factors to be considered: (1) physical, organizational, and social aspects of the work and the workplace, (2) physical and social aspects outside the workplace, and (3) the physical and psychological characteristics of the individual (National Research Council, 2001). For the individual, the characteristics include age, gender, years of experience, body mass index, personal habits to include smoking and exercise activity, and some aspects of genetically determined predispositions. The complexity of the problem is further increased because all of these factors interact and vary over time and from one situation to another. Another explanation for the weak correlations may be that specific subscales (time management, decision making and management style/feedback) were taken from the original work organization questionnaire. However, the Cronbach's Alpha was reasonably high, indicating a fair measure of consistency among the test questions that made up each subscale. Overall, these findings are consistent with evidence that psychosocial factors are predictive of injury, but not strongly predictive (Kalimo et al., 1997).

The last portion of Phase II asked the nurses to rank order (by physical demand) the top 10 tasks identified in Phase I, the procedural task analysis. The top four physically demanding tasks were bed to chair, chair to bed, bedside commode to bed and bed to bedside commode. These transfer types are primarily movements into and out of the bed and tasks associated with ADLs. Comparisons can be made between the perceived physically demanding tasks identified in this study and results from Garg et al. (1992) in a long-term care facility (Table 8).

Table 8: Task Comparison by Physical Demand

	Acute Care Facility	**Long-Term Care Facility Garg et al. (1992)**
Highest Physical Demand	Bed to Chair	Toilet to Wheelchair
↓	Chair to Bed	Wheelchair to Toilet
	Bedside Commode to Bed	Wheelchair to Bed
	Bed to Bedside Commode	Bed to Wheelchair
	Chair to Bedside Commode	Bathtub to Chair
	Bed to Bed*	Chairlift to Chair
	Bed to Gurney*	Weighing Patient
	Gurney to Bed*	Lifting Patient Up in Bed**
	Up in Bed**	Repositioning Patient in Bed**
Least Physical Demand	Side to Side**	Repositioning Patient in Chair**

*Lateral transfers
**Repositioning transfers

As can be seen, the perceived physically demanding tasks are similar because they both involve movements in and out of bed and ADL tasks. Although more frequent in acute care facilities, repositioning tasks were perceived to be less physically demanding in this study. Conversely, McCoskey's (2007) study in an acute care hospital found that over 50% of all lateral transfers, including repositioning transfers, required moderate or great physical exertion. These findings were also consistent with the results of Owen et al. (2002), who found that nurses experience the greatest amount of physical stress when repositioning patients. Waters et al. (2007) conducted a study of high-risk tasks for critical care nurses. They determined that the most physically demanding tasks for this population were, in order: (1) transporting patients in occupied beds and stretchers, (2) lateral transfers, (3) repositioning patients up in bed, (4) repositioning patients side to side in bed, (5) making occupied beds, (6) applying antiembolism stockings and (7) lifting and moving heavy items. As observed in this list, critical care nurses perceive lateral and repositioning transfers as more physically demanding than movements in or out of bed and transfers associated with ADL tasks. Because the current study findings were different from other published studies in acute care facilities, it demonstrates the need to determine what types of perceived physically demanding movements and transfers are taking place within each facility.

Generally, a lack of equipment use was observed throughout the units. During the observations, it was noted that approximately 30% of the units had equipment available to transfer patients. Diverse equipment was used, including surfboards, gait belts and trapeze bars. With respect to equipment, Nelson et al. (2006) reported that 96% of the nurses who had input on equipment selection and training prior to use, rated transfer equipment as extremely effective. This supports the need for further research to identify specific barriers to equipment use, appropriate equipment selection and equipment training programs based on the unique patient-handling demands within acute care facilities.

Several limitations were present in the current study. Participation was voluntary in both phases, and no effort was made to balance participation across job titles (e.g., by stratified sampling). Therefore, the resulting sample had unequal numbers of nurses for each job title. Specifically, there were many more RNs than LPNs/LVNs or NAs. Though the proportions were roughly representative of workers in the facility studied, some caution is warranted regarding analyses involving comparisons between job titles. In addition, the types of transfers performed by those who did not participate in the study may have been different than those who participated. Observations in Phase I were not consecutive, but instead were conducted on six inpatient units for two non repeating days for three two-hour randomized periods. In contrast, Garg et al. (1991) used 79 four-hour observations that were consecutive. Use of nonconsecutive collection times may have produced a non-representative sample of transfer types. However, the times chosen were selected based on when most transfers were conducted. Another limitation arose from facility-imposed restrictions in Phase II. The research team was not permitted to interface with the nursing staff during this phase. Rather, the nursing administration was given copies of the questionnaire to distribute to the unit nurse managers. Although standardized instructions were provided to nursing administration and unit managers, there was no guarantee that these instructions were used. Also, the research team was unable to field any questions the nurse participants had during completion of the questionnaire. The response rate to these questionnaires was only 24.7%, though it was not apparent that any response bias or potential confounding effects were present.

Despite these limitations, two major findings were obtained from this study. First, the top 10 transfer types were identified in an acute care facility. Having this list will aid in making decisions concerning the types of equipment and training that are needed to decrease the nurses' exposure to injuries. Second, transfers performed in acute care facilities differ from those in long-term care facilities. This difference is likely due to a different focus on patient care. Long-term care facilities are primarily focused on custodial care, and have a defined population with similar dependency levels. Because patients are fairly stable and the dependencies are fairly similar, it is easier to plan daily movements and tasks, and also easier to plan and implement interventions. In contrast, acute care involves a variety of patients, changing dependency levels, differing equipment needs and diverse settings in which the patients are being transferred. Differences in the types of transfers being performed across types of healthcare facilities, as well as across units within acute care facilities, point to the importance of determining the patient-handling demands and needs that are unique to each type of healthcare facility. Generalizing across facilities or units may lead to incorrect assumptions and conclusions about physical demands being placed on nurses.

In summary, transfer types used for patient handling and equipment usage vary across healthcare environments, specifically between acute and long-term care facilities. These differences must be considered in order to promote nurse and patient safety and reduce the prevalence of WMSDs among nurses. Identifying what patient-handling demands are taking place in each facility is an important initial step so that interventions can be developed to decrease exposures and, ultimately, injuries.

4.0 Laboratory Analysis of Physically Demanding Patient-Handling Tasks: Effects of A Low-Cost Manual Assistive Device and Assistance

Abstract

***Background*:** Healthcare workers continue to have one of the highest incidence rates of WMSDs compared to other occupations. Patient-handling tasks are the precipitating event in the majority of back injuries among nursing staff. Despite this knowledge, patient handling remains a frequent and necessary task and evidence-based practices and ergonomic methods are needed to reduce injury risks.

Methods: This study was designed to identify the most physically demanding patient-handling element(s) within several tasks, and to determine the effects of an assistive device and assistance from another person based on perceived exertion and perceived injury risk. Sixteen nurse volunteers were recruited to simulate patient-handling tasks with and without assistance from another person and with and without use of an assistive device.

Results: Three major findings were obtained. First, tasks conducted with assistance are perceived to be lower in exertion and injury risk. Second, this study found that the movement element of all tasks was perceived to have the highest exertion and injury risk over the other task elements, preparation and completion. Third, nurses perceive physical effort to be greater than injury risk regardless of assistance, equipment or specific task. This difference suggests that nurses perceive the amount of physical exertion they perform to be greater than their perceived injury risk.

Conclusions: Health care providers who handle and move patients, and those responsible for the management of such providers, should understand that the highest levels of physical demands, and hence injury risk, are most likely to occur with the movements associated with patient handling. Furthermore, it is important to use solutions that are available to minimize physical demands during patient-handling.

4.1 Introduction

Nurses play an important role in the health care system. They provide care, assist patients and perform many different activities during the course of their workday. Patient-handling tasks are particularly problematic for nursing personnel. Patients may move unexpectedly and can become uncooperative or even combative, which changes the load demands and greatly alters the physical challenge associated with the activity. The cumulative exposure to the forceful exertions required by patient-handling tasks likely results in an increased risk for a variety of work-related injuries among nursing personnel.

According to the Bureau of Labor Statistics (2003), nursing personnel rank highest in incidence of nonfatal occupational injuries and illnesses, with 12.6 injuries per 100 full-time employees reported in 2002. Approximately one-third of these injuries resulted in absence from work (Bureau of Labor Statistics, 2004). Nursing aids and orderlies were reported to have the highest number (44,000) of absentee days due to musculoskeletal disorders. Further, injuries resulting from patient-handling and movement tasks continue to affect the nursing profession.

Back injuries are of particular concern and can be debilitating for nurses. A high prevalence of low back disorders has been found among nurses performing patient-handling tasks (Lagerstrom et al., 1998; Nelson & Fragala, 2003; Videman et al., 2005). Approximately 38% of nurses report back injuries during their career (Heck, 2002). Retsas and Pinikahana (2000) reported incidence rates of 52.2% for patient-handling injuries and 38% of nurses suffered occupationally related back pain severe enough to require leave from work (Owen, 2000).

Musculoskeletal disorders in nurses have been attributed in large part to patient-handling and lifting activities. Biomechanical studies (Daynard et al., 2001; Garg et al., 1992; Herrin et al., 1986; Jang et al., 2007; Kumar et al., 2003; Marras et al., 1999) have shown that these activities place high levels of compressive force on low-back structures, far exceeding the lifting limits recommended by the U.S. National Institute of Occupational Safety and Health (NIOSH, 1997). An association between mechanical loading on the low back (i.e. compression and shear) and the reporting of LBP has been demonstrated in several studies (Chaffin & Park, 1973; Marras et al., 1999; Norman et al., 1998). Further, most of the occupationally related LBP in nursing staff appears to be the result of frequent manual lifting of patients (Allen et al., 2002; Bell et al., 1979; Engst et al., 2005; Harber et al., 1985; Owen et al., 1992).

The most common approach to prevention of low back injuries has been education and training in lifting techniques and back care (Nelson & Baptiste, 2004). Existing evidence, however, provides mixed support for the efficacy and effectiveness of these methods (Dehlin et al., 1976; Harber et al., 1985; Hayne, 1994; Nelson & Baptiste, 2004; Nelson et al., 2006; Nussbaum & Torres, 2001). Owen and Garg (1991) maintain that body mechanics training and techniques for the prevention of back injury remains a viable intervention. Other investigators (Dehlin et al., 1976; Nelson et al., 2006; Waters et al., 2007) emphasize that training should not be the sole intervention; in order for the training process to provide long-term benefits, it must be part of a more systematic ergonomics approach.

Following the classical ‘hierarchy of controls’, a preferred method for decreasing a nurse’s exposure to hazards involves the use of engineering controls, such as patient-handling assistive devices. Current technology, such as overhead ceiling lifts, stand assists, lateral transfer devices and gait belts, has increased the availability and range of devices for patient-handling tasks. In an effort to reduce injuries to nurses, some facilities have purchased these lifting devices. As a result of a settlement signed in January 2002, Beverly Enterprises (the nation’s largest nursing home chain) agreed to train personnel and install equipment in 270 facilities throughout the United States. This agreement settled citations issued by OSHA to five Pennsylvania nursing homes operated by Beverly Enterprises for exposing their workers to musculoskeletal injuries (Bureau of National Affairs, 2002).

Several reports have suggested that the use of assistive devices may reduce a nurse’s exposure to risk factors (Allen et al., 2002; Evanoff et al., 2003; Fragala & Santamaria, 1997;

Waters et al., 2007). Despite this evidence, and an abundance of new technology, injuries persist. One reason for this may be that some facilities use assistive devices as a sole intervention. Although patient-handling devices decrease stress on the back, studies strongly support that devices alone are not the only solution (Garg et al., 1991; Nelson, 2002; Nelson et al., 1997; Nelson et al., 2006; Waters et al., 2007). To be more efficient, patient-handling devices should be part of a multifaceted program (Fragala & Santamaria, 1997; Nelson et al., 2006; Owen et al., 2000; Waters et al., 2007). Additional reasons that injuries persist may be that increased time demands, decreased availability, and patient preference contribute to the intermittent use of assistive devices (Bell, 1987; Garg et al., 1991; Nelson & Baptiste, 2004; Nelson & Fragala, 2003; Waters et al., 2007).

Lift teams are another type of control used to decrease nurses' exposure to ergonomic risk factors. Some facilities have chosen to implement lift teams dedicated to performing the majority of lifting and transferring of patients. The team's policy is to use lifting devices whenever possible; manual lifting is conducted only when necessary. Charney (1997) demonstrated that the use of lift teams resulted in a reduction in injuries by almost 70% and lost days by 90%. An increased benefit to the patients was also suggested, since use of lift teams allowed patients to be moved or transferred in a safer and easier manner. On a smaller scale, team lifts are conducted frequently by nursing staff rather than designated lifting teams, and Corlett et al. (1994) provided guidance for the use of single- versus two-person lifting depending on patient status.

Despite the existence of different methods and interventions, it has yet to be determined if specific elements of the patient-handling task are more physically demanding than others (i.e. task preparation, actual movement, or task completion). The complex and highly variable nature of patient handling complicates such analysis; patient transfers include many different components, making it difficult to compare one transfer movement to another. For example, a one-person transfer of a patient from wheelchair to bed might involve 28 steps, but the procedure for one person repositioning a patient in bed could take 13 steps.

As noted earlier (Section 2.4), ergonomists and employers use diverse methods to evaluate the jobs and tasks that expose workers to ergonomic stresses. Subjective measures are used commonly to elicit information from workers on issues such as level of discomfort, perceived exertion, preference, etc. Such subjective input is an important complement to behavioral and physiological measurements of physical performance and work capacity, since it relies on and stems from the reactions of those actually doing the tasks.

This study was designed to determine: (1) which element(s) of a patient-handling task are the most physically demanding, and (2) the effects of a low-cost, manual assistive device and assistance from another person. To simplify the diverse components associated with patient-handling activities, elements of each patient-handling task were categorized as preparation (of device and patient), actual movement and completion of the task (e.g., repositioning the patient in bed). A task simulation was conducted using four tasks identified previously (in Chapter 3) as the most physically demanding: bed to chair, chair to bed, commode to bed and bed to commode. Outcomes were based on perceptual responses of nurses following completion of these simulated tasks.

4.2 Methods and Materials

4.2.1 Goals

The goals of this study were two-fold. First, identify the most physically demanding element(s) (i.e., preparation, movement and completion of patient-handling tasks) based on the following dependent measures: nurses' perceived exertion and perceived injury risk. Second, determine the effect of the use of an assistive device and assistance from another person based on these same outcome measures.

4.2.2 Participants

Women make up the majority of the nursing workforce. Harber (1985) found that 96% of nurses are females. In 2001, of the 3,218,182 nurses in the United States, 187,463 (approximately 5.8%) were male (Lucas, 2003). These numbers suggest minimal demographic changes in that 16-year period with regard to women in nursing. Therefore, this study focused solely on female nurse volunteers.

Nurse volunteers were recruited from local hospitals in the Southwest Virginia area. Participation was open to RNs, LPNs/LVNs and NAs involved in patient handling on acute care units. All participants were in good health and had no self-reported history of musculoskeletal injuries or surgeries within the past year. Nurses performing strictly administrative work were excluded from participation. To account for any health issues that would prevent volunteers from participating in the study, all potential participants completed a screening questionnaire (Appendix D). After completing the screening phase, volunteers were informed as to their eligibility and told that the study required them to participate in two separate sessions: familiarization and actual task simulation.

