NIOSH Research Efforts to Prevent Musculoskeletal Disorders in the Healthcare Industry

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Healthcare workers, including orthopaedic nurses, face a number of risk factors in the workplace for musculoskeletal disorders such as back and shoulder injuries. These disorders are associated with excessive back and shoulder loading due to manual patient handling, applying excessive forces during pushing and/or pulling of objects, required use of awkward postures during patient care, and working long hours and shiftwork. No healthcare workers are immune from injury because workers in all clinical areas are exposed to occupational risk factors, including hospitals, nursing homes, emergency services, critical care, operating rooms, orthopaedic units, and home healthcare environments. This article includes a summary of the scientific efforts of the researchers and their partners at the National Institute for Occupational Safety and Health (NIOSH) in evaluating and developing the best practice recommendations for reducing risk of these disorders for exposed workers. The studies conducted by NIOSH researchers and their partners approach the problem from a variety of perspectives, ranging from comprehensive epidemiological studies examining the effectiveness of implementation of a safe patient handling and movement program to laboratory studies evaluating the biomechanical stress associated with using patient handling equipment, and education training programs for use in schools of nursing to educate new workers about safe work practices. Results of these studies have provided scientific evidence that significant occupational risks for musculoskeletal disorders exist and that effective interventions are available to reduce the risk for these workers.

Background

Oftentimes, healthcare workers experience musculoskeletal disorders (MSDs) at a rate exceeding the rate of workers in construction, mining, and manufacturing (Li, Wolf, & Evanoff, 2004; Nelson, Fragala, & Menzel, 2003). Results of a national survey (Guo et al., 1995) determined that among female workers, the occupational category of nursing aides, orderlies, and attendants was rated as the highest risk employees for back injuries with an estimated 269,000 cases reported annually.

Healthcare workers face a number of risk factors for MSDs in the workplace, such as back and shoulder injuries. These disorders are associated with excessive back and shoulder loading due to lifting heavy loads during manual patient handling, applying excessive forces during pushing and/or pulling of objects, required use of awkward postures during patient care, and working long hours and/or working shiftwork.

The frequency and severity of exposure to these risk factors varies, depending upon the type of the healthcare environment. Some healthcare environments, such as in spinal cord injury or orthopaedic units, require a high number of full body transfers. In addition, orthopaedic nurses must handle patients with a variety of special conditions, such as casts, external hardware, and body position requirements, further complicating transfers. Other healthcare environments require fewer full body transfers, but remain high-risk environments, because conditions may be unfavorable to using assistive equipment for patient transfers, such as emergency responders or home healthcare (HHC) workers. For this reason, it is important to determine the barriers and facilitators for implementing safe patient handling programs by clinical setting.

It is worth noting that a number of studies have shown that when the appropriate patient handling equipment (such as hoists and lateral transferring devices) is used, the risk of MSD is significantly reduced (Collins, Wolf, Bell, & Evanoff, 2004; Garg, 1999; Nelson, Owen et al., 2003; Nelson et al., 2006). Studies have also shown that the payback period for return on investment for purchasing

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"The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health."

the equipment is usually less than 3 years (Collins et al., 2004; Nelson et al., 2006; Tiesman, Nelson, Charney, Siddharthan, & Fragala, 2003).

NIOSH has developed a comprehensive program of research consisting of a number of projects aimed at preventing MSDs with these work-related exposures. To ensure that the research program is scientifically sound, researchers at NIOSH with advanced level research training in epidemiology, biomechanics, psychology, and nursing are directing their attention to these problems. The research program includes studies aimed at the prevention of MSDs due to patient handling, prevention of injuries due to slips, trips, and falls, and prevention of injury and illness due to long hours of work and shift work. This effort is increasingly important because of the current nursing shortage, the aging nursing workforce (average age of 46.8 years), and the obesity epidemic in the US that is resulting in increased weight of patients to be handled. It is likely that the implementation of the results of this research program will significantly help reduce injuries and illnesses for healthcare workers, as well as promote nurse recruitment and retention.

Description of NIOSH Research Efforts

Efforts Focused on Evaluating the Effectiveness of Safe Patient Handling Programs

Prevention of MSDs in Nursing Homes

Two major efforts have been undertaken by NIOSH. The first is a comprehensive lab and field study to identify safer ways to lift and move nursing home residents by removing the excessive forces and extreme postures that can occur when manually lifting residents. Extensive research has documented high levels of biomechanical stress on caregivers when performing patient lifting and repositioning tasks (Garg, Owen, Beller, & Banaag, 1991; Lloyd, 2004; Marras, Davis, Kirking, & Bertsche, 1999; Nelson, Lloyd, Menzel, & Gross, 2003; Ulin et al., 1997; Zhuang, Stobbe, Hsiao, Collins, & Hobbs, 1999). Historically, the caregiver has used his or her own strength to provide manual assistance to the resident. In the light of the success demonstrated in laboratory studies and small field studies (Garg & Owen, 1992), NIOSH conducted a large field study to determine if an intervention consisting of mechanical equipment to lift physically dependent residents, training on the proper use of the lifts, a safe lifting policy, and a preexisting medical management program would reduce the rate and the associated costs of the resident handling injuries for the nursing personnel in a real world setting (Collins et al, 2004).

