Long-Term Efficacy of an Ergonomics Program That Includes Patient-Handling Devices on Reducing Musculoskeletal Injuries to Nursing Personnel

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Human Factors: The Journal of the Human Factors and Ergonomics Society 2012 54: 608 originally published online 16 March 2012

DOI: 10.1177/0018720812438614

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Objective: The aim of this study was to evaluate long-term efficacy of an ergonomics program that included patient-handling devices in six long-term care facilities (LTC) and one chronic care hospital (CCH).

Background: Patient handling is recognized as a major source of musculoskeletal disorders (MSDs) among nursing personnel, and several studies have demonstrated effectiveness of patient-handling devices in reducing those MSDs. However, most studies have been conducted in a single facility, for a short period, and/or without a comprehensive ergonomics program.

Method: Patient-handling devices along with a comprehensive ergonomics program was implemented in six LTC facilities and one CCH. Pre- and post-intervention injury data were collected for 38.9 months (range = 29 to 54 months) and 51.2 months (range = 36 to 60 months), respectively.

Results: Postintervention patient-handling injuries decreased by 59.8% (rate ratio [RR] = 0.36, 95% confidence interval [CI] [0.28, 0.49], $p < .001$), lost workdays by 86.7% (RR = 0.16, 95% CI [0.13, 0.18], $p < .001$), modified-duty days by 78.8% (RR = 0.25, 95% CI [0.22, 0.28], $p < .001$), and workers' compensation costs by 90.6% (RR = 0.12, 95% CI [0.09, 0.15], $p < .001$). Perceived stresses to low back and shoulders among nursing staff were fairly low. A vast majority of patients found the devices comfortable and safe. Longer transfer times with the use of devices was not an issue.

Conclusion: Implementation of patient-handling devices along with a comprehensive program can be effective in reducing MSDs among nursing personnel. Strategies to expand usage of patient-handling devices in most health care settings should be explored.

Keywords: patient transfer, musculoskeletal injuries, ergonomic intervention, nursing personnel, patient handling, injury reduction

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HUMAN FACTORS
Vol. 54, No. 4, August 2012, pp. 608-625
DOI:10.1177/0018720812438614

INTRODUCTION

Musculoskeletal injuries (MSDs), in particular, back and shoulder injuries, are a major problem for nursing personnel in all settings of patient care, including hospitals, long-term care, and home health care (Bureau of Labor Statistics [BLS], 2009; Hegmann & Garg, 2004; Lagerström, Hansson, & Hagberg, 1998; Myers, Silverstein, & Nelson, 2002; Waters, Collins, Galinsky, & Caruso, 2006). According to the BLS (2009), nursing aides (NAs) had the highest incidence rate of days-away-from-work injuries and illnesses (465 per 10,000 workers) and the third highest number of these injuries and illness (44,930) among all occupations in 2007. Regarding MSDs, NAs had the highest incidence rate of days-away-from-work injuries and illnesses (252 per 10,000 workers), a rate more than 7 times the national MSD average for all occupations (BLS, 2009). In 2006 (most recent data available), the majority of injuries and illnesses (56%) among NAs involved health care patients, with 86% of those injuries attributable to overexertion (BLS, 2007).

Although the precise causes of MSDs among nursing personnel are not known, many studies have reported that manual lifting and transferring of patients, especially frequent lifting, was associated with increased incidence of low-back pain (Byrns, Reeder, Guang, & Pachis, 2004; Engkvist et al., 1998; Hignett, 1996; Nelson, Fragala, & Menzel, 2003; Owen & Garg, 1993; Retsas & Pinikahana, 2000; Smedley, Egger, Cooper, & Coggon, 1997; Vasihadou, Karvolntzis, Soumilas, Roumehotis, & Theodosopoulou, 1995; Winkelmolen, Landeweerd, & Drost, 1994; Yassi et al., 2001; Yassi, Khokhar, Tate, Cooper, & Vallentype, 1995; Zhuang, Stobbe, Hsiao, Collins, & Hobbs, 1999). According to Owen (1989), patient handling was the precipitator of back injuries in 89% of low-back injury reports filed by nurses in a hospital setting.