Sixteen nurses were recruited to participate to allow for balancing the order of experimental conditions. The participants ranged in age from 30 to 59 years, with a mean age of 44.3 years. Of the 16 participants, 11 were RNs, 2 LPNs and 3 NAs. Their experience ranged from 2 to 24 years with a mean of 11.5 years. One nurse participant was left-handed, 14 were right-handed and one participant did not indicate handedness. Mean (SD) body mass and stature were 72.7 (22) kg and 166.8 (5.2) cm, respectively.

4.2.3 Experimental Design

A repeated measures design was used in which three independent variables were manipulated: the patient-handling task (four levels), assistive device (two levels: with and without) and level of assistance (two levels: with and without assistance from another person). Dependent measures consisted of ratings of perceived exertion and the perceived injury risk. Each patient-handling task consisted of three different elements: preparation, actual movement and completion. To prevent any confounding influences related to ordering (e.g., learning), the presentation order of the 16 conditions was counterbalanced using a Latin square. Although several related studies exist, comparable data were not available to drive a formal power calculation. The sample size was, however, considered adequate to identify reasonably large effect sizes.

4.2.4 Independent Variables

4.2.4.1 Patient-Handling Tasks

Specific patient-handling tasks were determined from the nurses' ranking of physically demanding tasks (see Chapter 3). The task simulation focused on the four most physically demanding tasks identified by nurses in the previous study. The tasks included bed to chair, chair to bed, commode to bed and bed to commode.

4.2.4.2 Assistance Level

Multiple factors determine the method of patient movement. Dependency and cooperation levels, along with the patient's weight and overall medical condition, are important factors in decisions such as how many staff to use for the transfer and whether or not to use assistive devices. Two different types of lifts were used in this study: one- and two-person lifts. As described earlier, a one-person lift is appropriate for patients requiring limited assistance who weigh less than 50 kilograms and a two-person lift is used for patients weighing more than 50 kilograms and requiring extensive assistance with the movement (Corlett et al., 1994). During the two-person lift, the nurse participant dictated the movements, and a member of the research team assisted in the transfers.

4.2.4.3 Assistive Device

For the purposes of this study, a low-cost manual assistive device was used. Because powered devices can be cost-prohibitive, it is important to identify low-cost manual devices that do not require some type of modification in the infrastructure of the facility. The criteria used for the manual devices in this experiment were that they be priced under $700 U.S. and require no modification of infrastructure. Examples of low-cost manual devices include gait belts, lateral transfer aids, sliding boards and transfer poles. Different tasks require different assistive devices. For this study, a gait belt was chosen (see Table 1) because it met the cost criteria, provided the participants with the ability to grasp the belt while performing the transfer and was the appropriate device for the simulated tasks. The variable of interest was not the device but rather how the presence or absence of a device impacts the nurse during each task.

4.2.4.4 Task Element

Each patient-handling task was divided into three main task elements: preparation, movement and completion. The task elements were categorized as follows: preparation (of device and patient), actual movement and completion of the task (e.g., repositioning the patient in bed).

4.2.5 Dependent Variables

4.2.5.1 Rating of Perceived Exertion (RPE)

Subjective assessments of perceived exertion were obtained by using the Borg CR-10 Scale (Borg, 1970). This scale (Figure 6) has values that range from 0-10, although participants were permitted to go beyond 10, which represents maximal exertion. This scale is especially appropriate for subjective symptoms such as pain and workload.

0	Nothing at all
0.5	Extremely weak (just noticeable)
1	Very weak
1.5	
2	Weak (light)
2.5	
3	Moderate
4	
5	Strong (heavy)
6	
7	Very strong
8	
9	
10	Extremely strong (almost maximal)
	Maximal

Figure 6: Rating of Perceived Exertion (RPE) Scale (adapted from Borg, 1970)

4.2.5.2 Rating of Perceived Injury Risk (PIR)

Participants were asked to rate their perceived injury risk (PIR), associated with performing each element of the patient-handling task, using a visual analog scale (Figure 7). Such VASs are commonly used to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be measured. Operationally, a VAS is usually a horizontal line, often 100 millimeters in length, anchored by word descriptors at each end. The VAS score is determined by measuring from the left-hand end of the line to the point that the participant marks. These scales are useful for determining individual differences and responses highly correlate with the Borg RPE (Borg, 1998; Price, 1994).

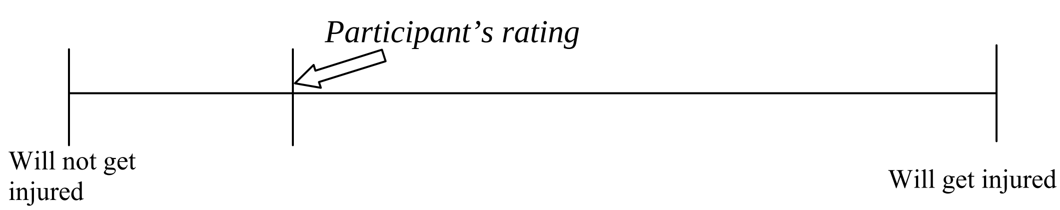


Figure 7: VAS, Perceived Injury Risk (PIR)

4.2.6 Procedures

4.2.6.1 Preliminary Session

Nurse participants practiced the procedures involved with each of the 16 patient-handling task conditions, including practice with the assistive device (gait belt) and use of the Borg CR-10 scale and VAS. Upon arrival, participants received verbal and written information regarding the purpose, goals and methods of the study. Participants were given an opportunity to ask questions pertaining to this study and completed an informed consent procedure approved by the Virginia Tech IRB. They were then introduced to the task simulation setting, which included the bed, chair, bedside commode, force platform and video cameras.

In order to understand use of the Borg CR-10 scale, participants performed a whole body exertion. This was accomplished by placing them in an apparatus that would allow them to exert force by bending their torso. A computer program provided the participants with feedback regarding the amount of force they were exerting. The participants were instructed initially to exert the maximum amount of force possible. From that information, the computer calculated 25 and 50% of their maximum exertion. The participants then exerted 25 and 50% of their maximum exertion, respectively, with feedback from the computer. During this time, participants also reviewed a visual representation of the Borg scale and stated their perceived level of exertion from 1 to 10 (10 representing maximum). It was explained that selecting "10" would indicate they are close to the point where they would feel a need to stop the exercise due to extreme physical exertion. Borg scale ratings were obtained immediately after completion of every element of the transfer movement. Participants were then given the opportunity to practice using the VAS. The scenario remained the same. They reviewed a visual representation of the VAS and marked the scale with their perceived injury risk if performing this task once a day for six months.

During this preliminary session, participants practiced all 16 conditions they used later, and received specific training. Standardized transfer elements were demonstrated to all participants by the principal investigator. Participants became familiar with the gait belt used for each patient-handling task and were allowed to practice their transfer methods with the gait belt. Additionally, participants met both the "patient" and the person assisting them during the two-person lift. The patient was a volunteer who simulated a moderate assistance dependency level. This dependency level was defined as the patient requiring 50% assistance from one person to perform physical activities (Patient Safety Center of Inquiry, 2001) and remained constant throughout all task conditions. For example, the first condition consisted of a patient-handling task where the participant transferred the patient without a device or assistance. Initially, the nurse participant was able to view the principal investigator and conduct the movement with cues. If errors were observed during the movement, the participant repeated the movement until no error was detected. When the nurse participant performed the task without errors, the transfer was repeated without cues.

The patient-handling task was categorized by each task element: preparation, actual movement and completion. Each condition was repeated for three trials. After completion of the first trial, the participants provided a VAS rating of the preparation phase of the transfer—their perceived exertion and perceived injury risk. After the second trial was conducted, participants rated the movement phase and, after the third trial, they rated the completion phase. Participants were cued for each response by visual representations of the Borg RPE Scale and VAS. Upon completion of each condition, participants took a rest period of two minutes. This procedure continued until the participants practiced all 16 conditions.

4.2.6.2 Task Simulation

The familiarization and task simulation sessions were separated by at least 48 hours to ensure that there was no residual fatigue from the previous session. The two sessions were separated by no longer than one week as a longer time span may affect reliability. To ensure against time of day bias, both sessions were conducted at approximately the same time. During the task simulation session, participants performed the patient-handling tasks under all 16 conditions and data were collected. Upon arrival at the task simulation session, participants were given an opportunity to practice both the transfer movements and the use of the gait belt. They were reminded to provide ratings of perceived exertion and to mark the VAS after completion of each task element. All procedures continued as outlined in the familiarization and practice session (Section 4.2.6.1) until all 16 conditions were completed. Safety was a priority for all participants involved; if a participant felt any concern, the researcher stopped the task. All participants received monetary compensation for their time and all videotaped recordings remained confidential.

4.3 Data Analysis

A four-factor repeated measures analysis of variance (ANOVA) was conducted to determine significant differences between task, assistive device, assistance from another person and task element and their interactions on the subjective measures. If significant differences were found, post-hoc comparisons were conducted using a Tukey-Kramer HSD test. Normality was confirmed using the Shapiro-Wilk test. For all tests, statistical significance was defined as $p < .05$. The statistical model that represents the experimental design was:

$$\mathbf{Y} = \mu + \alpha_i + \beta_j + \delta_k + \lambda_l + \gamma_n + \alpha\delta_{ik} + \alpha\lambda_{il} + \beta\delta_{jk} + \beta\lambda_{jl} + \delta\lambda_{kl} + \alpha\delta\lambda_{ikl} + \beta\delta\lambda_{jkl} + \rho_m + \varepsilon_{o(ijklmn)}$$

where,

μ = Population mean
α= Task, i = type of task
β= Device, j = with/without
δ= Level of assistance, k = one- or two-person lift
λ = Task element, l = (preparation, movement, completion)
γ = Participants, n = participant number
ρ = Task order, m
ε = Random error
o = Random error index

4.4 Results

4.4.1 Ratings of Perceived Exertion (RPE)

Significant effects on RPE were observed for level of assistance ($p < 0.001$), task element ($p < 0.001$) and their interaction ($p = 0.005$). RPEs for movements with and without assistance were 2.3 (1.3) and 3.1 (1.7), respectively. The largest levels of perceived exertion were reported for the movement element (3.6 (1.7)), followed by completion (2.5 (1.5)) and preparation (1.9 (0.9)). The assistance x task element interaction (Figure 8) was evident as a different effect of assistance between the elements. Assistance reduced RPE more substantially during movement and completion, in comparison with preparation. RPEs were consistent across tasks ($p = 0.20$), though they tended to be slightly higher for tasks involving moving patients out of bed versus back to bed (mean RPEs of 3.0 and 2.9, respectively). While not significant as a main effect ($p = 0.087$), use of an assistive device resulted in 5.6% lower RPEs. No other interactive effects were significant ($p > 0.42$).

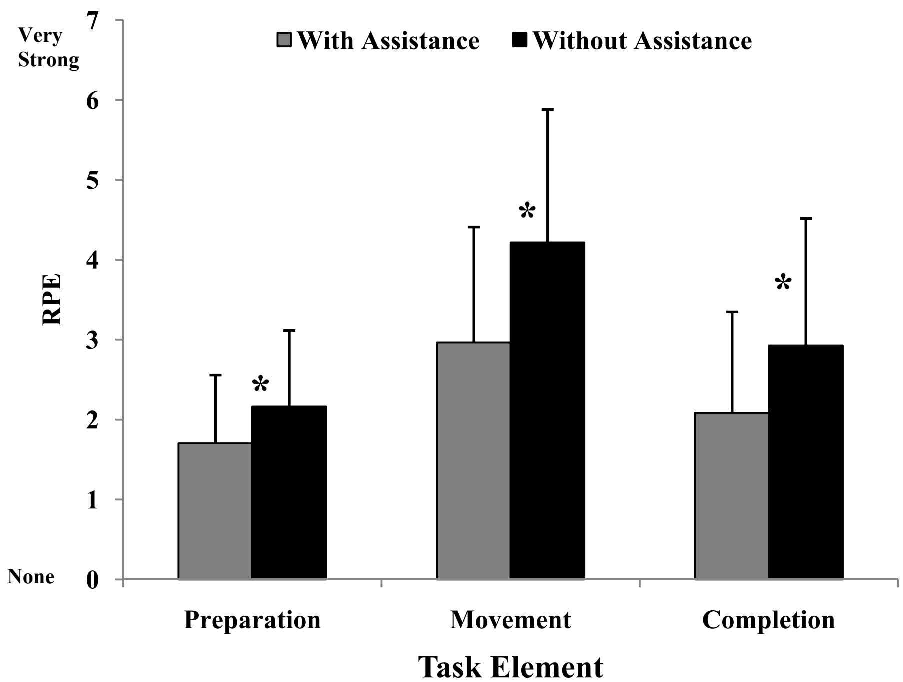


Figure 8: Rating of Perceived Exertion (RPE) by Level of Assistance and Task Element. Error bars indicate standard deviations and * indicates a significant effect of assistance.

4.4.2 Ratings of Perceived Injury Risk (PIR)

Significant effects on PIR were observed for level of assistance ($p < 0.001$), use of an assistive device ($p = 0.046$), task element ($p < 0.001$) and the interaction of level of assistance on task element ($p = 0.004$). PIRs for movements with and without assistance were 1.7 (1.2) and 2.8 (1.9), respectively. Use of an assistive device yielded lower PIR. On average, PIR for movements with and without the use of an assistive device were 2.1 (1.6) and 2.4 (1.8), respectively. The largest levels of perceived injury risk were for the movement element (3.1 (2.0)) followed by completion (1.9 (1.4)) and preparation (1.7 (1.2)). The assistance x task element interaction was caused by a different effect of assistance between the elements (Figure 9). PIRs were consistent across tasks ($p = 0.13$), though they tended to be slightly higher when moving patients out of bed versus back into bed (mean PIRs of 2.2 and 2.3, respectively). No other interactive effects were significant ($p > 0.16$).

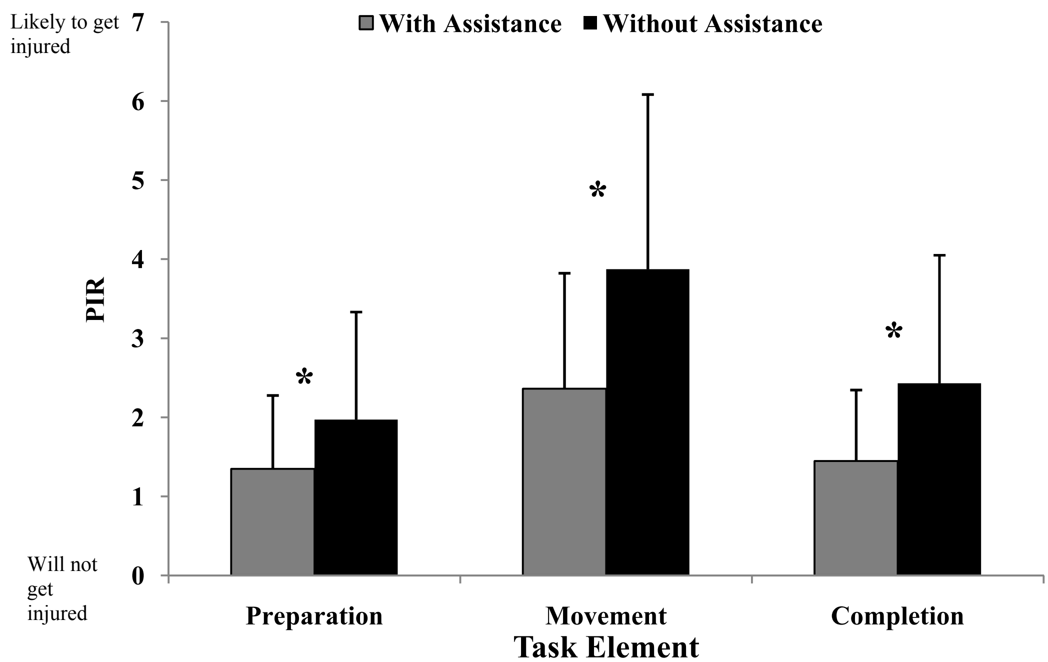


Figure 9: Rating of Perceived Injury Risk (PIR) by Level of Assistance and Task Element. Error bars indicate standard deviations and * indicates a significant effect of assistance.