During the 6-year period, from January 1995 through December 2000, a cohort of 1,728 nursing personnel worked for a total of 3,714,785 work hours, with 1,841,236 hours worked in the preintervention and 1,873,549 hours worked in the postintervention period. The demographics of the nursing work force remained relatively unchanged during the preintervention and postintervention time periods. There was a significant reduction in the resident handling injury incidence, workers' compensation costs, and lost workday injuries after the intervention. Adjusted rate ratios were 0.39 (95% Confidence Interval 0.29–0.55) for workers' compensation claims, 0.54 (95% Confidence Interval 0.40–0.73) for Occupational Safety and Health Administration 200 logs and 0.65 (95% CI 0.50–0.86) for the first reports of employee injury. (Rate ratios below 1 indicate that a risk has been reduced.) The initial investment of $158,556 for lifting equipment and worker training was recovered in less than 3 years on the basis of postintervention savings of $55,000 annually in workers' compensation costs. The rate of postintervention assaults on caregivers during resident transfers was down 72, 50, and 30% on the basis of workers' compensation, Occupational Safety and Health Administration, and the first reports of injury data, respectively.

This study, which was directed by Dr. James Collins from NIOSH, won the prestigious National Occupational Research Agenda (NORA) partnering award in 2004. The study also resulted in the publication of a recent NIOSH numbered document titled "Safe Lifting and Movement of Nursing Home Residents" (Collins, Nelson, & Sublet, 2006).

A second major study funded by NIOSH through cooperative agreement involved the study of the long-term effectiveness of a "Zero-Lift Program" in seven nursing homes and one hospital (Garg, 1999). The primary objective of this study was to reduce injuries to healthcare workers resulting from manual lifting and transferring of patients. The "zero-lift programs," using employee management advisory teams (participatory-team approach), were implemented in seven nursing homes and one hospital. The eight facilities varied in the available number of beds (mean = 145, range = 85–253) and number of nursing personnel (mean = 94, range = 57–136). All eight facilities had a large number of acute care patients.

The "zero-lift programs" were implemented using ergonomic principles. Ergonomics is defined as the science of fitting the task to the worker. In this study, the ergonomics program involved replacing manual lifting and transferring of patients, with modern, battery operated, portable hoists, and other patient transfer assistive devices. Ergonomics committees with nearly equal representation from management and employees selected the equipment and implemented the "zero-lift programs." Injury statistics were collected during postintervention for 51 months (range = 36–60 months) and were compared with preintervention data for 37 months (range = 30–54 months). The number of injuries from patient transfers decreased by 62% (range = 39–79%), lost workdays by 86% (range = 50–99%), restricted workdays by 64% (96% decrease to 17% increase), and workers' compensation costs by 84% (range = 53–99%). Overall, the eight facilities experienced decreases of 32% in all injuries, 62% in all lost workdays, 6% in all restricted workdays, and 55% in total workers' compensation costs. The program produced many intangible benefits including improvements in patient comfort and safety during transfers and patient care. The nursing personnel perceived that their backs were less sore and that they were less tired at the end of their shifts. More pregnant and older workers were able to perform their regular duties and stay on the job for a longer period. (NIOSH Contact Person: Dr. James Collins, DSR, Morgantown WV, jcollins1@cdc.gov)

Prevention of MSDs in Home Healthcare Work Environments

Home healthcare is the fastest growing segment of the healthcare industry and an underexplored subpopulation

of healthcare professionals. Of particular concern is HHC workers' exposure to high levels of physical workload imposed by patient care and cleaning tasks. Forceful exertions and awkward postures involved in lifting, moving, bathing, and dressing patients have been shown to be associated with high rates of back injury and other MSDs in HHC (Galinsky, Waters, & Malit, 2001). For several years, the overexertion injury rate for HHC workers has been more than double the national rate for all industries, ranking among the 10 highest (Bureau of Labor Statistics [BLS], 2006), yet little empirical research has been conducted to determine the primary work factors associated with musculoskeletal symptoms in this population of workers. HHC workers are unique among healthcare professionals. In addition to patient personal care (e.g., bathing, dressing, lifts, and transfers), additional job responsibilities of home care aides include laundry, housecleaning, rearranging furniture, meal preparation, grocery shopping, and client transportation. Home healthcare-related musculoskeletal injuries have been attributed primarily to the forceful exertions and awkward postures imposed by patient lifts and transfers, yet these risk factors also characterize many other home care work tasks. In focus groups conducted by NIOSH, HHC workers rated housekeeping tasks as being as physically demanding as patient lifts and transfers (Baron & Habes, 2004). To our knowledge, the literature to date on overexertion injuries in HHC workers has not included empirical assessment of whether patient handling adds significantly to injury risk, beyond that which is posed by housekeeping and other tasks alone.

In a NIOSH study aimed at quantifying work hazards in HHC, a survey was administered to geographically diverse groups of HHC workers ($N = 744$) from 11 participating HHC provider organizations in Arkansas, California, Illinois, and Oregon. Data were collected during 2002–2004. The response rate was 64%. Initial analyses to explore potential associations between patient handling and workers' reports of musculoskeletal symptoms have been completed (Galinsky, Parsons, & Krieg, 2004; Parsons, Galinsky, Waters, & Feng, 2006). Logistic regression was used to compare survey responses of workers who routinely performed one or more patient handling tasks with survey responses of workers who did not routinely perform one or more patient handling tasks. A worker was categorized as a "patient handler" (PH) if one or more of the following patient care tasks were performed regularly: transfer in/out of bed, reposition in bed or chair, transfer on/off toilet, adult diaper changing, transfer in/out of tub, bathing, and dressing/undressing. Figures 1 and 2 provide a breakdown of those reporting musculoskeletal symptoms during the preceding 12 months by patient handling status. As can be seen in Figure 1, a higher percentage of PHs than of non-PHs reported having back pain lasting for a week or more. In addition, as shown in Figure 2, higher percentages of PHs than of non-PHs reported having back, shoulder/neck, and leg/feet pain lasting for any length of time.