Biomechanical studies of manual lifting and transferring of patients have reported high peak compressive forces exceeding the 3400 N limit recommended by the National Institute for Occupational Safety and Health (Daynard et al., 2001; Garg & Owen, 1994; Garg, Owen, Beller, & Banaag, 1991a, 1991b; Marras, Davis, Kirking, & Bertsche, 1999; Schibye et al., 2003; Skotte, Essendrop, & Hansen, 2002; Ulin et al., 1997; Waters, Putz-Anderson, Garg, & Fine, 1993) and suggested that these activities expose nursing personnel to high risk of low-back disorders. Similarly, a few studies have reported high cumulative spinal loads from patient-handling activities (Daynard et al., 2001; Village et al., 2005). In psychophysical studies, nursing personnel have reported high perceived stresses on low back and shoulder during manual lifting and transferring of patients (Garg et al., 1991a, 1991b; Garg & Owen, 1992; Owen & Fragala, 1999; Owen, Keene, & Olson, 2002; Village et al., 2005; Winkelmolen et al., 1994; Yassi et al., 2001).

Historically, education and training in body mechanics and lifting and transferring techniques have been used to reduce MSDs in nursing personnel (Garg & Owen, 1992; Lagerström & Hagberg, 1997; Silverstein, 2006; Videman et al., 1989; Yassi et al., 2001). With a few exceptions, these approaches have not been effective in reducing MSDs in nursing personnel (Feldstein, Valanis, Vollmer, Stevens, & Overton, 1993; Garg & Owen, 1992; Hartvigsen, Lauritzen, Lings, & Lauritzen, 2005; Hignett, 1996; Jensen et al., 2006; Johnsson, Carlsson, & Lagerström, 2002; Lagerström & Hagberg, 1997; Videman et al., 1989). Appropriate patient-transferring assistive devices, including mechanical patient-lifting hoists, offer engineering solutions to reducing biomechanical stressors among nursing personnel. Several field studies have examined the efficacy of assistive devices, in particular, mechanical hoists, in reducing MSDs among nursing personnel (Brophy, Achimore, & Moore-Dawson, 2001; Charney, 2000; Charney, Simmons, Lary, & Metz, 2006; Collins, Wolf, Bell, & Evanoff, 2004; Engst, Chhokar, Miller, Tate, & Yassi, 2005; Evanoff, Wolf, Aton, Canos, & Collins, 2003; Garg & Owen, 1992; Guthrie et al., 2004; Li, Wolf, & Evanoff, 2004; Lynch & Freund, 2000; Miller, Engst, Tate, & Yassi, 2006; Nelson et al., 2006; Owen et al., 2002; Yassi et al., 2001).

All these studies, except three (Charney et al., 2006; Collins et al., 2004; Evanoff et al., 2003), have evaluated the efficacy of patient-transferring devices either in one nursing facility and/or for a short term (often ≤1 year). Most studies have involved only mechanical lifts, and a few have involved repositioning devices. With the exception of Owen et al. (2002), none of these studies has reported the impact of patient-handling assistive devices on patient comfort, safety, and patient transfer time. Few studies have addressed the barriers to efficaciously implementing patient-handling devices.

The objective of this study was to determine long-term efficacy of a comprehensive ergonomic intervention that included patient-handling devices in multiple nursing facilities on patient-handling injuries to nursing personnel. In addition, impact of patient-handling devices on perceived stresses to nursing personnel, comfort and safety of patients, and patient transfer time were studied.

Prior Intervention Studies on Assistive Devices

The following is a brief summary of many prior intervention studies on assistive devices:

Charney (2000) evaluated the effectiveness of mechanical lifts in combination with an already existing lift team ($N = 20$ personnel) in an acute care facility (200 beds) through the use of a preintervention (2 years) and postintervention (1 year) design. Number of lost-time injuries decreased from 10 to 2, lost days from 27 to 0, and restricted workdays from 161 to 2.

Lynch and Freund (2000) implemented a program consisting of patient-transferring devices (walking belts, transfer boards, and hoists), administrative controls, and proper body mechanics when transferring patients in a 440-bed acute care hospital. The authors compared postintervention injuries (1 year) with average injuries across a 3-year preintervention period. The lost-time injuries decreased by 30% and the average number of lost workdays per back injury by 73%.