4.4.3 Correlations Between RPE and PIR

Across all conditions, the correlation between RPE and PIR was 0.718, and ranged from 0.644 to 0.752 across different levels of the independent variables (Table 9). Additionally, the correlations demonstrated a consistent relationship between RPE and PIR, with perceived exertion consistently higher than perceived injury risk.

Table 9: Comparisons and Correlations Between RPE and PIR

Independent Variables	Independent Variables	RPE*	PIR	Correlation† (r values)
Task	Bed to Chair	2.81 (1.59)	2.28 (1.58)	0.724
	Bed to Commode	2.72 (1.52)	2.33 (1.73)	0.699
	Chair to Bed	2.61 (1.62)	2.09 (1.65)	0.743
	Chair to Commode	2.56 (1.50)	2.25 (1.81)	0.720
Assistance	With	2.25 (1.32)	1.72 (1.21)	0.752
	Without	3.10 (1.67)	2.76 (1.94)	0.671
Assistive Device	With	2.60 (1.55)	2.13 (1.57)	0.729
	Without	2.74 (1.57)	2.35 (1.81)	0.710
Task Element	Preparation	1.93 (0.93)	1.66 (1.20)	0.644
	Movement	3.59 (1.68)	3.12 (2.01)	0.657
	Completion	2.51 (1.49)	1.94 (1.40)	0.715
Overall		2.68 (1.56)	2.24 (1.70)	0.718

* All RPE scores were significantly ($p<0.001$) greater than PIR scores.
† All correlations were significant ($p < 0.001$).

4.5 Discussion

Nurses continue to have one of the highest injury incidence rates compared to other professions or occupations (Bureau of Labor Statistics, 2004, 2006, 2007). While there does not appear to be a specific method for health care workers to safely lift or move patients manually, nurses are routinely called upon to assist with lifting, transferring and repositioning dependent patients. Thus, this study evaluated the effect of an assistive device and assistance from another person on perceptions of exertion and injury risk in order to understand this relationship and gain insight into some of the problems involved in patient handling.

Nurses perceived that lifting with assistance from another person decreased their physical exertion and injury risk; these decreases were relatively consistent across the study conditions. This finding is consistent with that of Restas and Pinikahana (2000) who reported that nurse participants believed having assistance when lifting a patient would avoid risk of injury to both themselves and their patients. However, Engkvist (2004) prospectively investigated accident processes among nursing personnel, and found that in 61% of the injuries investigated, two or more nurses assisted during transfers. Further, Marras et al. (1999) reported that manual transfers of patients in and out of bed resulted in high spinal loads and risk of low back injuries regardless of whether the transfers were performed by one or two people. These prior results, along with that of the present study, suggest a potential mismatch between perceived and actual injury risk. As such, education should be provided to nurses and other health care providers focusing on the role of assistance from another person and the fact that an injury risk remains regardless of additional personnel.

Not surprisingly, the movement element in all tasks had the highest levels of perceived exertion and injury risk. Indeed, the most substantial movement of the patient takes place during the movement phase, and thus can be expected to require the highest levels of physical effort. Comparable findings were found by Vieira (2007), who divided patient transfers into three phases: preparation, positioning and pulling. The pulling phase is similar to the present study's movement element and was where estimated spinal compression was highest, suggesting that this phase was more physically demanding. Perceived exertion and injury risk were relatively higher for the completion than the preparation phases. This is consistent with the observation that more physical tasks are performed as part of the completion phase, including fixing bed linen and ensuring that the patient is properly positioned in bed.

Nurses perceived physical exertion (RPE) to be relatively higher than the risk of incurring injury (PIR) for all the combinations of assistance, equipment and specific tasks. On average, exertion was rated as moderate and perceived injury risk as less than moderate. This difference suggests that nurses perceive the amount of physical exertion they perform to be greater than their perceived risk of injury. The correlations demonstrated that the perceived exertion (RPE) and injury risk (PIR) ratings were significantly, although moderately, correlated ($r = .658$). RPE is a categorical measurement using whole and half units while PIR is measured on a continuous scale. Despite the difference in scales of measurement, the results in this study were very similar. The same effects were found for both dependent measures and this is supported by the correlations. This may also suggest that both variables—perceived exertion and perceived risk of injury—may be addressing the same thing and future work may not need to use both measures. In future studies, these scales may require calibration by the participants.

Furthermore, the relationship of perceived exertion and injury risk that is demonstrated in this study is consistent with the evidence that nurses underreport injuries. French et al. (1997) found that, although nurses experience some form of back pain, 92% did not report this to their employers. Reasons for this underreporting may include dedication to their patients and their job. Nurses perceive that reporting back pain decreases their ability to conduct patient care (Bulaitis, 1992). Nurses may also believe that back pain is an inevitable part of their job, resulting in even greater underreporting (Malone, 2000). This was supported by Siddharthan's (2006) findings that older health care workers and those with more experience were less likely to report injuries. Additional reasons for underreporting cited by Siddharthan (2006) included peer pressure, frustration with workers' compensation procedures and the time involved with reporting.

There is strong evidence that patient handling is the precipitating event in the majority of back injuries among nursing staff (Garg & Owen, 1992; Goldman et al., 2000; Marras et al., 1999; Nelson & Baptiste, 2006; Nelson et al., 2006). The evidence demonstrates that patient-handling equipment decreases the physical demand on workers. Advancement of technology has produced a variety of assistive lifting devices for patient-handling tasks including overhead ceiling lifts (portable and fixed), stand assists, lateral transfer devices, friction-reducing devices and gait belts. Although studies have demonstrated that the use of an assistive device decreases biomechanical forces throughout the spine (Garg et al., 1991; Marras et al., 1999; Ulin et al., 1997), nurses still opt to manually move patients, even when assistive devices are present. This is consistent with the earlier observational findings (Chapter 3). Although assistive devices were available, 87% of the nurse participants reported that they did not use them. This may be due to several influences. Nelson and Fragala (2003) found nurses do not use assistive devices during the course of their workday because (1) they perceive that using assistive devices takes more time and devices may not be available when needed, (2) assistive devices may be difficult to use, (3) there may be space constraints within the room or (4) the patient may prefer a manual transfer rather than being transferred using an assistive device.

Another reason for decreased equipment use may be the different attitudes humans have developed about automation and technology. Often these attitudes are formed by the reliability or accuracy of the technology (Parasuraman, 1997; Vicente, 2003) or their trust in the technology and their self-confidence in their abilities to control the system (Bisante & Seong, 2001). Few technologies gain instant acceptance when introduced into the workplace. Human operators may initially dislike and even mistrust new automated systems. As experience is gained with the new system, automation that is reliable and accurate will tend to earn the trust of the user. When corporate policy mandates the use of automation or technology, operators may resort to creative methods to disable devices. To avoid this, it is imperative that users are trained in the use of technology to increase their self-confidence.

Several limitations were present in the current study. Participation was voluntary, and no effort was made to balance participation across job titles (e.g., by stratified sampling). Therefore, the resulting sample had unequal numbers of nurses for each job title. Specifically, there were many more RNs than LPNs/LVNs or NAs. Though the proportions were representative of nurses in acute care facilities, some caution is warranted regarding analyses involving comparisons between job titles. This study was conducted in a laboratory setting rather than an occupational setting, and may limit external validity. Furthermore, a “cooperative” patient was used which may not be an accurate simulation of dependence. The simulated tasks were primarily movements in and out of the bed. As found in Chapter 3, lateral movements and repositioning tasks are also performed frequently throughout acute care hospitals, but such tasks were not included in this study.

Several primary results emerged from this study. First, assistance from another person decreased perceived exertion and injury risk in all experimental conditions. These perceptual changes are contradictory to evidence demonstrating that assistance (or sharing the burden) does not substantially decrease injury risk. Second, the movement element of all tasks was perceived to have the highest levels of exertion and injury risk. As such, future efforts to reduce injury might focus initially on this element. Third, nurses perceive physical exertion to be greater than the perceived injury risk regardless of task, level of assistance or use of an assistive device. This perception by nurses indicates a need for education on the cumulative injury process and the role of assistive devices in decreasing injury risk. Although this study focuses on perceived patient-handling exertion and injury risk from patient movements in and out of bed, it lays the foundation for future research on exertion and injury risk during lateral transfers and repositioning of patients. Further, the findings of this study may provide a starting point in developing interventions specifically targeting tasks moving patients in and out of bed and thereby reducing the risk of injuries related to patient handling.

5.0 A Comparative Analysis of Expert Ratings of Patient-Handling Tasks

Abstract

Background: Musculoskeletal disorders account for the majority of occupational injuries and illnesses resulting in lost work time and compensation expenditures. Nursing staff are consistently among the top 10 occupations experiencing work-related musculoskeletal disorders. These injuries have been attributed to the physically demanding nature of the tasks nurse perform during the course of their day. Patient handling remains a frequent and necessary task and therefore, it is important to identify methods experts can use in the nursing field that would capture the magnitude of the exposures and demonstrate inter-rater reliability.

Methods: Three groups of participants were involved, with different levels of ergonomics expertise (i.e. researchers, consultants, and graduate students). Participants evaluated four patient-handling tasks with different levels of assistance and assistive device, and these evaluations were then compared to nurses' ratings of the same tasks obtained earlier (Chapter 4).

Results: Three major findings were obtained. First, the movement element of all tasks was perceived to have the highest exertion, injury risk and risk factor rating for all expert groups. Second, the ratings provided by researchers, consultants, and students demonstrated poor agreement with the nurses' ratings. Third, in the risk factor analysis, poor agreement was observed in posture and speed.

Conclusions: It is important that health care providers who handle and move patients understand that the highest levels of physical demands, and hence injury risk, are most likely to occur with the movements associated with patient handling. Furthermore, it should be recognized that expert ratings are the first step in identifying and eliminating ergonomic hazards within the workplace. Additional studies are needed to provide insight on expert ratings and how experts integrate time-varying activities when assessing ergonomic hazards.

5.1 Introduction

Nurses play an important role within the health care system, providing primary, secondary and tertiary level health care. In 2005, the nursing occupation ranked third with the most cases of time away from work due to musculoskeletal injuries (Bureau of Labor Statistics, 2006). These injuries are, in large part, a result of the physically demanding nature of the tasks nurses perform during the course of their workday. These tasks often require frequent manual lifting and transferring of patients between beds, stretchers, wheelchairs, toilets and showers, and repositioning patients in beds. Existing evidence suggests that the physical demands required for such tasks exceed the capabilities of health care workers (Collins et al., 2004; Jang et al., 2007; Marras et al., 1999) and may result in musculoskeletal disorders.

Decreasing retention is a contemporary problem in the nursing profession, with some evidence suggesting that more than 40% of the current working RN population planned to leave their positions within the next three years (Steinbrook, 2002). One reason for this is the exposure to physical stress. For example, Stubbs et al. (1986) indicated that as many as 12% of nurses leave the profession each year due to back injury. A reduction in the supply of nurses, and an increasing demand for trained health care professionals, clearly suggest that access to health care and the quality of that care could be threatened in the years ahead. While research and intervention has made progress in preventing career-ending injuries, it is difficult to apply current evaluative tools to the complex nursing profession, potentially preventing the validation of assessments.

Reducing hazards within the workplace begins with identification of exposure to potential risk factors, and employers have explored several strategies to identify and control exposures within the work environment. They often consult ergonomists who visit the workplace in order to evaluate and rate ergonomic stressors known to cause fatigue, discomfort and injury. Experts identify those jobs, tasks or task elements that can lead to discomfort or injury and then propose methods for reducing the workers' exposure to risk factors. Trained workers or other employees who possess varying degrees of familiarity with the jobs they assess are also used to identify risk. However, assessments provided by different experts can differ. For example, Winnemuller et al. (2004) compared assessments provided by ergonomists, workers and supervisors, and found that supervisors and workers tended to overestimate the presence of risk.

Job analysis is a method that documents workplace hazards through risk identification, design or redesign of ergonomic interventions and quantification of physical exposures. Ergonomists and other experts use different analysis methods to identify and evaluate the magnitude of these hazards. For example, Lowe (2004a; Lowe, 2004b) employed an observational analysis method to evaluate the accuracy of observational estimates involving risk factors associated with WMSDs of the upper extremities. A variety of methods were used, including direct instrumentation of the upper extremity (electrogoniometer and motion capture), videotaping, and job simulation. Several limitation of these methods were demonstrated: ergonomists made errors in the classification of peak and most frequently occurring postures, inter-rater agreement among job ratings was lower for some postures and self-reported years of experience did not accurately predict upper extremity postures.

Experts employ a variety of methods when conducting workplace evaluations. Assessment tools such as the Strain Index (Moore & Garg, 1995) and the Rapid Upper Limb Assessment (McAtamney & Corlett, 1993) evaluate the worker's exposures to postures, forces and muscles activities that could result in the development of a WMSD. An acceptable score in either of these assessment tools does not guarantee that the workplace is free of ergonomic hazards, nor does an unacceptable score assure that a problem exists. These tools detect the presence of work postures or other risk factors that require further attention. Limitations with these tools include:

- They represent merely a snapshot in time of the work cycle. If the work cycle is long or postures are varied, multiple snapshots may be needed.
- Their assessments may not consider all risk factors.

- They might be appropriate only for single repetitive tasks.
- Because the assessment might consist of subjective elements and may be more complex than simple ratings, multiple experts may be needed to reach consensus.

Experts and employers have used various assessments methods to evaluate the level of worker exposure to risk factors. Because of the wide variety of both the assessment tools and the items being assessed, it is difficult to determine a ’best’ tool for evaluating hazards in the workplace. For example, because patient-handling tasks vary in complexity and style, it would be difficult for a researcher to observe all postures adopted by nurses in the performance of daily tasks. Further, as seen in Lowe’s studies (2004a), accuracy decreased when a researcher observed frequent and multiple postures. Using a simple scoring scheme (three categories), Keyserling and Wittig (1988) compared expert scores to a quantitative measure (NIOSH lift equation). Consistent agreement was observed for 30% of the scores and consensus was also demonstrated for 87.5% of the scores. These results indicated the experts’ ratings generally agreed with NIOSH ratings. Such findings could imply that less complex scoring schemes could decrease variability among the raters. Because of this variability, it is important to identify methods experts can use in the field that would capture the magnitude of the exposure(s). Optimally, this method should demonstrate inter-rater reliability and consistency with objective measures (e.g., NIOSH lift equation). If there is consistency in ratings, this may imply that the appropriate method or tool is being used, and that the group understands the rating scheme. If there is divergence in the ratings, this may imply the method or tool may be too complex and calibration is needed for the tool. The aim of this study was to determine the level of agreement within and between the expert (researchers, consultants and students) ratings and the nurses' subjective ratings.

5.2 Methods and Materials

5.2.1 Overview

This study involved three groups of participants with different levels of ergonomics expertise (researchers, consultants, and doctoral students) who evaluated video segments of simulated nursing tasks obtained earlier (Chapter 4). Participants evaluated four patient-handling tasks with different levels of assistance (one- or two-person lift) and assistive devices (with and without a device). Ratings were provided for each task element (preparation, movement and completion), with respect to exertion and injury risk. Participants also rated effort, posture and speed of each task element for different body parts such as upper and lower back and extremities.