Results of logistic regression analyses are shown in Table 1. As can be seen in Table 1, the odds ratios for all of the outcomes shown in Figures 1 and 2 were significant. Patient handling was significantly associated with workers' reports of musculoskeletal discomfort in the back,

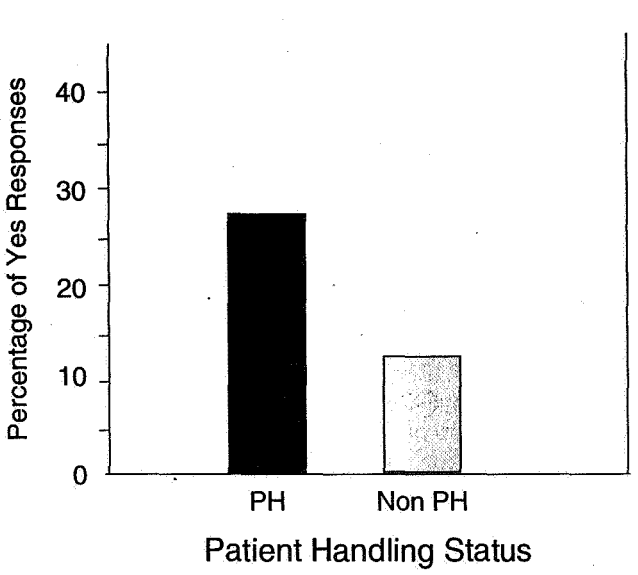

FIGURE 1. In the past 12 months, have you had back pain which lasted every day for a week or more?

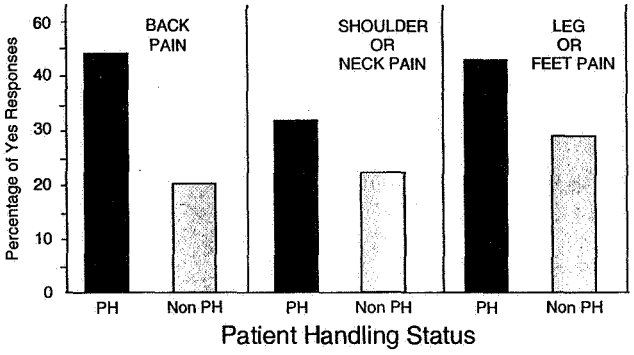

FIGURE 2. In the past 12 months, have you had pain in your back; shoulders/neck; legs/feet for any length of time?

shoulders/neck, and legs/feet. Patient handling remained a significant predictor of perceived discomfort after adjusting for the effects of potential confounding variables such as worker age, weight, nonwork-related physical activities, smoking status, medical conditions, work durations, and nonwork-related caretaking of children and disabled family members. These results supplement a growing body of evidence confirming the potential physical hazards of patient handling in HHC (Galinsky, Waters, & Malit, 2001). Subsequent analyses of the survey data will further explore the impact of physical factors associated with patient handling, as well as the impact of psychosocial factors such as work control and social support on MSDs. (NIOSH Contact Person: Dr. Traci Galinsky, DART, Cincinnati, OH, tgalinsky@cdc.gov)

Safe Patient Handling and Movement Curriculum for Schools of Nursing

Owing to the scarcity of current evidence-based training material for safe patient handling, many schools of nursing (SON) continue to teach outdated manual patient handling techniques that rely on the use of "proper" body mechanics, even though these techniques have been shown to be unsafe. This reliance by SON on teaching

TABLE 1. Response Items for Which Patient Handling was a Significant Predictor of Pain

	p value	Odds Ratio	95% Confidence Interval
In the past 12 months, have you had back pain lasting every day for a week or more?	.0002	2.11	1.42–3.13
In the past 12 months have you had back pain lasting any length of time?	.0001	2.07	1.48–2.87
In the past 12 months have you had shoulder or neck pain lasting any length of time?	.03	1.5	1.05–2.13
In the past 12 months have you had pain in your legs or feet lasting any length of time?	.0003	1.83	1.32–2.53

these outdated training techniques for patient handling is reinforced by the NCLEX-RN nurse licensing exam that continues to include questions aimed at the use of body mechanics for patient handling. To address this need, in 2004, NIOSH, the American Nurses Association, and the Veterans Administration Patient Safety Center of Inquiry in Tampa ("the consortium") collaborated to develop and evaluate a new safe patient handling and curriculum module that could be used in SON to change the way student nurses are taught to move and handle patients. The goal of the 18-month project was to "translate current research related to safe patient handling into the curricula taught in nursing schools in the United States." The objectives of the project were to

1. Develop, implement, and evaluate a "train-the-trainer" program for safe patient handling and movement, targeting faculty at 26 SON.
2. Develop, implement, and evaluate an evidence-based safe patient handling curriculum module at 26 SON throughout the United States.
3. Compare the knowledge, attitudes, and beliefs of the students who were educated and trained at 26 SON using the evidence-based safe patient handling curriculum module with nursing students at 3 schools offering a more traditional fundamental nursing school curriculum.
4. Describe the process of implementing this evidence-based safe patient handling curriculum module at 26 SON throughout the United States.