Yassi et al. (2001) conducted a randomized control trial in a large hospital (medical, surgical, and rehabilitation; $N = 346$ nurses and aids). The control group (Arm A) received training in lifting techniques (only upon request) and equipment use, Arm B received 3 hr of training and adopted a "safe lifting" program (one mechanical lift, transfer belts, and two to four sliding devices), and Arm C received 3 hr of training and adopted a "no strenuous lifting" program (total body lifts, sit-stand lifts, and a set of sliding boards). At a 1-year follow-up of the three arms, although the injury rates were not significantly affected by the intervention, there was improved comfort with patient handling, decreased staff fatigue, and decreased physical demands in Arm C ($p < .01$).

Owen et al. (2002) implemented an ergonomics program in an experimental hospital (40 beds, 37 volunteers) and compared program effectiveness with a control hospital (40 beds, 20 volunteers). Patient-transferring devices included total lifts, sit-stand lifts, walking belts with handles, friction-reducing devices, and toileting devices for toileting in bed. The authors reported that the perceived stresses to nursing staff were lower and that the patients felt more comfortable and secure in the experimental hospital ($p < .01$). The study compared postintervention injuries (18 months) with those in preintervention (18 months) in the experimental hospital. Back and shoulder injuries decreased by 40%, lost workdays by 95.3%, and restricted workdays by 20%. The authors concluded that the number of injuries decreased and that the severity of injuries was reduced (lost and restricted workdays).

Evanoff et al. (2003) conducted a pre- and postintervention study in four hospitals and five long-term care facilities (N = 6,835 full-time work years for the entire study period). Assistive devices included full-body lifts and stand-up lifts, and all members of nursing staff were requested to attend a 2-hr hands-on instructional course on lift operation. Pre- and postintervention periods ranged from 2 to 3 years (a total of 5 years). Analysis of combined data showed significant decreases in recordable injury rate (relative risk [RR] = 0.82, 95% confidence interval [CI] [0.68, 1.00]), lost-workday injury rate (RR = 0.56, 95% CI [0.41, 0.78]), and lost-workday rate (RR = 0.42, 95% CI not provided). Larger reductions were reported in long-term care facilities. Furthermore, observed reductions in injury and lost-workday injury rates were greater in those units that reported greater use of the lifts. The authors recommended, "Future work should focus on strategies to facilitate greater use of mechanical lifting devices" (Evanoff et al., 2003, p. 456).

Li et al. (2004) reported effectiveness of using mechanical lifts (portable full-body lifts and stand-up lifts) and friction-reducing sheets on patient-handling injuries in three nursing units of a 111-bed community hospital (138 health care workers) with a preintervention (19 months) and postintervention (26 months) design. The study reported decreases, statistically not significant, in Occupational Safety and Health Administration (OSHA) recordable adjusted injury rate (RR = 0.50, 95% CI [0.20, 1.26]) and lost-workday injury rate (RR = 0.35, 95% CI [0.10, 1.16]). The authors reported that one of the problems encountered was the reluctance of many nursing staff to use mechanical lifts for patient transfers.

Collins et al. (2004) determined the effectiveness of a "best-practices" program in six nursing homes (a total of 552 beds and 1,728 nursing personnel) with a pre- and postintervention design (36 months each). The program included mechanical lifting equipment and repositioning aids, worker training on use of these devices, a medical management program, and a written zero-lift policy. Adjusted RRs for patient-handling injuries were 0.54 (95% CI [0.40, 0.73]) for injuries reported on OSHA 200 logs, 0.65 (95% CI [0.50, 0.86]) for first reports of employee injury and 0.39 (95% CI [0.29, 0.55]) for workers' compensation injury claims. The rate of lost and restricted-workday injuries also declined with RRs of 0.34 (95% CI [0.20, 0.60]) and 0.62 (95% CI [0.44, 0.87]), respectively. The estimated payback period was slightly less than 3 years.

Nelson et al. (2006) evaluated the effectiveness of a patient care ergonomics program that included a no-lift policy in seven facilities (19 nursing home care units and four spinal cord injury units, 20 to 60 beds per unit and 19 to 53 nursing personnel per unit) with a pre- and postintervention design (two 9-month periods)

without a control group. Patient-handling devices included ceiling lifts, floor-based total and sit-stand hoists, mechanical transfer aids, friction-reducing devices, and belts with handles. Only musculoskeletal injuries that occurred during patient transfer were studied. Postintervention injury rates decreased in 15 units, increased in 7 units, and remained unchanged in 1 unit. Overall, injury rate decreased by 29.6% (p = .04), modified-duty days by 20.2% (p = .02), and lost workdays by 18.2% (p = .79). The estimated annualized cost savings for the entire program was $204,599. The authors concluded that a 3-year follow-up period would be ideal because of the cumulative nature of nursing injuries.