5.2.2 Experimental Goals

The goals of this research were to:

1. Assess the level of inter-rater agreement on the risk exposure-level ratings among the raters with different levels of expertise (researchers, consultants and students).
2. Evaluate the agreement between the expert ratings of the risk factors and the nurses' subjective responses taken from the prior study (RPE and PIR).

5.2.3 Experimental Design

A full-factorial repeated measures design was used, in which five independent variables were manipulated: the patient-handling task, level of assistance, use of an assistive device, task elements and participant expertise. Participant ratings of each task and element were recorded as dependent measures.

5.2.4 Participants

Three different groups of participants (three individuals within each group) analyzed videotape segments taken from Chapter 4. Participants had varying levels of experience in physical ergonomics, specifically identifying physical risk factors within occupational tasks (Table 10). One group consisted of researchers within the ergonomics community, currently teaching in a University-level ergonomics program. Another group included ergonomics consultants who had a minimum of five years' experience identifying physical risk factors within occupational tasks. The third group of experts consisted of ergonomics doctoral students with one year of completed study, conducting research in the area of physical ergonomics.

Table 10: Participant Groups, Inclusion Criteria and Demographics

Participant Group	Inclusion Criteria	Demographics
Researchers	Currently teaching in a University-level ergonomics program	Age Range: 31-52 y/o 3-5 years of experience
Consultants	Minimum of five years' experience working in the area of physical ergonomics	Age Range: 31-32 y/o 7-11 years of experience
Doctoral Students	One year of completed study, conducting research in the area of physical ergonomics	Age Range: 26-27 y/o

5.2.5 Independent Variables

The participants evaluated video segments of simulated nursing tasks obtained from Chapter 4. The independent variables (also from Chapter 4) included the patient handling task (Section 4.2.4.1), level of assistance (Section 4.2.4.2), assistive device (Section 4.2.4.3), and task element (Section 4.2.4.4). The level of expertise among the experts was also added as an independent variable.

5.2.6 Dependent Variables

5.2.6.1 Rating of Perceived Exertion

Subjective assessments of perceived exertion were obtained using the Borg RPE Scale (Borg, 1970). This scale (Figure 6) has values that range from 0-10, although participants were permitted to go beyond 10, which represents maximal exertion.

5.2.6.2 Rating of Perceived Injury Risk

Experts involved in this study rated the PIR for each element (preparation, actual movement, and completion) of the patient-handling task. A VAS was used to obtain this measure (Figure 7). This question was framed as the PIR when performing each task once a day for six months.

5.2.6.3 Ratings of Effort, Posture and Speed

Participants rated the nurses' performance of patient-handling movements in the following categories: effort, posture and speed. They provided ratings after each task: preparation, actual movement and completion. Experts viewed all 16 nursing participants performing the task element in each condition and provided a mean score for all participants.

Experts often use the Strain Index (Moore & Garg, 1995) to identify jobs with high risk for distal upper extremity morbidity. The tool consists of six variables rated on a scale of 1-5, with 5 being the most extreme or "worst case." Each rating has a corresponding multiplier, and the product of the multipliers gives the Strain Index score. A score of 3 or less is considered safe, while a score of 7 or greater is considered hazardous. Scores between 3 and 7 are borderline and require further analysis. The tool requires knowledge of time and motion studies, and multiple raters are used to reach a consensus on variable values. The Strain Index has been validated in several studies conducted in different work environments (Knox & Moore, 2001; Moore et al., 2001; Rucker & Moore, 2002). The rating categories used in this study, and defined below, are taken from the Strain Index.

<u>Effort</u>
1. Barely noticeable or relaxed effort
2. Noticeable or definite effort
3. Obvious effort; unchanged facial expression
4. Substantial effort; changes facial expression
5. Uses shoulder or trunk to generate force

<u>Posture</u>
1. Perfectly neutral
2. Near neutral
3. Non-neutral
4. Marked deviation
5. Near extreme

<u>Speed</u>
1. Extremely relaxed pace
2. “Taking one’s own time”
3. “Normal” speed of motion
4. Rushed, but able to keep up
5. Rushed and barely or unable to keep up

5.2.7 Experimental Procedures

Participants received verbal and written information regarding the purpose, goal and methods of this study. Participants were given an opportunity to ask any questions pertaining to this study and then asked to read and sign an informed consent form provided by the Virginia Tech IRB. All participants were required to fill out a demographic sheet. Following this, participants were given time to become familiar with the tasks and assessment method. The preliminary session involved viewing a digitized video clip and reviewing the rating scale. Participants practiced the assessment method by viewing a manual materials-handling task and rating the elements of the task by using the proposed rating scheme (RPE, PIR and risk factor rating).

When participants expressed comfort with the assessment method and the rating scheme (Figure 10), they viewed the patient-handling digitized clips. Participants viewed all 16 nursing participants performing the task element in each condition, in random order, and then provided a mean score for RPE, PIR posture, effort and speed. No time limits to complete the task were placed on the participants; however, they were instructed to work for one-hour time periods, with rest breaks of 10 minutes between each hour.

	Posture			Effort			Speed		
Subtask Description	**Lower Back**	**UE**	**LE**	**Lower Back**	**UE**	**LE**	**Lower Back**	**UE**	**LE**
Preparation									
Movement									
Completion									

Task No.	Borg (0~10)	VAS Marking (Mark)	VAS
Prep		**Least** |————| **Most**	
Move		**Least** |————| **Most**	
Comp		**Least** |————| **Most**	

Figure 10: Rating Sheet

5.3 Data Analysis

A five-factor analysis of variance (ANOVA) was used to assess the effects of expertise level (nurses and the three experts groups), task, task elements, assistance level and assistive device usage (nested within task). The statistical model that represents the experimental design is:

$$Y = \mu + \alpha_i + \beta_{j(i)} + \delta_k + \lambda_l + \rho_m + \gamma_{n(m)} + \alpha\delta_{ik} + \alpha\lambda_{il} + \alpha\rho_{im} + \beta\delta_{j(i)k} + \beta\lambda_{j(i)l} + \beta\rho_{j(i)m} + \delta\lambda_{kl} + \delta\rho_{kn(m)} + \lambda\rho_{ln(m)} + \alpha\delta\lambda_{ikl} + \alpha\delta\rho_{ikm} + \alpha\lambda\rho_{ilm} + \beta\delta\lambda_{j(i)kl} + \beta\delta\rho_{j(i)km} + \beta\lambda\rho_{j(i)lm} + \alpha\delta\lambda\rho_{iklm} + \beta\delta\lambda\rho_{j(i)klm} + \varepsilon_{o(ijklmn)}$$

where,

μ = Population mean
A: α = Task, i = type of task
B: β = Device, j = with/without
nested within task
C: δ = Level of assistance, k = one- or two-person lift
D: λ = Task element, l = (preparation, movement, completion)
G: ρ = Expert group (Nurses, Researchers, Consultants, Students), m
S: γ = Participants, n = participant number
nested within nurse/expert group
E: ε = Random error, o = random error index

Where relevant, Tukey's HSD was used post-hoc to compare pairs of tasks. For all tests, statistical significance was defined as $p < 0.05$. To evaluate the extent of agreement within and between the participant groups, a Kendall's coefficient of concordance (or, Kendall's *W*) was used to compare the RPE/PIR ratings for all tasks. Coefficients were categorized as follows (Fleiss, 1982): < 0.40: poor, 0.40 – 0.75: fair to good, and greater than 0.75: excellent. Additionally, the nonparametric Spearman's correlation coefficient was used to assess the relationship of expert raters' risk ratings to the nurses' subjective measures such as the Borg and VAS. Normality was confirmed using the Shapiro-Wilk test. While the statistical analyses included five factors, the presentation of results is limited to main and interactive effects involving participant group (nurses and the three expert groups).

5.4 Results

5.4.1 Ratings of Perceived Exertion

Significant effects on RPE were observed for expertise level ($p < 0.001$), task element x expert ($p < 0.001$) and task x task element x expert ($p < 0.001$). Consultants reported the highest exertion (4.4 (2.4)), followed by researchers (3.0 (1.9)), students (2.8 (1.4)) and nurses, (2.7

(1.6)). The interaction of task element by expert found that the movement element demonstrated the highest RPE for all expert groups; however, nurses perceived the completion element to have higher exertion than preparation, while the other expert groups perceived the opposite effect (Figure 11).

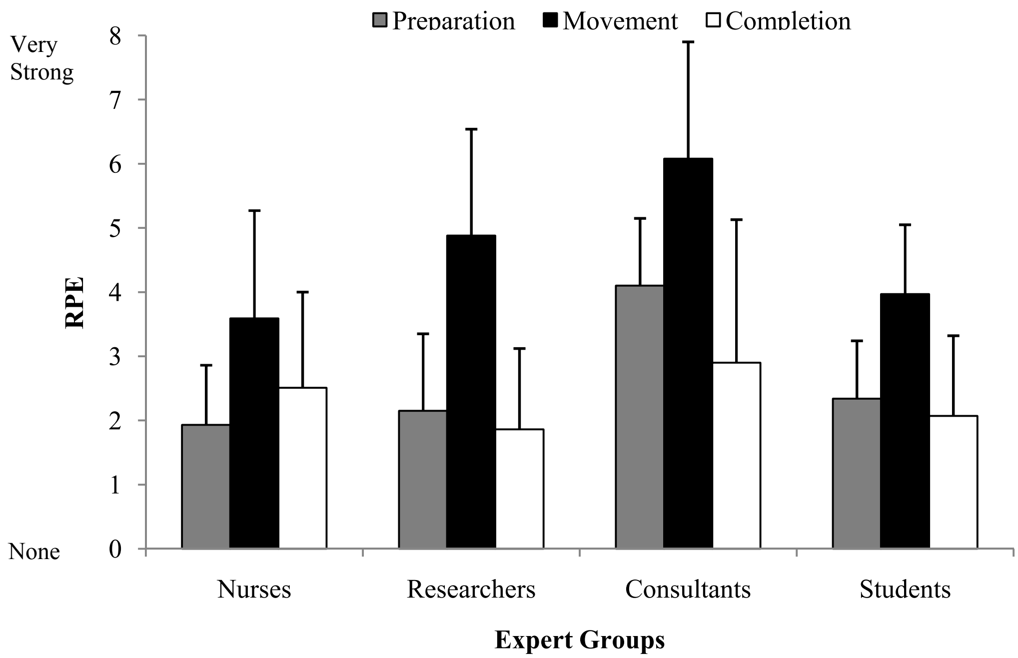


Figure 11: Rating of Perceived Exertion (RPE) by Expert Group and Task Element
Error bars indicate standard deviations

A significant second-order interaction was observed for task x task element x expert (Figure 12). All expert groups indicated that the movement element demonstrated the highest level of exertion. Consultants rated RPE the highest in all phases except for the completion phase for tasks out of bed. Nurses demonstrated a similar trend in RPE for all tasks and task elements. Regardless of task, nurses reported the largest levels of RPE for the movement element, followed by completion and preparation. For transfers out of bed, researchers, consultants, and students perceived the preparation element as having a higher RPE than the completion phase; however, nurses perceived the completion phase to be higher in exertion than preparation. Similarly, for transfers into bed, researchers, consultants, and students perceived the completion phase having higher RPE, whereas nurses perceived the preparation phase as higher.

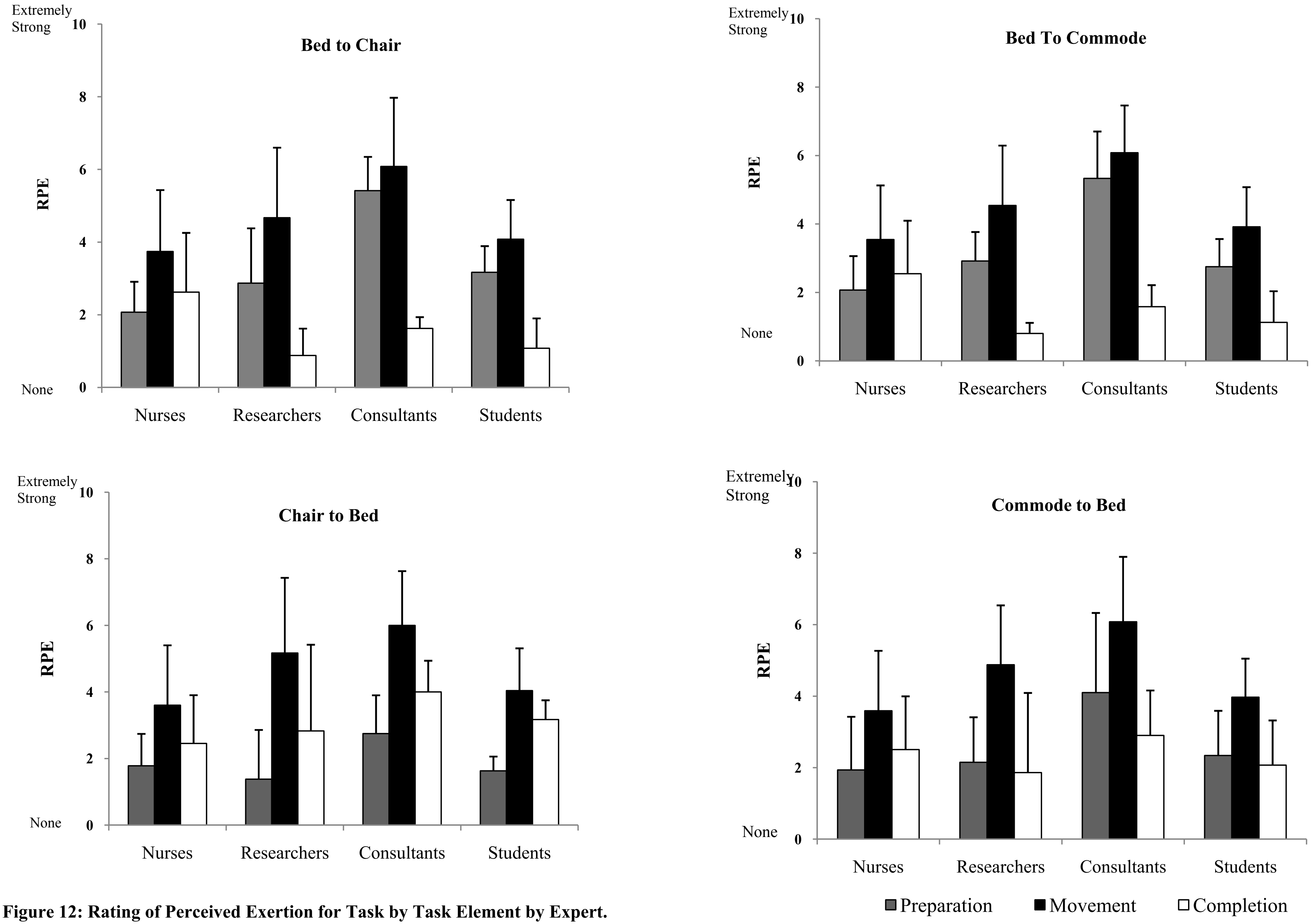


Figure 12: Rating of Perceived Exertion for Task by Task Element by Expert. Error bars indicate standard deviations

5.4.2 Ratings of Perceived Injury Risk

Significant effects on PIR were observed for expert group ($p < 0.001$), task element x expert ($p < 0.001$) and task x task element x expert ($p < 0.001$). Consultants reported the highest PIR (3.8 (2.7)), followed by students (3.0 (1.8)), researchers (2.3 (2.1)) and nurses (2.2 (1.7)). While the movement element demonstrated the highest PIR among all groups (Figure 13), nurses perceived completion to have higher PIR than preparation, where the researchers, consultants, and students perceived preparation to be higher than completion.