The data analysis from the evaluation phase of the project has not yet been completed, but the details of the project are described by Menzel, Hughes, Waters, Shores, and Nelson (in press). The curriculum consists of five main elements—a narrated slide presentation with an embedded video, a series of algorithms (decision tools that help nurses assess patient needs to decide which equipment is appropriate for a specific patient handling activity), didactic materials, laboratory activities, and a quiz to help the students evaluate their knowledge of the new patient handling concepts. In designing the study, the consortium agreed that a clinical component was needed, in which students would be provided with hands-on practice on the proper selection and the use of patient handling equipment. To provide the clinical skills laboratory practice, the consortium asked equipment vendors to loan or donate equipments to the participating SON.

The Safe Patient Handling and Movement training presentation can be downloaded at the NIOSH Web site (http://www.cdc.gov/niosh/review/public/safe-patient/), and the Safe Patient Handling and Movement algorithms, didactic materials, and quiz can be downloaded at the Veterans Affairs Patient Safety Center of Inquiry Web site(http://www.visn8.med.va.gov/visn8/patientsafetycenter/safePtHandling/default.asp). (NIOSH Contact Person: Dr. Thomas R. Waters, DART, Cincinnati, OH, twaters@cdc.gov)

Using the NIOSH Lifting Equation to Determine the Maximum Recommended Weight Limits for Manual Patient Lifting Tasks

Healthcare workers are often required to manually lift patients or their extremities as part of their job duties or to provide assistance to partially dependent patients to stand from a prone or a sitting position. It is important to determine whether these manual patient lifting tasks exceed the recommended lifting limits. The Revised NIOSH Lifting Equation (RNLE), an ergonomic assessment tool for use in determining recommended weight limits (RWL) for specific two-handed manual lifting tasks, allows for an input of various lifting stressors such as horizontal and vertical reach locations, task asymmetry, frequency and duration of lifting, and the hand-to-object coupling (Waters, Putz-Anderson, & Garg, 1994; Waters, Putz-Anderson, Garg, & Fine, 1993). On the basis of these inputs, the equation is used to calculate the RWL for the selected task parameters. Owing to the limitations in the data used to derive the equation, the assessment of patient handling tasks was specifically excluded as a limitation of the equation. National Institute for Occupational Safety and Health is now reviewing this recommendation, to consider if the RNLE might be applicable for some patient handling tasks such as those where the person being lifted is noncombative or where there is little or no movement of the patient during the lifting task.

Dr. Waters, a NIOSH researcher, recently described situations where it might be possible to use the RNLE to assess certain patient handling tasks and indicated that in order to use the RNLE to help determine safe weight limits for patient lifting, some assumptions would be necessary (Waters, 2006). According to Dr. Waters, it is likely that the persons performing the patient lifting task typically would not be able to get as close to the load as they he would if they were lifting a box or another fixed object. This is because many patient handling tasks require the worker to reach out to perform the lift and because the lift usually entails carefully lowering the patient into a chair or onto a bed at the end of the lift, which does not allow the worker to get close to the load. As the minimum horizontal reach distance for the NIOSH equation was set at 10", a larger

minimum horizontal reach distance would be appropriate for determining the maximum weight limit for generalized patient lifting tasks. Waters (2006) indicated that the minimum horizontal distance for the RNLE should be increased from the original 10″ to a distance of 14–15″. This horizontal distance was suggested because it is the average distance of the center of the hands from the spine when the upper arm is parallel to the trunk and the forearm is at a 90° angle to the upper arm, which is a posture typically observed when lifting patients or body parts. On the basis of this suggested minimum horizontal distance and the RNLE formula, the maximum weight to be lifted would be 35 lbs. It should be noted that the maximum weight to be lifted could even be lower, depending upon the other task conditions (e.g., if the reach distance is greater then 14–15″ or if the lift occurs near the floor, etc.). If the RNLE is determined to be applicable for patient lifting, it would have to be assumed that the patient is able to follow directions and is noncombative. This limitation is due to the RNLE requirement that unexpected and dynamic loads should not be present. Waters (2006) stated that "avoiding lifting tasks that exceed the recommended maximum weight limit for patient lifting tasks would likely help reduce the potential for low back disorders for nurses" and that "It will sometimes be difficult for nurses to know the amount of weight being lifted, so it may be difficult to know when the maximum weight limit would have been exceeded." To avoid an excessive exposure to the physical demands resulting from manual patient lifting, assistive handling equipment may be needed. The use of the RNLE should provide useful information to those responsible for assessing some lifting tasks performed by healthcare workers. It should be noted that NIOSH will continue to evaluate ways to provide guidance for assessing patient lifting tasks and to identify methods to determine a maximum recommended weight limit for certain patient lifting tasks (e.g., slow, smooth, and nonaccelerating lifts), but to date, NIOSH has not changed its guidance regarding the use of the RNLE for assessing patient lifting tasks. (NIOSH Contact Person: Dr. Thomas R. Waters, DART, Cincinnati, OH, twaters@cdc.gov)