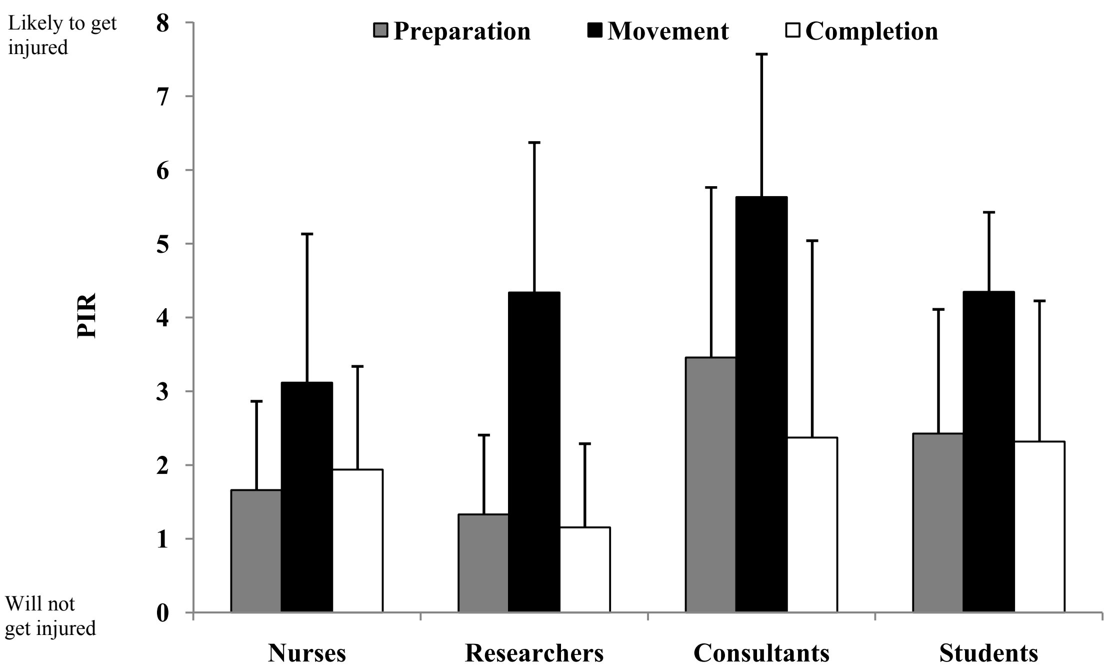


Figure 13: Rating of Perceived Injury Risk (PIR) by Expert Group and Task Element. Error bars indicate standard deviations.

A significant second-order interaction was observed for task x task element x expert (Figure 14). All expert groups agreed the movement element demonstrated the highest PIR. Across all tasks, consultants provided the highest ratings in all phases except for the completion phase for tasks out of bed. Nurses demonstrated a similar trend in PIR for all tasks and task elements. For example, the largest levels of PIR were reported for the movement element followed by completion and then preparation. For transfers out of bed, researchers, consultants, and students perceived the preparation element as having a higher injury risk than the completion phase; however, nurses perceived the completion phase as higher in PIR than the preparation phase. For transfers from chair to bed, all expert groups (nurses, researchers, consultants, and students) perceived the completion phase as a higher injury risk. However, for transfers from the commode to the bed, researchers, consultants, and students perceived the preparation phase to involve higher injury risk and nurses again perceived the completion phase as having higher injury risk.

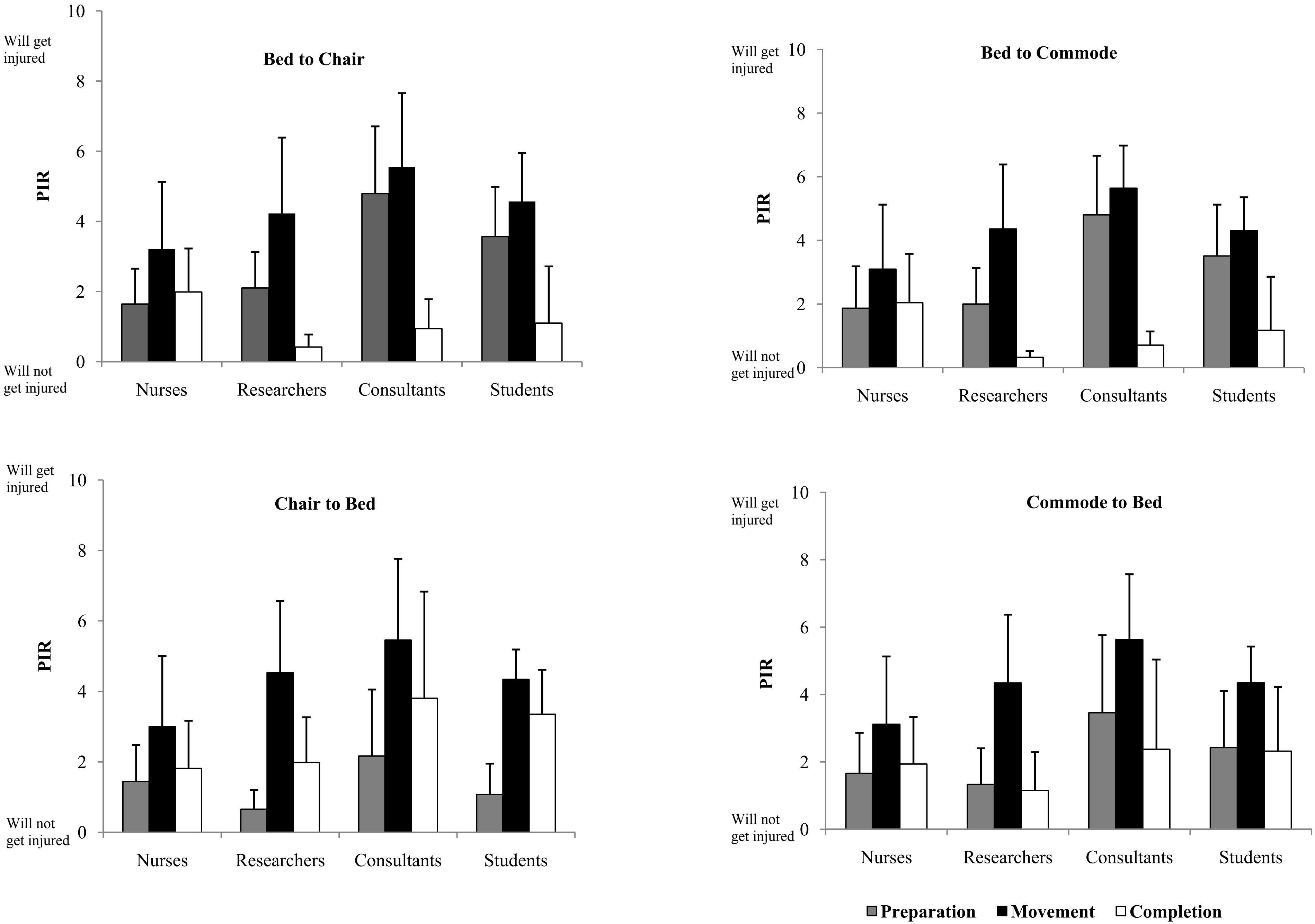
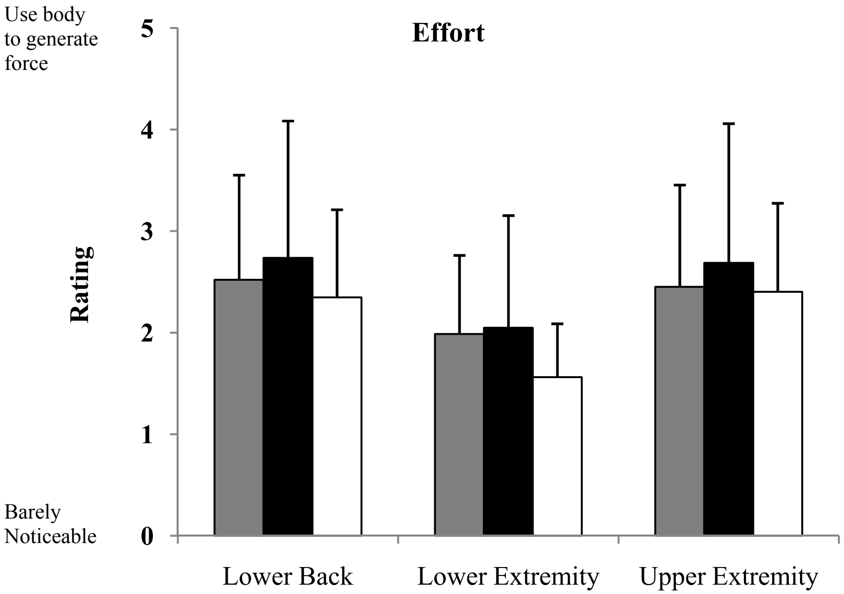


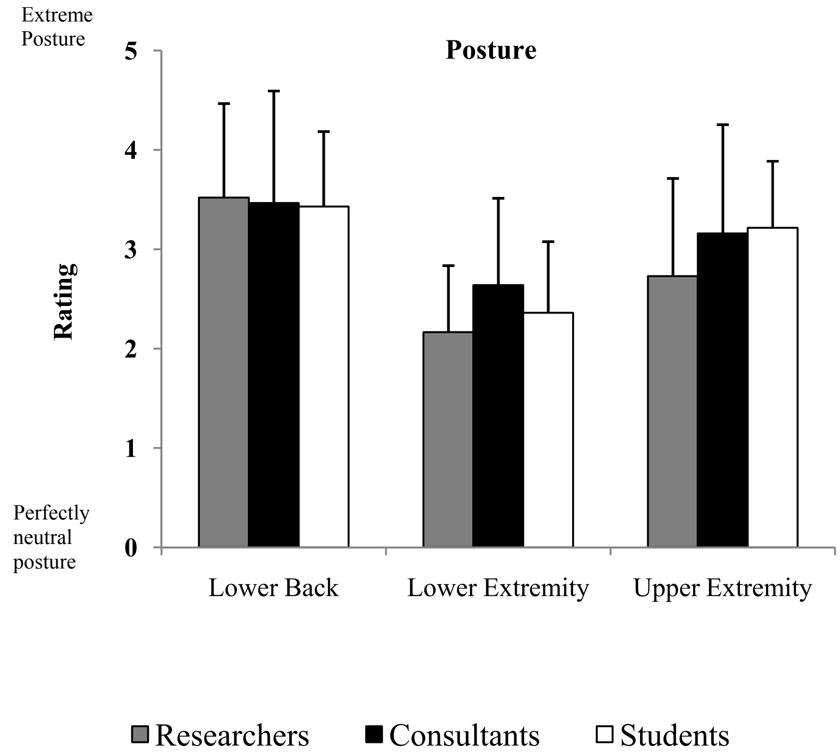
Figure 14: Rating of Perceived Injury Risk for Task by Task Element by Expert. Error bars indicate standard deviations

5.4.3 Ratings of Effort, Posture and Speed

Significant effects on effort and posture were observed for level of assistance ($p < 0.001$), task element ($p < 0.001$), expert group ($p < 0.001$) and body part $p < 0.001$). Additionally, significant effects for speed were observed for task element ($p < 0.001$) and body part ($p < 0.001$). Mean effort and posture ratings for "without" assistance were 2.5 (1.1) and 3.1 (1.0) compared to "with" assistance of 2.1 (1.0) and 2.9 (1.0), respectively. As seen previously, the highest ratings were observed in the movement element for effort, posture and speed (3.0 (1.0), 3.2 (0.9) and 3.0 (0.4)), followed by preparation (2.0 (0.09), 3.0 (1.0) and 2.6 (0.6)) and completion (1.9 (0.9), 2.6 (1.0) and 2.5 (0.7)). Consultants reported the highest mean effort rating (2.5 (1.3)) compared to researchers and students (2.3 (1.0)) and (2.1 (0.9)), respectively. The posture ratings were slightly different. Consultants reported the highest mean posture rating (3.1 (1.1)), followed by students and researchers 3.0 (0.8) and 2.8 (1.9), respectively. The highest posture rating was observed for the lower back (3.5 (1.0)), followed by the upper extremity and lower extremity (3.0 (1.0) and 2.4 (0.8). Similar effort ratings were reported for the lower back and upper extremity (2.5 (1.1) and 2.5 (1.2)) followed by the lower extremity (1.9 (0.9)). There were minimal differences in body part on the speed risk factor. The lower back and upper extremity received similar ratings (2.7 (0.7) and 2.7 (0.6)), followed by the lower extremity 2.6 (0.6).

A significant effect was found for effort and posture for the body part x expert group interaction (Figure 15). For effort, all experts provided higher ratings for the lower back and upper extremity compared to the lower extremity. For posture, all experts indicated the lower back to have the highest rating (3.5, (2.2), 3.5 (0.9), 3.4 (0.8)), followed by the upper extremity (3.2 (1.1), 2.7 (1.0), 3.2 (0.7)) and lower extremity (2.6 (0.9), 2.2 (0.7), 2.4 (0.7)). The researchers provided lower ratings for the upper and lower extremities versus the consultants and students. All body parts and experts had similar ratings for speed.





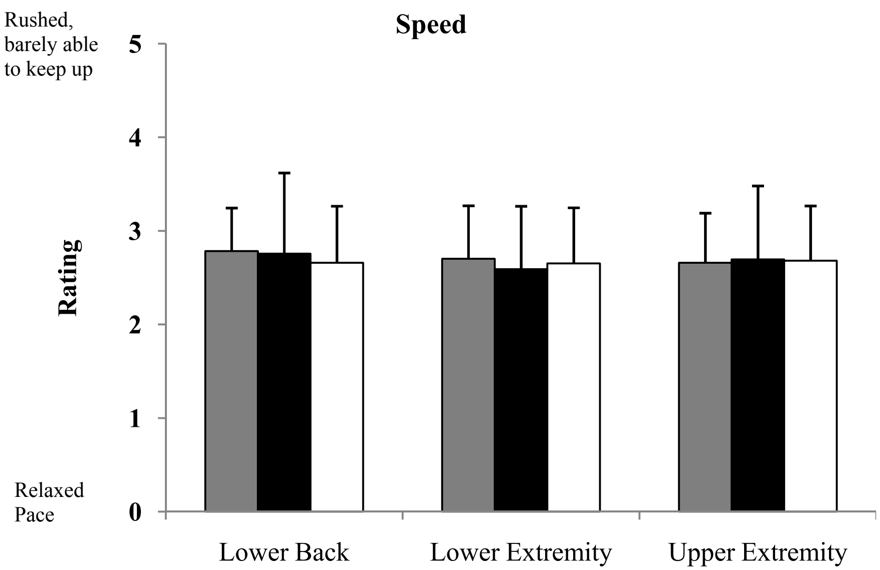


Figure 15: Rating of Risk Factor by Body Part by Expert. Error bars indicate standard deviations

The task x task element interaction demonstrated similar results as seen in Chapter 4. The movement element of all tasks received the highest rating. For tasks moving patients out of bed, the preparation element demonstrated a higher rating than the completion element. An opposite effect was observed for tasks moving patients into bed, with the completion element demonstrating a higher rating than the preparation element.

Significant effects were observed for the body part x task element interaction for effort and posture, but not speed. The movement element had the highest rating for effort and posture followed by preparation and completion. The lower back received the highest rating for effort and posture, followed closely by the upper extremity and lower extremity. For speed, all body parts and task elements received similar ratings.

5.4.4 Agreement Among Participant Groups

Coefficients for RPE are summarized in Table 11. Agreement across all expert groups was fair to good. Researchers and students demonstrated excellent agreement across all tasks. Researchers and consultants, and consultants and students demonstrated excellent agreement for tasks moving patients out of bed; however, the coefficients decreased for tasks moving patients into bed. Nurses and all other expert groups reported poor to good agreement across all tasks.

Table 11: Kendall's Coefficient of Concordance of Perceived Exertion Across All Expert Groups

Expert Groups	Tasks			
	Bed to Chair	Bed to Commode	Chair to Bed	Commode to Bed
All Expert Groups	0.528	0.471	0.564	0.557
Researchers and Consultants	0.841	0.853	0.437	0.564
Researchers and Students	0.964	0.882	0.850	0.875
Consultants and Students	0.828	0.813	0.424	0.460
Nurses and Researchers	0.555	0.465	0.615	0.591
Nurses and Consultants	0.478	0.418	0.514	0.483
Nurses and Students	0.526	0.456	0.612	0.556

Coefficients for PIR are summarized in Table 12. Agreement across all expert groups was fair to good. Researchers and students demonstrated excellent agreement across all tasks. Researchers and consultants and consultants and students demonstrated excellent agreement for tasks moving patients out of bed; however, the coefficients decreased for tasks moving patients into bed. Nurses and all other expert groups reported poor to fair agreement across all tasks.

Table 12: Kendall's Coefficient of Concordance of Perceived Injury Risk Across Expert Groups

Expert Groups	Tasks			
	Bed to Chair	Bed to Commode	Chair to Bed	Commode to Bed
All Expert Groups	0.451	0.460	0.410	0.459
Researchers and Consultants	0.782	0.879	0.467	0.519
Researchers and Students	0.951	0.891	0.800	0.849
Consultants and Students	0.757	0.810	0.355	0.386
Nurses and Researchers	0.445	0.422	0.438	0.485
Nurses and Consultants	0.365	0.373	0.339	0.382
Nurses and Students	0.423	0.383	0.394	0.440

Coefficients for RPE and PIR within each expert group are summarized in Table 13. Across all tasks, all expert groups demonstrated fair to good agreement. Researchers showed the most agreement with each other for both RPE and PIR (Kendall's = 0.678 and 0.755, respectively) followed by students (0.550 and 0.440), nurses (0.531 and 0.385) and consultants (0.477 and 0.383).

For each task, researchers demonstrated the most agreement with each other for both RPE and PIR, followed by students. Consultants demonstrated excellent agreement for tasks out of bed, but poor agreement for tasks into bed for both RPE and PIR. Nurses reported fair to good agreement with RPE, but poor agreement with PIR.

Table 13: Kendall's Coefficient of Concordance of RPE and PIR Across Expert Groups

Expert Group	Task	RPE	PIR
Nurses	Overall	0.531	0.385
	Bed to Chair	0.548	0.405
	Bed to Commode	0.462	0.359
	Chair to Bed	0.588	0.372
	Commode to Bed	0.529	0.417
Researchers	Overall	0.678	0.755
	Bed to Chair	1.000	1.000
	Bed to Commode	0.924	1.000
	Chair to Bed	0.821	0.910
	Commode to Bed	1.000	1.000
Consultants	Overall	0.477	0.383
	Bed to Chair	0.741	0.651
	Bed to Commode	0.812	0.812
	Chair to Bed	0.295	0.212
	Commode to Bed	0.339	0.235
Students	Overall	0.550	0.440
	Bed to Chair	0.939	0.910
	Bed to Commode	0.841	0.813
	Chair to Bed	0.891	0.778
	Commode to Bed	0.752	0.709

Coefficients for the risk factors (effort, posture and speed) are summarized in Table 14. Fair to good agreement was observed for effort, specifically in the lower back. This agreement was observed for all experts, pairs of experts and within expert groups, except for consultants. Poor agreement was demonstrated among the consultants for effort in all body parts. Researchers and students demonstrated a fair to good agreement for effort in the upper and lower extremity, while researchers and consultants demonstrated poor agreement for effort in the lower and upper extremity. For effort researchers demonstrated fair to excellent agreement, consultants demonstrated poor agreement and students demonstrated fair to good agreement in all body parts. Poor agreement was observed for posture and speed for all experts, pairs of experts and within expert groups.

Table 14: Kendall's Coefficient of Concordance of Risk Factors Across Expert Groups

	Effort		
Expert Group	**Lower Back**	**Lower Extremity**	**Upper Extremity**
All Expert Groups	0.537	0.375	0.390
Researchers and Consultants	0.540	0.332	0.388
Researchers and Students	0.657	0.496	0.481
Consultants and Students	0.436	0.320	0.323
Researchers	0.765	0.539	0.565
Consultants	0.385	0.195	0.290
Students	0.552	0.481	0.403

	Posture		
Expert Group	**Lower Back**	**Lower Extremity**	**Upper Extremity**
All Expert Groups	0.169	0.112	0.140
Researchers and Consultants	0.236	0.146	0.159
Researchers and Students	0.176	0.089	0.128
Consultants and Students	0.146	0.127	0.136
Researchers	0.400	0.156	0.151
Consultants	0.233	0.162	0.171
Students	0.071	0.134	0.116

	Speed		
Expert Group	**Lower Back**	**Lower Extremity**	**Upper Extremity**
All Expert Groups	0.248	0.251	0.131
Researchers and Consultants	0.205	0.190	0.054
Researchers and Students	0.285	0.319	0.127
Consultants and Students	0.275	0.264	0.236
Researchers	0.236	0.281	0.333
Consultants	0.247	0.183	0.172
Students	0.347	0.379	0.045

5.5 Discussion

Ergonomic experts are frequently called upon to visit workplaces in order to evaluate and assess ergonomic stressors that may cause fatigue, discomfort, or injury. Individuals with expertise in occupational ergonomics are required to identify jobs/tasks that are likely to cause discomfort and injury and provide advice on approaches to eliminate ergonomic stressors.

In the area of patient handling, it has been demonstrated that there is no safe method for health care workers to lift or move a patient manually (Garg et al., 1991; Marras et al., 1999). Despite this, nurses are routinely called upon to assist with lifting, transferring and repositioning dependent patients. Compared to other professions or occupations, nursing is consistently among the top 10 occupations to have one of the highest injury rates (Bureau of Labor Statistics, 2005, 2006, 2007).

The causes of injuries due to manual handling among nurses are complex, with most discussions focusing on back injury. It is important to identify methods subject-matter experts (SMEs) can use in the field to capture the magnitude of the nurses' exposures, but it also important to gain insight to the experts' reasoning and conclusions. The aim of this study was to determine the level of inter-rater and intra-rater agreement among the nurses and expert groups' RPE and PIR for task conditions and assess the levels of inter-rater and intra-rater agreement on risk factor ratings. Three significant findings resulted from this research.

First, the movement element had the highest level of RPE and PIR and risk factor ratings for all expert groups. Not surprisingly, the most substantial effort by the nurse takes place during the movement phase of the transfer, and thus can be expected to require the highest levels of physical effort. This is consistent with earlier evidence from Vieira (2007), who also divided transfer tasks into specific phases: preparation, positioning and pulling. The pulling phase, similar to the movement element in the current study, was where estimated spinal compression was highest, suggesting that this phase was more physically demanding. Generally, all expert groups agreed that the movement element demonstrated the highest RPE and PIR; however, nurses perceived the completion element to have a higher RPE and PIR than the preparation element, while researchers, consultants, and students perceived the reverse.

This difference in perception may be due to the different training/education between the expert groups. Historically, the nursing curriculum has concentrated primarily on the mechanics of nursing, such as pharmacology, pathophysiology, skills laboratory, etc. Nurses are not taught different strategies that would decrease their injury risk and physical exertion during the performance of their duties. As reported in the literature, nurses believe that discomfort and injury is an inevitable part of their job and leads to underreporting of their injuries (Bulaitis, 1992; Malone, 2000). In 2004, the American Nurses Association (ANA), the National Institute of Safety and Health (NIOSH) and the Veterans Administration collaborated to develop a curriculum for use by nursing schools that introduced safe patient handling and movement concepts into the curriculum. This new curriculum introduced research-based ergonomics concepts (fitting the job to the worker) into the education of these nursing students. The desired result is to close the gap between research, education and clinical practice as nursing graduates move into leadership positions and become role models and change agents in the nursing profession.

Furthermore, when comparing the risk factor ratings of effort, posture and speed, all experts indicated that the lower back was the body part with the highest risk based on effort and posture. These findings support several earlier biomechanical studies (Marras et al., (1999), Daynard, (2001), Kumar et al., (2003), and Videman, (2005) showing that patient-handling activities place high levels of compressive force on low-back structures, typically exceeding recommended limits (NIOSH, 1997). Generally, effort and posture demonstrated similar patterns with respect to body parts and task elements, and minimal differences were noted in speed across all variables and conditions.

Second for RPE and PIR, there was poor to fair overall agreement between all pairs of expert groups (nurses, researchers, consultants, and students) regardless of task. While excellent agreement was observed in RPE and PIR for researchers and students, there was poor to fair agreement between nurses and all other expert groups. Researchers and students demonstrated excellent agreement within their groups regardless of task or measure (RPE/PIR) and consultants demonstrated agreement based on task (fair to excellent for tasks out of bed and poor for tasks into bed). Nurses' agreement was based on the measure (RPE/PIR). Poor agreement was observed for PIR and fair to good for RPE. There may be several reasons for these differences. The group sizes for nurses (n = 16) and the three expert groups (n = 3) were different and the group size for the nurses could lead to a larger variability in their perceptions, particularly since nurses were not calibrated in using the measurement scales. Furthermore, due to the small sample size among the participants, one expert with an extreme rating can cause a discrepancy. Another explanation is that nurses underreport injuries and likely underestimate their injury risk which is observed in their coefficients for PIR. Also, researchers and students were from the same teaching institution will may account for their higher degree of agreement between and among the two groups. It should also be noted that if different tasks or tasks elements are identified as being 'important' by the subject experts, then employers may take different approaches towards prevention and intervention.

Third, in the risk factor analysis, poor agreement was observed for posture and speed regardless of body part or expert group. There may be several reasons for this outcome. The risk factor findings were based on different rating schemes than RPE and PIR. The ratings used for RPE and PIR were overall scores, while the ratings for the risk factor analysis were linked to task element and body part. Another explanation for poor agreement stems from the results of Lowe (2004a), who evaluated the accuracy of observational estimates involving risk factors associated with WMSDs. One conclusion from this work was that accuracy decreases when experts observe frequent and multiple postures and conditions. This may explain the poor levels of agreement within and among the expert groups found here. Further support for this comes from Keyserling and Wittig (1988) who analyzed expert ratings of ergonomic stressors. Experts were allowed to provide written comments and explanations of their scores. Different ratings were noted for posture and the authors concluded that the discrepancy among the experts resulted from different perceptions of the trunk posture. They further concluded that the scatter of expert ratings was due to the irregular occurrence or non-observation of the posture.

It should also be noted that the use of observational techniques are extremely prevalent and a common approach to quantifying workplace exposures. The present work, however, indicated only poor to fair agreement between the workers (nurses) and the SMEs and also among the SMEs. This may imply that new methods are needed to obtain consensus among SMEs and that input from the workers should be included when assessing the workplace. In work by Keyserling and Wittig (1988), SMEs were allowed to explain how they achieved their scores. This may be a method by which experts can find consensus with their ratings. With respect to the obtaining input from workers, SMEs may need to conduct focus groups as part of the assessment, to obtain information regarding task performance, body part discomfort, injury perception etc. Within the nursing occupation, underreporting is prevalent and documented in the literature. However, underreporting is also present in other industries and occupations (Azaroff et al., 2002; The Committee on Education and Labor, 2008). Injury under-reporting is a major problem because every injury that is not reported is an injury whose root cause will not be investigated. Managers will not be able to improve the level of safety in the workplace if they do not study and learn from incidents in order to avoid their occurrence in the future. Additionally, inaccurate injury reporting skews company injury rates to a level that may be misleading. On paper, a company may appear to be safe and incident free, when in reality injuries are occurring and never being reported. This can become an endless cycle in which company safety is never improved because upper management may not even realize that the problem exists.

Although this study focuses on perceived patient-handling exertion and injury risk from patient movements in and out of bed, it lays the foundation for future research on exposure and risk assessment. The results of this study can be used in the future to: (1) focus on identification and analysis of specific parts of the manual transfers that health care providers perform during the course of their day; (2) provide more information on methods /tools that used by SMEs to evaluate workers' exposures to ergonomic risk factors; and (3) provide information on ways to increase expert consensus when evaluating work-related tasks. Although somewhat exploratory, the current study is still considered relevant because it addresses injuries in health care providers who are at high risk for injury.

There are several directions for future research. First, in this study, the primary tasks that were being assessed were movements into and out of bed. Future studies should focus on lateral transfers and repositioning tasks as these transfers occur most frequently in an acute care hospital. Second, nurses should be provided with training on safe patient-handling strategies and ergonomic awareness and determine if training affects their perception of exertion and injury risk. A follow-on study to compare the nurses' ratings with other expert groups on RPE, PIR and risk factors is recommended. When conducting this study, equal sample sizes should be used across all expert groups. Third, the measurement methods used in this study should be extended to different occupations and to field settings both to further validate the methods and to assess exposure across different work environments.

6.0 Conclusions and Recommendations

Work-related musculoskeletal disorders (WMSDs) continue to have high prevalence rates in many occupations, and nurses continue to have one of the highest injury incidence rates compared to other professions or occupations (Bureau of Labor Statistics, 2004, 2006, 2007). A majority of these non-fatal occupational injuries among nurses are work related and primarily due to patient handling tasks. Although it has been demonstrated that there is no safe method for health care workers to lift or move a patient manually, nurses are routinely called upon to assist with lifting, transferring and repositioning dependent patients. The causes of injuries due to manual handling among nurses are complex and therefore it is important to: (1) identify the most frequently occurring patient-handling tasks in an acute care facility; (2) determine the rank order of these tasks based on perceived physical demand; (3) define the specific task elements within a subset of frequent patient-handling tasks based on perceived exertion; (4) describe the moderating effect of assistive devices or an additional person on the physical demands and performance; (5) analyze subjective evaluations of each task element; and (7) evaluate the agreement on risk exposure assessment among ergonomists (experts) and the association between expert evaluations and nursing staff ratings. As a whole, this research expands the knowledge of patient-handling tasks and risks in acute care facilities, and the potential for risk reduction using common engineering and administrative controls. This research also offers contributions to nursing practice and training programs by providing information to serve as the basis for standards of practice and nursing procedures.

The current research accomplished several steps towards understanding the effects of assistance and assistive devices and determining the level of expert agreement on patient handling tasks. The first study (Chapter 3) identified the top 10 patient handling tasks being conducted in an acute facility and ranked by physical demand. Although the frequently occurring tasks were lateral transfers and repositioning, the nurses identified the top four tasks, in terms of physical demand, as being bed to chair, bed to commode, chair to bed and commode to bed. Having this list will aid in making decisions concerning the types of equipment and training that are needed to decrease the nurses' exposure to injuries.

A laboratory simulation was used for the second study (Chapter 4). The top four patient handling tasks were simulated by nursing staff in a laboratory setting, and they provided perceptual responses regarding exertion and injury risk. The effect of an assistive device and assistance from another person were evaluated based on these perceptions. Nurses perceived that assistance decreased their physical exertion and injury risk although nurses consistently perceived exertion to be relatively higher than their injury risk.