Partnership to Develop Ergonomic Guidelines for Operating Room Nurses

Under the leadership of the VA Patient Safety Center of Inquiry in Tampa and the Association for Perioperative Registered Nurses, and as part of the NIOSH Research to practice effort, an interdisciplinary panel of experts was formed to examine tasks performed by OR staff and to identify those tasks with high risk for MSDs. The panel included experts in perioperative nursing, ergonomics, biomechanics, engineering, industrial hygiene, and injury prevention. The professional nurse representatives included clinical, administrative, education, and research perspectives. The team was tasked with developing an ergonomic guideline for seven high-risk perioperative tasks identified as having potentially a high risk for MSDs. For each of the seven tasks, the team developed a series of ergonomic tools for assessing the tasks and making various recommendations regarding the ways to reduce the risk to the caregiver. The tasks included the following: (1) a lateral transfer from stretcher to operating room (OR) bed; (2) repositioning patients in OR beds; (3) lifting and holding legs, arms or head for prepping; (4) prolonged standing; (5) holding retractors for an extended period of time; (6) lifting and carrying supplies/equipment; and (7) pushing, pulling, and moving equipment on wheels. Once the seven high-risk tasks were identified, the team developed the ergonomic solutions to address each task. For each tool, the developers provided a rationale for the selected criteria and how weight and force limits were calculated. Empirical data were used to derive the recommended maximum forces and weights for manual handling for a wide range of tasks performed in the OR work environment. These ergonomic tools were based on consensus and ergonomic criteria typically used in assessing the physical demands of manual handling activities. The recommendations are under review and will be likely published sometime in 2007. A journal article describing the development process is under review (Nelson, Waters, Spratt, Peterson, & Hughes, 2006). (NIOSH Contact Person: Dr. Thomas R. Waters, DART, Cincinnati, OH, twaters@cdc.gov)

Efforts Focused on Prevention of Slip, Trip, and Fall Injuries

Preventing Slips, Trips, and Falls in Hospitals

Globally, falls represent the third leading cause of disability in the general population after depression and anemia. Falls are also the second leading global cause of accidental death, after motor vehicle collisions. The health services sector is the largest employer in the U.S. private industry with some 10 million workers. In 2002, more U.S. healthcare workers were injured than the workers in construction and mining combined. Slip, trips, and falls (STFs) accounted for the largest proportion of lost time injuries to healthcare workers (21%). The incidence rate of same level STF injuries in hospitals was considerably higher than that in private industry (39.9 vs. 25.4 per 10,000 full-time equivalent employees). The large population of workers at risk and the frequent occurrence makes STF incidents a substantial problem for healthcare workers. A current project focusing on prevention of STF incidents concurrently applied the following study methods (Collins et al., 2006):

1. NIOSH researchers conducted a descriptive analysis of 6 years of historical STF incident surveillance data from study hospitals to target intervention strategies.
2. The Liberty Mutual and Johns Hopkins researchers conducted case-crossover and case follow-back studies by telephone interviewing hospital employees who suffered a fall; digital photographs of their shoe soles and flooring conditions at the fall site were also collected to identify the transient risk factors and describe the STF circumstances to target interventions.
3. The Finnish Institute for Occupational Health (FIOH) conducted laboratory studies to evaluate the slipperiness of hospital flooring (existing and promising slip-resistant flooring) and shoes (most commonly worn and promising slip-resistant), tested with a range of contaminants (dry, water, water/cleaning solution, and glycerol [simulated grease]).
4. NIOSH incorporated the findings from the three companion studies along with the on-site hazard assessments at the study hospitals to establish the "best

practices" STF injury prevention program. NIOSH researchers then conducted a prevention effectiveness field study that designed, implemented, and evaluated the "best practices" STF prevention program in five acute care hospitals.

The descriptive analysis identified 314 STF workers' compensation claims; the highest injury rates were among workers in food and kitchen services and EMS personnel. The highest frequency of STF incidents occurred among nursing staff and office workers. The narratives of all cases were reviewed to examine the details of the circumstances, locations, and patterns of work-related STF incidents and to identify countermeasures that could be implemented and evaluated as part of the field study.

The case-crossover/case-followback study included healthcare workers (n = 123) who reported an incident of STF to the occupational health department, who were then recruited and interviewed using a structured telephone questionnaire (Courtney et al., 2006). Participants were predominantly female (86%) with a mean age (range) of 46 (19–67). Nurses (33%), secretaries or clerks (13%), and health technologists and technicians (9%) were the most frequently reported employees. The causes and types of falls in the study are shown in Table 2.

Although the hands, knees, and buttocks were most often the points of impact, the back, knees, ankles, and feet were the most frequently injured. Strains and sprains (29%), contusions (27%), and nonspecific pain and soreness (22%), were typical. Other injuries included abrasions, fractures, edema, and lacerations. Overall, 94% of the subjects were injured with an average of two injuries per STF event. Data from this study were used to emphasize control of contaminants and improve surface transitions and conditions in the intervention study.

The study examining exposure assessment in the field and the lab, which was conducted by the Finnish Institute for Occupational Health research staff, identified slip-resistant shoes and flooring that performed optimally under wet, greasy, and dry conditions (Collins et al., 2006).

TABLE 2. Causes and Types of Falls in Health Care Workers

Causes and Types of Falls	Percentage of Health Care Workers Who Fell
Slipping or tripping	88
Slipping	53
Tripping	32
Liquid contaminants (e.g., water, cleaning solutions)	36
STF occurred at a transitional area	64
Dry/wet	32
One type of floor to another	22
Uneven surfaces	15
Fell forward	41
Fell to the side	23
Fell backward	21

The intervention study provided slip-resistant shoes to the food service and housekeeping staff. Slip-resistant floors were installed during renovations. NIOSH and Liberty Mutual scientists used slip meters to examine the slipperiness of floor surfaces at study sites that were of concern to hospital safety staff.

For the second field study, conducted in conjunction with BJC Healthcare, researchers compared the injury, disability, and injury-related cost experience of a cohort of approximately 35,000 hospital staff for a 6-year preintervention period (1996–2001) with a 36-month postintervention period (2003, 2004, and 2005) in three hospitals (Collins et al., 2006). Workers' compensation data, Occupational Safety and Health Administration injury and illness logs, employee first reports of an injury, and personnel records were used to compute injury rates. The "best practices" slip, trip, and fall intervention consisted of slip-resistant shoes for food service workers and housekeeping staff, slip-resistant flooring added during renovations, revised housekeeping procedures, on-site hazard assessments to identify and eradicate STF hazards, ice cleats for home health nurses, and STF hazard awareness, which was promoted through paycheck inserts and e-mails. Housekeeping managers wore beepers with numbers advertised through e-mails notifying all staff to promptly reports spills and other contaminants on the floor. Outside the hospitals, an aggressive snow and ice removal program strategically located containers with ice melting chemicals that could be applied by any employee who noticed icy conditions. Three downspouts were rerouted under sidewalks at a shuttle bus stop after descriptive analyses identified a STF injury cluster. Hazard assessments revealed that the down spouts were dumping freezing water onto the sidewalk. A training program educated all hospital staff on the importance of preventing STF incidents. The preliminary analyses of 9 years of workers' compensation data in the BJC Health System hospitals indicate that the comprehensive "best practices" STF prevention program resulted in an estimated 45% reduction in workers' compensation STF injury incidence rate. This study, which was directed by Dr. James Collins from NIOSH, won the prestigious NORA partnering award in 2006. (NIOSH Contact Person: Dr. James Collins, DSR, Morgantown WV, jcollins1@cdc.gov)

Health and Safety Outcomes Related to Work Schedules in Nurses

In the United States, a high percentage of the 1.3 million nurses employed in hospitals are on shift work schedules to provide essential nursing care that is required around the clock. According to Trinkoff, Geiger-Brown, Brady, Lipscomb, and Muntaner (2006) more than 25% of nurses reported working 12 hours or more a day and 33% worked more than 40 hours a week. The U.S. government statistics for the year 2000 report that 50% of all full-time nurses worked more than 42 hours per week (Spratley, Johnson, Sochalski, Fritz, & Spencer, 2001). Both shift work and long work hours are associated with several health and safety risks including musculoskeletal injuries (Fredriksson et al., 1999; Lipscomb, Trinkoff, Geiger-Brown, & Brady, 2002; Waersted & Westgaard, 1991). Although limited in scope, these studies demonstrate that long hours of work and shiftwork are likely to play an im-

portant role in the development or exacerbation of work-related MSDs. For this reason, additional studies are needed to substantiate these preliminary findings.

In order to address this information gap, NIOSH researchers, in partnership with the American Nurses Association (ANA), designed and conducted a study of nurses that examines associations between work schedules and self-reported health and safety outcomes in registered nurses. The partners provided input for the study design and measures and assisted with recruiting hospital sites. The study is based on the theoretical model by Barton et al. (1995), who proposed that shift work exerts a negative effect on health and safety outcomes by disturbing sleep, circadian rhythms, and family and social life, which, in turn, have adverse health effects.

The study examines the outcomes that are frequently studied in the shift work literature including sleep, symptoms, needlestick injury, and automobile crashes, as well as several types of health problems, including musculoskeletal symptoms. The study will identify the characteristics of work schedules that are most associated with health and safety risks in hospital-based nurses, so that those characteristics can be adjusted or avoided. The study had three specific aims:

1. To examine if certain characteristics of shift work schedules, such as shift length (i.e., 12 and 8-hour shifts), night work, and rotating work schedules are associated with health and safety outcomes.
2. To examine how shift work and overtime interact to influence the health and safety outcomes.
3. To examine if disturbances of sleep, family, and social life mediate the effects of work schedules on health and safety outcomes.

The ANA's National Database of Nursing Quality Indicators program recruited 20 large hospitals across the United States for the study. Six hundred nurses from these hospitals volunteered to participate. The subjects worked full time in the current hospital for the previous year and were on their assigned work schedule for the previous 6 months. They worked at least 50% of the time in direct patient care on medical, surgical, step down, or intensive care units.

The volunteers were followed for 3 months. At the beginning of the study period, participants completed a 35-minute survey consisting of standardized questions about health, injuries, demographics, lifestyle, sleep, personality characteristics, coping strategies, and work-related information. This included questions about the location and the intensity of any musculoskeletal discomfort and any back pain during the previous year. During the 3-month period, participants kept a simple prospective 3-month overtime diary. During the last week of the study period, participants kept a 7-day sleep/activity diary and completed a final 35-minute survey with the same questions as the first survey. The hospitals provided work start and end times for each participant during the 3-month study period. The National Database of Nursing Quality Indicators program provided unit data on staffing and skill mix that was matched with the data of this study.