The aim of the third study (Chapter 5) was to determine the level of agreement between and within different expert groups. These groups viewed the laboratory simulation from Chapter 4 and provided ratings for the risk factors (effort, posture, and speed), RPE, and PIR. The major finding from this study was that poor agreement existed between nurses and expert groups (researchers, consultants and students). Although the experts groups exhibited some level of agreement (fair to good), it was consistently noted that nurses demonstrated poor agreement with SMEs (i.e. those who would be assessing ergonomic hazards within the workplace).

The findings of this research demonstrate the need for the following: (1) identify frequently occurring and physically demanding patient handling tasks that are conducted within a medical treatment facility, (2) educate nurses on the cumulative injury process and on specific safe patient-handling strategies that decrease their injury risk, (3) develop interventions that target specific patient handlings or elements of the task that pose a greater risk to the nurse, (4) implement multi-faceted safe patient handling programs, and (5) develop methods used by SMEs to assess workers' exposures to ergonomic risk factors and provide information on ways to increase SME consensus when assessing work-related tasks.

As observed in Chapter 3, patient-handling tasks can differ from facility to facility and unit to unit. In order to implement the proper solutions and interventions, it is important to target those tasks that are unique to each facility. Generalizing across facilities or units may lead to incorrect assumptions and conclusions about physical demands being placed on nurses. Secondly, as demonstrated in Chapter 4, nurses perceived the amount of physical exertion they perform to be greater than their perceived risk of injury. Because of this, nurses need to be educated in the cumulative injury process and the signs and symptoms that precede an injury and the strategies that can decrease their injury risk. This includes strategies such as the use of assistive devices and other ergonomic methods. While using assistive devices decreases injury risk, it important to remember that there are multiple users of the device. Because of this, a systems engineering approach should be used to develop new technologies and controls.

Despite these strategies (e.g. availability of assistive devices), nurses still opt to manually move patients. Methods to have nurses 'buy in' to these strategies include the use of patient handling champions within their facilities, social marketing and the use of diffusion theory. Further, a multifaceted approach to safe patient handling has demonstrated a decrease in injuries and a cost savings to the facility (Nelson et al., 2006; Waters et al., 2007). Multifaceted programs include management support, use of facility champions, training at all levels (worker, middle management and upper management) in ergonomic strategies and a safe patient handling program, training and use of assistive devices (to include annual competencies), implementation of a safe patient handling policy, and methods to identify high-risk units, tasks or patients.

Lastly, patient handling remains a frequent and necessary task and therefore, it is important to identify methods SMEs can use in the field that would capture the magnitude of the exposures in this area. It is important that health care providers who handle and move patients understand that the highest levels of physical demands, and hence injury risk, are most likely to occur with the movements associated with patient handling. Furthermore, it should be recognized that expert ratings are the first step in identifying and eliminating ergonomic hazards within the workplace.

Despite the recognition that patient handling is a high-hazard task, the incidence of musculoskeletal disorders persists at high rates for nurses demonstrating the need for continued action. As of 2008, the following states enacted safe patient handling legislation – Texas, Washington, New Jersey, Maryland, Minnesota, New York, Rhode Island, Ohio, and Hawaii. Other states such as California, Florida and Illinois have introduced legislation. The American Nurses Association supports these legislative initiatives and continues to seek new ways to advance this issue on both the state and federal level.

6.1 Future Directions

There are several directions for future research. First, lateral transfers and repositioning tasks should be addressed. These tasks are performed much more frequently within acute care facilities. Secondly, low-cost devices for moving patients in and out of bed were assessed during this study. Assistive devices for lateral transfers and repositioning tasks should also be evaluated. Third, a follow-on study to compare the nurses' ratings with other expert groups on RPE, PIR and risk factors is recommended. Further, additional studies are needed to provide insight on expert ratings and how experts integrate time-varying activities when assessing ergonomic hazards.

The current research laid the groundwork for measuring the magnitude of physical exposure simultaneously in the patient handling environment. The research supported earlier evidence that suggest nurses underreport their discomfort and injury and which in turn contributes to increased exposure and risk. This knowledge will enable practitioners to focus interventions and designs to those factors in the work environment that contribute significantly to increased exposure and thereby more effectively reduce WMSD risk.

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APPENDICES

APPENDIX A: DATA COLLECTION SHEET

Observational Task Analysis

Unit No.		**Date**	
Job Title	(RN/LPN/CNA)	**Start time**	
Nurse No.		**Stop time**	

Patient-Handling Type Details
1. Transfer type **From:** Chair, Bed, Wheelchair, Guerney, Commode, Shower, Floor, Other ______________ **To:** Chair, Bed, Wheelchair, Guerney, Commode, Shower, Floor, Other ______________ **Repositioning:** Side to Side, Up in bed, Other ______________
2. Patient's Dependency Level: Independent, Minimum Assistance, Moderate Assistance, Maximal Assistance, Total Dependence
3. Patient's Cooperation Level: Cooperative, Unpredictable, Varies
4. Number of Staff Performing Transfer (1, 2, 3, 4, 5, 6)
5. Equipment use: Yes No Gait Belt, Slide Board, Lateral Transfer Aid, Sling, Other ____________________________
6. Patient Weight: _____________

Patient Privacy:

_______ Patient approves of observation

_______ Patient sedated or confused and unable to provide an answer

_______ Patient refused the observation. Information obtained from nurse

Elemental Actions to accomplish Patient-Handling Tasks (After listing the steps, please indicate the beginning of movement and completion phases)
1.
2.
3.
4.
5
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Additional Comments

APPENDIX B: NURSE'S QUESTIONNAIRE

Demographics **ID#:**______________

Job Title:
O RN
O LPN/LVN
O Nurse Aid

Gender:
O Female O Male

Typical Shift Worked
O Day: 7:00AM to 7:00PM
O Evening: 7:00PM to 7:00AM
O Other: _______________

Average # of transfers performed per day: _______

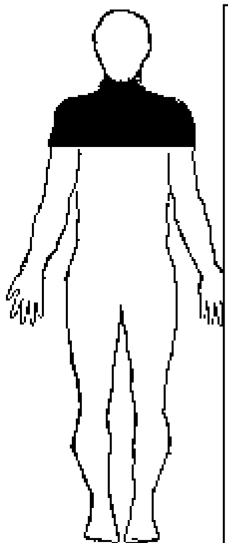
Average time spent per transfer: _________**minutes**

Age: ___ 21-25 y/o ___ 26-30 y/o ___ 31-35 y/o ___36-40 y/o ___41-45 y/o ___46-50 y/o ___51-55 y/o ___55 + y/o

Type of Ward: ________________________ **Number of years doing patient-care?** ________

Neck/Shoulders

1. **Any discomfort in the past 12 months?**
   O Yes (if Yes, go to question 2)
   O No (if No, go to upper/lower back)



2. **Please check the words that best describe your problem?**
   O Aching O Numbness O Tingling
   O Burning O Cramping O Stiffness
   O Swelling O Pain OWeakness
   O Loss of Color O Other

3. **When did you first notice the problem**?______(month)______(year)

4. **How long did the episode last?**
   O 1 hour O 1 day O 1 week
   O 1 month O 6 months

5. **How many episodes have you had in the past year**?_______________

6. **Have you had this problem in the past 7 days**? O Yes O No

7. **How would you rate this problem right now?**
   1 2 3 4 5 6 7
   None Mild Strong Severe

8. **How would you rate this problem when it is the WORST?**
   1 2 3 4 5 6 7
   None Mild Strong Severe

9. **Have you had medical treatment for this problem?**
   O Yes O No
   If yes, did treatment help? O Yes O No

10. **How much time have you lost in the last year because of this problem?** (include sick and comp days) ______________days

11. **For civilians-Was a worker's comp claim filed**? O Yes O No

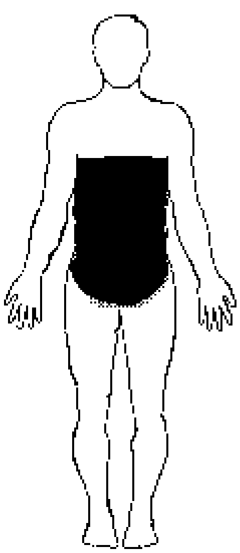
12. **How many days in the last year were you on restricted or light duty because of this problem**?_________________ days

13. **What do you think caused the problem?**_______________

____

Upper/Lower Back

1. **Any discomfort in the past 12 months?**
   O Yes (if Yes, go to question 2)
   O No (if No, go to upper extremity)



2. **Please check the words that best describe your problem?**
   O Aching ONumbness O Tingling
   O Burning OCramping O Stiffness
   O Swelling OPain O Weakness
   O Loss of Color O Other

3. **When did you first notice the problem**?______(month)______(year)

4. **How long did the episode last?**
   O 1 hour O 1 day O 1 week
   O 1 month O 6 months

5. **How many episodes have you had in the past year**?_______________

6. **Have you had this problem in the past 7 days**? O Yes O No

7. **How would you rate this problem right now?**
   1 2 3 4 5 6 7
   None Mild Strong Severe

8. **How would you rate this problem when it is the WORST?**
   1 2 3 4 5 6 7
   None Mild Strong Severe

9. **Have you had medical treatment for this problem?**
   O Yes O No
   If yes, did treatment help? O Yes O No

10. **How much time have you lost in the last year because of this problem?** (include sick and comp days) ______________days

11. **For civilians-Was a worker's comp claim filed**? O Yes O No

12. **How many days in the last year were you on restricted or light duty because of this problem**?_________________ days

13. **What do you think caused the problem?**_______________

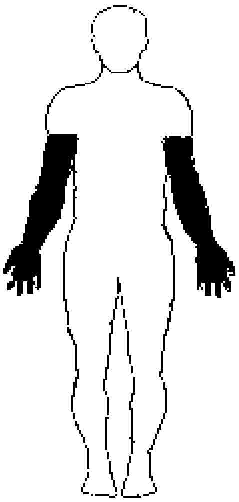
____

Upper Extremity

1. Any discomfort in the past 12 months?

O Yes (if Yes, go to question 2)

O No (if No, go to lower extremity)



2. Please check the words that best describe your problem?

O Aching O Numbness O Tingling
O Burning O Cramping O Stiffness
O Swelling O Pain OWeakness
O Loss of Color O Other

3. When did you first notice the problem?______(month)______(year)

4. How long did the episode last?

O 1 hour O 1 day O 1 week
O 1 month O 6 months

5. How many episodes have you had in the past year?_______________

6. Have you had this problem in the past 7 days? O Yes O No

7. How would you rate this problem right now?

1	2	3	4	5	6	7
None		Mild		Strong		Severe

8. How would you rate this problem when it is the WORST?

1	2	3	4	5	6	7
None		Mild		Strong		Severe

9. Have you had medical treatment for this problem?

O Yes O No

If yes, did treatment help? O Yes O No

10. How much time have you lost in the last year because of this problem? (include sick and comp days) ______________days

11. For civilians-Was a worker's comp claim filed? O Yes O No

12. How many days in the last year were you on restricted or light duty because of this problem?_________________ days

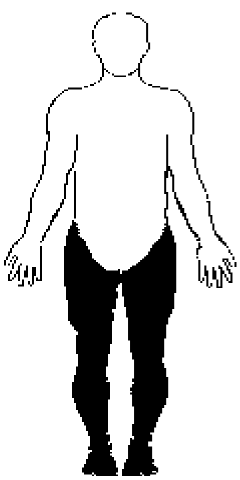
13. What do you think caused the problem?_______________

Lower Extremity

1. Any discomfort in the past 12 months?

O Yes (if Yes, go to question 2)

O No



2. Please check the words that best describe your problem?

O Aching O Numbness O Tingling
O Burning O Cramping O Stiffness
O Swelling O Pain OWeakness
O Loss of Color O Other

3. When did you first notice the problem?______(month)_____(year)

4. How long did the episode last?

O 1 hour O 1 day O 1 week
O 1 month O 6 months

5. How many episodes have you had in the past year?_______________

6. Have you had this problem in the past 7 days? O Yes O No

7. How would you rate this problem right now?

1	2	3	4	5	6	7
None		Mild		Strong		Severe

8. How would you rate this problem when it is the WORST?

1	2	3	4	5	6	7
None		Mild		Strong		Severe

9. Have you had medical treatment for this problem?

O Yes O No

If yes, did treatment help? O Yes O No

10. How much time have you lost in the last year because of this problem? (include sick and comp days) ______________days

11. For civilians-Was a worker's comp claim filed? O Yes O No

12. How many days in the last year were you on restricted or light duty because of this problem?_________________ days

13. What do you think caused the problem?_______________

Previous Training on Patient Care Techniques:

1. ____

2. ____

3. ____

Work Organization Questionnaire

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. In my group, people cannot afford to relax.	☐	☐	☐	☐	☐
2. In our group, there is constant pressure to keep working.	☐	☐	☐	☐	☐
3. In my group, there is a sense of urgency about everything.	☐	☐	☐	☐	☐

	Very little	A little	Some	A Lot	A Great Deal
4. To what extent do you take an active part in making decisions that affect you?	☐	☐	☐	☐	☐
5. To what extent do you take an active part in determining the way things are done on the job?	☐	☐	☐	☐	☐
6. To what extent do you determine which part of the task you will do?	☐	☐	☐	☐	☐

	Very Little						Very Much
7. To what extent do supervisors or co-workers let you know how well you are doing on the job?	☐	☐	☐	☐	☐	☐	☐

	Very Inaccurate						Very Accurate
8. The supervisors and co-workers on this job almost never give me any "feedback" about how well I am doing in my work.	☐	☐	☐	☐	☐	☐	☐
9. Supervisors often let me know how well they think I am performing on the job.	☐	☐	☐	☐	☐	☐	☐

APPENDIX C: PRIORITIZING PHYSICALLY DEMANDING PATIENT-HANDLING TASKS

PRIORITIZING PHYSICALLY DEMANDING PATIENT-HANDLING TASKS

Directions: Assign a rank (from 1 to 10) to the tasks you consider to be physically demanding tasks contributing to musculoskeletal injuries for persons providing direct patient care. A "1" should represent the highest risk, "2" for the second highest, etc. For each task, consider the frequency of the task (high, moderate, low) when assigning a rank. Delete tasks not typically performed on your unit.

Patient-Handling Tasks	**Rank** 1 = Most Physically Demanding 10 = Least Physically Demanding	**Frequency of Task** H = High M = Moderate L = Low

.
Adapted from VA Patient Safety Center of Inquiry (2001)

APPENDIX D: HEALTH AND HISTORY QUESTIONNAIRE

Health and History Questionnaire

Name:____

Address:____

Telephone Number:______________________ E-Mail:_______________________

I. Participant Information

1. Gender: ☐ Male ☐ Female
2. Age: __________

II. Medical History: Back or Shoulder Pain

During the last month:

3. Have you had back or should pain lasting more than 30 minutes? ☐ Yes ☐ No
4. Have you had any severe back or shoulder pain (no matter how brief) which made you stop what you were doing? ☐ Yes ☐ No
5. Have you taken medication for back or shoulder discomfort? ☐ Yes ☐ No

During the last year:

6. Have you suffered from any back or shoulder problems? ☐ Yes ☐ No
7. Have you ever had surgery because of back or shoulder problems? ☐ Yes ☐ No
8. Have you been hospitalized because of back or shoulder problems? ☐ Yes ☐ No
9. Have you had any joint dislocations, broken bones, or other physical injuries? ☐ Yes ☐ No
10. Have you ever suffered from any musculoskeletal problems? ☐ Yes ☐ No
11. Specify, if any:__________________________________

III. Knowledge of Training and Ergonomics

12. Have you ever received any training in how to transfer or move patients?
    ☐ Yes ☐ No
13. If so, how frequently? ____
14. Have you ever had experience (more than 3 months with lifting or handling heavy objects or materials?
    ☐ Yes ☐ No
15. Have you ever received training or instructions on proper lifting techniques?
    ☐ Yes ☐ No
16. Do you have any knowledge of or experience with back injury prevention methods?
    ☐ Yes ☐ No

Signature and Date:____

APPENDIX E: DEFINITIONS

Definitions

There is strong evidence that musculoskeletal disorders are associated with work-related lifting and forceful movements. The risk of injury increases as the physical demands of a task increase. When the physical demands of a task exceed the physiological capabilities of worker, an injury will likely occur. Certain characteristics of the work setting have been associated with injury. These work characteristics are called risk factors. The following definitions will be used for this study.