The data analysis will include multiple and logistic regression tests to examine the relationships between work schedules and health and safety outcomes, while controlling statistically for other risk factors. All of the data have been collected and statistical analysis has begun, but the final report is not yet completed. A poster discussing the new one-page sleep/activity diary that was incorporated into the study was recently presented at the 17th International Symposium on Shiftwork and Working Time (Caruso, Rosa, & Lee, 2005). Future studies will introduce improved work schedules in healthcare settings and test the effectiveness of those interventions in improving the nurses' alertness, health, and satisfaction. (NIOSH Contact Person: Dr. Claire C. Caruso, DART, Cincinnati, OH, ccaruso@cdc.gov)

Efforts Focused on Engineering Controls for the Prevention of Injuries to Healthcare Workers

It has been shown that the use of assistive equipment as part of a safe patient handling and movement program can significantly reduce the risk of MSDs for caregivers who have to handle and move patients (Collins et al., 2004; Garg, 1999; Nelson et al., 2006). These studies have shown that the load on the back and the shoulders is significantly reduced compared with the manual handling methods. Assistive technology for patient handling and movement includes ambulatory assist equipments, sit-to-stand lifts, and floor-based mobiles and ceiling or track-mounted overhead full body lifts. Much of this equipment has been previously described (Collins et al., 2006; Parsons, Galinsky, & Waters, 2006a, 2006b). The following section describes a series of studies conducted by NIOSH researchers aimed at evaluating the effectiveness of this equipment to reduce the risk of excessive loads during patient handling activities.

Assessment of Patient Handling Equipment

As a precursor to the nursing home field study described above, a biomechanical (Zhuang et al., 1999) and psychophysical evaluation (Zhuang, Stobbe, Collins, Hsiao, & Hobbs, 2000) measured physical exposures associated with nine battery-powered lifts and three manual methods for transferring physically dependent residents from a bed to a chair. Mechanical lifts were shown to reduce the compressive forces placed on the nursing assistant's back by an estimated 60%, remove two-thirds of the lifting activities per transfer, and increase the resident's perceptions of comfort and security when compared with being manually lifted. Zhuang et al. (1999) examined the psychophysical effects associated with the use of nine battery-powered lifts, a sliding board, a walking belt, and a baseline manual method for transferring nursing home patients/residents from a bed to a chair. Psychophysics is the study of the workers' perception of physical stress. The objectives of the psychophysical assessment were to investigate the effects of resident-transferring methods on the psychophysical stress of the nursing assistants performing the transferring task and to identify transfer methods that could reduce the psychophysical stress reported by the nursing assistants. Nine nursing assistants served as test subjects. Two elderly persons participated as residents. The results indicated that the psychophysical stresses on the nursing assistants were significantly lower when performing resident transfers with some of the assistive devices than when performing transfers with the baseline manual transfer method. The nursing assistants generally preferred the

basket-sling lift and stand-up lift to other methods. The residents' comfort and security ratings indicated that the comfort and security with most of the assistive devices were greater than or equal to the baseline manual method. Most of the comments of the nursing assistants and the residents on the assistive devices were favorable.

In the second study, Zhuang et al. (2000) conducted a biomechanical evaluation of the same devices as in the 1999 study. Biomechanics is the study of the physical loads on the tissues of the body. The objectives of the biomechanical evaluation were (1) to investigate the effects of transfer method and resident weight on the biomechanical stress of the nursing assistants performing the transferring task, and (2) to identify the resident-transferring methods that could reduce the biomechanical stress on the nursing assistants. Nine nursing assistants served as test subjects, and two elderly persons participated as residents. A four-camera motion analysis system, two force platforms, and a three-dimensional biomechanical model were used to measure biomechanical load. The results indicate that the transfer method and the resident weight affect a nursing assistant's low-back loading. The basket sling and overhead lift devices significantly reduced the nursing assistants' back-compressive forces during the preparation phase of a resident transfer. In addition, the use of basket sling, overhead, and stand-up lifts removed about two thirds of the exposure to low-back stress (lifting activities per transfer) as compared with the baseline manual method. Thus, the use of these devices reduces biomechanical stress and thereby will decrease the occurrence of resident-handling-related low back injuries. Furthermore, lifting device maneuvering forces were found to be significantly different, and a number of design/use problems were identified with various assistive devices. (NIOSH Contact Person: Dr. James Collins, DSR, Morgantown WV, jcollins1@cdc.gov)

Comparison of Pushing, Pulling, and Turning Forces Required for Ceiling-Mounted Versus Floor-Based Full Body Sling Lifts

Two NIOSH laboratory studies aimed at evaluating the physical demands associated with use of two types of full body patient lifting devices (i.e., overhead track-mounted devices compared with floor-based devices) have been conducted. Overhead track-mounted and floor-based full body lifts have been shown to significantly reduce the risk for caregivers, but healthcare companies face a dilemma in trying to decide which type of full body lift to purchase for their unique situation. Although floor-based lifts are portable and can be moved from room to room, they require significantly higher forces to push, pull, or rotate the patient into position for transfer during the lift than do overhead track-mounted lifts. Overhead track-mounted lifts, on the contrary, are always available in the room, but may be more expensive than floor-based lifting devices if numerous rooms require lifting equipment. Few studies have been conducted in examining the differences in pushing, pulling, and rotation forces required to operate the various types of full body lifts under different operating conditions (e.g., different floor surfaces, weight conditions, and tasks). A NIOSH study examining the effect of different load weights (five weight categories) and different floor types (three floor types) on the required pushing, pulling, and rotating forces was recently completed. The data analysis has not been completed and a final report is not available, but preliminary observations suggest that the effects of varying patient weight and floor conditions will be as expected. That is, the required pushing, pulling, and rotating forces needed to move a patient of varying weight across different flooring conditions will be greater for a floor-based assistive device than for an overhead track-mounted device. Many of the movement conditions for the floor-based lift require high pushing and pulling forces that may be considered excessive for women. Industry stakeholders should find it helpful to know the physical demands required to operate the various types of lifting equipment under variable conditions in order to purchase the most appropriate equipment for their use. If they choose the floor-based models because of convenience and cost factors, they will want to ensure that their existing staffs will be capable of safely operating the equipment.

A second NIOSH-sponsored study compared the differences in the required pushing, pulling, and rotating forces between a track-mounted overhead lift and floor-based lifts for different floor conditions and movements (Waters, Rice, Woolley, & Jolliff, 2003). The results of the second study are shown in Figures 3 and 4. The authors concluded that the floor-based lifts require significantly more force to push, pull, or rotate patients, with floor-based lifts requiring approximately seven times more rotation force than the ceiling-based lifts. On the basis of the findings, the researchers concluded that many women would lack the strength and capabilities required for certain movements with fully loaded floor-based lifts, and spinal

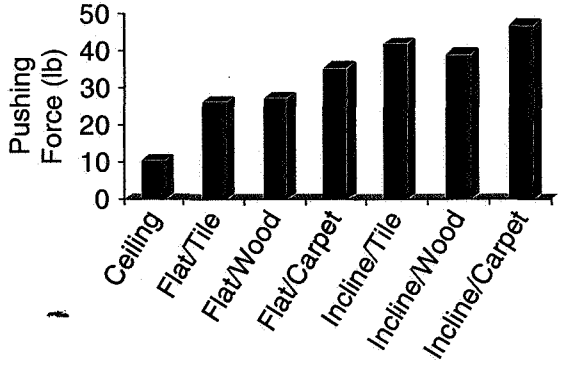

FIGURE 3. Peak force required, by device and movement type (Waters et al., 2003).

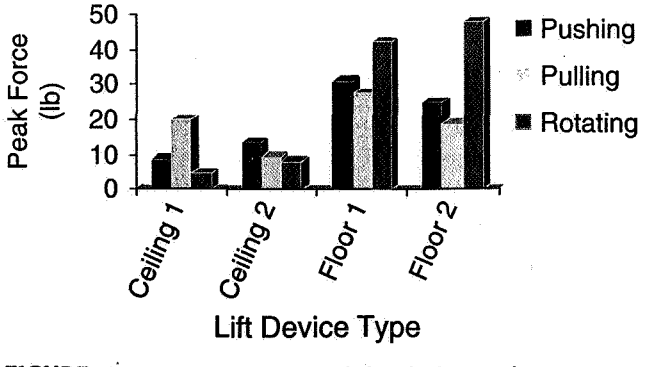

FIGURE 4. Peak force required, by device and movement type (Waters et al., 2003).

forces would increase dramatically when pushing a patient up an incline. (NIOSH Contact Person: Dr. Thomas R. Waters, DART, Cincinnati, OH, twaters@cdc.gov)

Conclusions and Future Directions

As can be seen by the wide range of research being conducted by the NIOSH researchers aimed at the prevention of MSDs and other injuries, much has been accomplished. We recognize, however, that much remains to be done. For example, more research is needed to reduce the incidence and the severity of work-related accidents and injuries to workers in the healthcare and social assistance sector, one of the eight primary industry sectors defined by the NIOSH's new NORA effort. Specifically, additional studies are needed to (1) further evaluate risk of back and shoulder disorders due to patient handling and/or work in awkward postures across various work environments; (2) evaluate the efficacy of safe patient handling and movement programs to reduce the risk of MSDs; (3) evaluate the effectiveness of programs designed to reduce the risk of slip and fall injuries; (4) design and evaluate programs designed to reduce the risk of violent assaults in the workplace; and (5) evaluate the cost and benefits resulting from the implementation of safe patient handling and movement programs. Studies are needed to reduce job stress, associated outcomes and diseases, and fatigue-related errors and injuries by improving the organization of work (including work schedules and work loads) and reducing exposure to psychologically unhealthy work environments. Finally, better surveillance is needed to determine and follow the frequency and the severity of occupational exposures and health outcomes among workers in the healthcare and social assistance sector.

The NORA, the process used by the NIOSH to identify and prioritize research efforts across the diverse range of occupational exposures and health problems, has recently adopted a new framework. The new framework is based on eight specific industry sectors, with the healthcare and social assistance being one of the eight sectors. Each sector will have a Sector Research Council, with participants from academia, industry, labor, and government. Each Council will draft sector-based research goals, objectives, and action plans. These agendas will provide guidance to the entire occupational safety and health community for moving research to practice in workplaces. In addition, a Cross-Sector Research Council will be formed to identify opportunities for common research across sectors. Information about NORA can be found at the following web site: http://www.cdc.gov/niosh/NORA/. The goal of the NORA Healthcare Sector Research Council will be to develop a research agenda that incorporates ideas from stakeholders and partners to assist NIOSH in improving the research process and moving research into practice.

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