Posture
Posture is the position of the body while performing work activities. Non-neutral posture is associated with an increased risk for injury. It is generally considered that the more a joint deviates from the neutral position, the greater the risk of injury. Bending is defined as flexion of the trunk, usually in the forward or lateral direction. Twisting involves rotation of the trunk. Non-neutral posture, related to bending and twisting, include placing the trunk and extremities in extreme positions or extreme angles. Risk is related to speed or changes and degree or deviation from non-neutral position.

Force
Forces on the body when performing a task can be defined as the effect of an exertion on internal body tissues. Examples of this include compression on a spinal disc from lifting, tension within a muscle/tendon unit from a pinch grasp or the physical characteristics associated with an object(s) external to the body such as the weight of a box, pressure required to activate a tool or pressure necessary to snap two pieces together. Generally, the greater the force, the greater the degree of risk. High force has been associated with risk of injury at the shoulder/neck, the low back and the forearm/wrist/hand.

Speed
The speed of work estimates the perceived pace of the job or task. It is suspected that a worker's muscles do not fully relax between tasks that require high speed or high frequency exertions.

Preparation
This phase of the transfer takes place from the moment the nurse approaches the patient up until the patient is moved. This includes all preparatory motions such as moving the patient to the edge of the bed, sitting the patient up in bed and laying the patient down in bed.

Movement
This phase of the transfer takes place from the moment the nurse conducts the actual movement – for example the patient is moved from the bed to the chair. No preparatory or completion movements are considered in this phase of the transfer.

Completion
This phase of the transfer takes place from the moment the actual movement has been completed to when the nurse walks away from the patient. Examples of this phase include helping the patient get positioned in the bed or chair.

APPENDIX F: INFORMED CONSENT FORMS

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants in Research Projects

Project Title: Identification of Physically Demanding Patient-Handling Tasks in Acute Care Hospitals, Study 1

Investigator(s): Myrna C. Callison and Dr. Maury Nussbaum, Faculty Advisor

I. Purpose

The purpose of this research is to examine physically demanding activities nurses perform in acute care hospitals. The results of the study will contribution to the further understanding of how nurses perform these tasks and identify groups at risk for incurring injury. This research will also offer contributions to nursing practice and training programs by providing information to serve as the basis for standards of practice and nursing procedures.

II. Procedures

The study will be divided into two separate phases and both phases will be conducted in a hospital in the Southwest Virginia area. After reading this informed consent, if you decide to participate in the study, you will be asked to sign the form. In the first phase, you will be observed conducting typical patient-handling activities during the course of your day. You will inform the observation team when a patient transfer or movement will be conducted. One member of the team will observe the transfer and document the following items: type of transfer, patient dependency and cooperation level, number of staff involved in the transfer, use of assistive devices, and the start and end times. The other members of the team will be available to conduct an observation in case multiple patient-handling activities are occurring at the same time.

The second phase of this study consists of a demographic and self-report of discomfort survey. Initially, you will be given a verbal description of the study and its objectives, and you will be asked to read and complete informed consent documents approved through the Institutional Review Board for research involving human participants. This survey will provide information on demographics of the nursing population, body part discomfort levels, and rankings of perceived physically demanding patient-handling tasks. All nurses working on inpatient units who routinely perform patient-handling tasks within the designated acute care facility will be recruited to participate. After completion of the demographic and discomfort survey, you will be asked to rank order, on the basis of physical demand, the top 10 most frequently occurring patient-handling tasks obtained from the prior observational task analysis. The survey should last no longer than 45 minutes.

III. Risks and Benefits

In this study, there is not more than minimal risk found in daily nursing and office activities. There are no direct benefits to by participating in this research, other than payment. No promise or guarantee of any benefits (other than payment) has been made to encourage you to participate. By participating in this study, you will be assisting the investigators in expanding the knowledge of patient-handling tasks in acute care facilities and offer contributions to nursing practices.

IV. Extent of Anonymity and Confidentiality
Your anonymity will be kept in the strictest of confidence. No names will appear on questionnaires or surveys, and a coding system will be used to associate your identity with questionnaire answers and data. All information will be collected in a file and locked when not being used. No videotaping or audio taping will occur during this study.

V. Informed Consent
You will receive two informed consent forms to be signed before beginning the experiment; one copy will be for your records and the other copy will be obtained for the investigator's records.

VI. Compensation
You will be compensated at a rate of $5 upon full completion of each survey.

VII. Freedom to Withdraw
You are free to withdraw from this study at any time without penalty or reason stated, and no penalty or withholding of compensation will occur for doing so.

VIII. Approval of Research
The Department of Industrial and Systems Engineering has approved this research, as required, by the Institutional Review Board (IRB) for Research Involving Human Participants at Virginia Polytechnic Institute and State University.

IX. Participant's Responsibilities
I voluntarily agree to participate in this study and understand I can quit any time.

X. Participant's Permission
I have read and understand the Informed Consent and conditions of this research project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I reserve the right to withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Participant's Signature Date

____

Experimenter's Signature Date

Signature Page

I have read the description of this study and understand the nature of the research and my rights as a participant. I hereby consent to participate with the understanding that I may discontinue participation at any time if I choose to do so.

____

Participant's Signature   Date

____

Printed Name

____

Experimenter's Signature   Date

The research team for this experiment includes Dr. Nussbaum and Myrna Callison. Team members may be contacted at the following address and phone number:

Dr. Maury Nussbaum
Grado Department of Industrial and Systems Engineering
250 Durham Hall
Blacksburg, VA 24061
540.231.6053

Myrna Callison
Grado Department of Industrial and Systems Engineering
536E Whittemore Hall
Blacksburg, VA 24061
540.392.3871

In addition, if you have any detailed questions regarding your rights as participant in University Research, you may contact the following individual:

Dr. David Moore
IRB Chair
Assistant Vice Provost Research Compliance
Director, Animal Resources
CMV Phase II
Virginia Tech (0442)
Blacksburg, VA 24061
(540) 231-9359

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants in Research Projects

Project Title: Identification of Physically Demanding Patient-Handling Tasks in Acute Care Hospitals, Study 2

Investigator(s): Myrna C. Callison and Dr. Maury Nussbaum, Faculty Advisor

I. Purpose

The purpose of this research is to examine physically demanding activities nurses perform in acute care hospitals. The results of the study will contribution to the further understanding of how nurses perform these tasks and identify groups at risk for incurring injury. This research will also offer contributions to nursing practice and training programs by providing information to serve as the basis for standards of practice and nursing procedures.

II. Procedures

The study will be divided into two separate phases and both phases will be conducted in the Industrial Ergonomics Laboratory (Whittemore Hall) at Virginia Polytechnic Institute and State University. In each session, you will be observed while conducting 16 different patient-handling tasks and will require approximately 4 hours. After reading this informed consent, if you decided to participate in the experiment, you will be asked to sign the form and to fill out a brief demographic questionnaire.

In the first practice session, you will be able to perform the patient-handling tasks before data is collected to allow you to get familiarized with the tasks, assistive devices, and rating scales. You will be allowed to have rest breaks of at least two minutes between each patient-handling task or as much as necessary. Immediately after each patient-handling task element, you will be asked to rate your perceived level of exertion using a written scale and you will provide a rating of the likelihood of becoming injured via a visual analogue scale, if you perform this task daily for six months. The second session (task simulation) will consist of the same procedures (performing 16 patient-handling tasks), but it will be held within one week after the first session is completed. In the task simulation session, all tasks will be videotaped.

III. Risks and Benefits

The primary risk involved with performing these tasks is musculoskeletal strain or sprain. The tasks to be performed in the study are comparable to real nursing tasks. The largest physical loads are expected to be in the shoulders and low back, and it is in these body parts that the likelihood of discomfort or pain may exist. The most probably negative outcome is localized muscle discomfort probably with a 1 to 2 day delayed onset. We expect that these outcomes are unlikely; however, it is important that you rest as much as you feel necessary during the study. Further, you should report any discomfort or pain that you experience during the study.

In this study, there are no direct benefits to by participating in this research, other than payment. No promise or guarantee of any benefits (other than payment) has been made to encourage you to participate; however, by participating in this study, you will be assisting the investigators in expanding the knowledge of patient-handling tasks in acute care facilities and offer contributions to nursing practices.

IV. Extent of Anonymity and Confidentiality

Your anonymity will be kept in the strictest of confidence. No names will appear on questionnaires or surveys, and a coding system will be used to associate your identity with questionnaire answers and data. All information will be collected in a file and locked when not being used. After you have participated, your names will be separated from the data.

While performing the patient-handling tasks, your movements will be videotaped. These videotapes will be securely stored in a cabinet in the Industrial Ergonomics Laboratory. Only the investigators, Myrna Callison and Dr. Nussbaum, will have access. The videotapes will be erased shortly after completion of the research project.

V. Informed Consent

You will receive two informed consent forms to be signed before beginning the experiment; one copy will be for your records and the other copy will be obtained for the investigator's records.

VI. Compensation

You will be compensated at a rate of $10 per hour for the time you actually spend in the study. Payment will be made immediately after you have finished each session.

VII. Freedom to Withdraw

You are free to withdraw from this study at any time without penalty or reason stated, and no penalty or withholding of compensation will occur for doing so.

VIII. Approval of Research

The Department of Industrial and Systems Engineering has approved this research, as required by the Institutional Review Board (IRB) for Research Involving Human Participants at Virginia Polytechnic Institute and State University.

IX. Participant's Responsibilities

I voluntarily agree to participate in this study and understand I can quit at any time.

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this research project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I reserve the right to withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Participant's Signature Date

____

Experimenter's Signature Date

Signature Page

I have read the description of this study and understand the nature of the research and my rights as a participant. I hereby consent to participate with the understanding that I may discontinue participation at any time if I choose to do so.

____

Participant's Signature   Date

____

Printed Name

____

Experimenter's Signature   Date

The research team for this experiment includes Dr. Nussbaum and Myrna Callison. Team members may be contacted at the following address and phone number:

Dr. Maury Nussbaum
Grado Department of Industrial and Systems Engineering
250 Durham Hall
Blacksburg, VA 24061
540.231.6053

Myrna Callison
Grado Department of Industrial and Systems Engineering
536E Whittemore Hall
Blacksburg, VA 24061
540.392.3871

In addition, if you have any detailed questions regarding your rights as participant in University Research, you may contact the following individual:

Dr. David Moore
IRB Chair
Assistant Vice Provost Research Compliance
Director, Animal Resources
CMV Phase II
Virginia Tech (0442)
Blacksburg, VA 24061
(540) 231-9359

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants in Research Projects

Project Title: Identification of Physically Demanding Patient-Handling Tasks in Acute Care Hospitals, Study 3

Investigator(s): Myrna C. Callison and Dr. Maury Nussbaum, Faculty Advisor

I. Purpose

The aim of this study is to evaluate the level of agreement on worker's risk exposure among experts and the association between expert evaluations, nursing staff ratings and biomechanical analyses. The results of the study will contribution to the further understanding of how nurses perform these tasks and may provide information on expert evaluations of patient-handling tasks. This research will also offer contributions to nursing practice and training programs by providing information to serve as the basis for standards of practice and nursing procedures.

II. Procedures

You will be asked to read and the informed consent form and if you decide to participate in the study, you will be asked to sign the form and fill out a brief demographic information sheet. Following this, you will be trained using the program and software. This training will involve viewing digitized video clips and practice with the rating scheme. You will practice using the program by viewing a manual material-handling task and then you will rate the task elements by using the proposed rating scheme. Along with this rating scheme, a visual analogue scale will be used to rate the nurse's likelihood of incurring injury if this task is performed daily for six months. See Form D for the spreadsheet, proposed rating scheme and visual analogue scale.

When you feel comfortable with the mechanics of the program and the rating schemes, you will be asked to review digitized video clips of patient-handling tasks conducted in a laboratory setting. You will view all 16 nurse participants performing one task elements of each patient-handling task at a time. Upon completion of one task element within one condition, you will be asked to provide a mean rating of effort, posture, and speed, along with the likelihood of incurring injury. This process will continue until all task elements within each condition are completed. Rest breaks are highly encouraged. At the very least, we recommend a 10 minute rest break for every hour that you are working.

III. Risks and Benefits

In this study, there is not more than minimal risk found in daily nursing and office activities. There are no direct benefits to by participating in this research, other than payment. No promise or guarantee of any benefits (other than payment) has been made to encourage you to participate.

By participating in this study, you will be assisting the investigators in expanding the knowledge of patient-handling tasks in acute care facilities and offer contributions to nursing practices.

IV. Extent of Anonymity and Confidentiality

Your anonymity will be kept in the strictest of confidence. No names will appear on questionnaires or surveys, and a coding system will be used to associate your identity with questionnaire answers and data. All information will be collected in a file and locked when not being used. No videotaping will occur during this study.

V. Informed Consent

You will receive two informed consent forms to be signed before beginning the experiment; one copy will be for your records and the other copy will be obtained for the investigator's records.

VI. Compensation

You will be compensated at a rate of $10 per hour for the time you actually spend in the experiment. Payment will be made immediately after you have completed the ratings of all patient-handling conditions.

VII. Freedom to Withdraw

You are free to withdraw from this study at any time without penalty or reason stated, and no penalty or withholding of compensation will occur for doing so.

VIII. Approval of Research

The Department of Industrial and Systems Engineering has approved this research, as required, by the Institutional Review Board (IRB) for Research Involving Human Participants at Virginia Polytechnic Institute and State University.

IX. Participant's Responsibilities

I voluntarily agree to participate in this study and understand I can quit at any time.

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this research project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I reserve the right to withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Participant's Signature   Date

____

Experimenter's Signature   Date

Signature Page

I have read the description of this study and understand the nature of the research and my rights as a participant. I hereby consent to participate with the understanding that I may discontinue participation at any time if I choose to do so.

____

Participant's Signature Date

____

Printed Name

____

Experimenter's Signature Date

The research team for this experiment includes Dr. Nussbaum and Myrna Callison. Team members may be contacted at the following address and phone number:

Dr. Maury Nussbaum
Grado Department of Industrial and Systems Engineering
250 Durham Hall
Blacksburg, VA 24061
540.231.6053

Myrna Callison
Grado Department of Industrial and Systems Engineering
536E Whittemore Hall
Blacksburg, VA 24061
540.392.3871

In addition, if you have any detailed questions regarding your rights as participant in University Research, you may contact the following individual:

Dr. David Moore
IRB Chair
Assistant Vice Provost Research Compliance
Director, Animal Resources
CMV Phase II
Virginia Tech (0442)
Blacksburg, VA 24061
(540) 231-9359