Washington Hospital Services implemented a zero-lift program (mechanical lifts) in 31 of its 38 rural hospitals (20 to 200 beds; Charney et al., 2006). The authors compared 1-year post- and preintervention patient-handling injury rates. Patient-handling injury claims decreased by 43%, lost-time injury rates by 50%, and total incurred cost per claim by 24%.

Miller et al. (2006) evaluated the effectiveness of ceiling lifts in a 63-bed long-term facility (45 nurses and aids) using a pre- and postintervention (1 year each) design with a concurrent control nursing home (100 beds, 29 nurses and aids) with portable mechanical lifts. In the intervention facility, patient-handling claims and cost decreased by one claim and 70%, respectively, whereas in the control facility, these increased by six claims and 241%, respectively.

METHOD

A pre- and postintervention design without a control group and a participatory approach were used to evaluate the efficacy of an ergonomic intervention involving patient-handling devices in six long-term care (LTC) facilities (Facility 6 provided combined data from two LTC facilities and is treated as one facility) and one chronic care hospital (CCH). In all seven nursing facilities, patient mix included totally dependent, extensive-assist, minimum-assist, and supervised residents. All seven nursing facilities had patients with Alzheimer's, dementia, and psychiatric problems and requiring skilled care. The research team assisted in developing and implementing ergonomics interventions in four nursing facilities (1 to 4, Table 1). The other three nursing facilities had an ongoing ergonomics program (5 to 7, Table 1) and developed ergonomic interventions in-house. Number of beds, number of nursing and total employees, patients' weight-bearing abilities, and pre- and postobservation periods for the seven nursing facilities are summarized in Table 1.

Ergonomics Program

Participatory ergonomics. The term *participatory approach* generally means worker involvement (Cohen, 1994). Levels and forms of participation include quality circles, labor-management committees, work teams, and gain sharing (Cohen, 1994). To address workplace hazards, companies have employed joint labor-management safety and health committees, work teams, direct worker input into hazard control, and worker participation in ergonomics problem solving (Cohen, 1994).

Haines, Wilson, Vink, and Koningsveld (2002) developed a framework for participatory ergonomics consisting of nine dimensions: (a) permanence of initiatives, (b) involvement, (c) level of influence, (d) decision-making power, (e) composition, (f) requirement, (g) focus, (h) remit, and (i) role of "ergonomics specialist" (hereafter referred to as D1 to D9). This study employed all nine dimensions.

Each facility developed a participatory ergonomics program to reduce patient-handling injuries throughout the entire facility (D3), primarily through implementation of "no-manual-lifting programs" (D7). The programs were developed and implemented by teams with representatives (D2) from management and volunteers (D2) from nursing, housekeeping, dietary, and maintenance departments (D5). An ergonomics specialist assisted Facilities 1 through 4 in developing and implementing their programs and provided guidance to all seven facilities after their programs began (D9). Team members invited several vendors to demonstrate their equipment and leave it with the facility for further evaluation. Each team was empowered (D4) to (a) select and purchase equipment for its

TABLE 1: Participating Nursing Facility Characteristics

Nursing Facility	Facility Type	Beds (*n*)	Total Employees (Total *n*)	Nursing Employees (Total *n*)	Nursing Employees (FTE)	Observation Period (months)		Patient Type			Patient-Handling Devices Cost (× 1,000)
						Pre	Post	% NWB	% WB	% Sup	
1	LTC	131	158	75	55.5	29	49	33	34	33	$45
2	LTC	133	137	83	63.8	30	49	7	43	50	$47
3	LTC	189	170	145	99.0	54	48	26	56	18	$51
4	LTC	253	230	161	124.3	54	48	25	35	40	$60
5	CCH	124	267	136	104.9	36	36	18	65	17	$62
6	LTC	245	250	177	147.0	36	60	—	—	—	$60
7	LTC	85	125	76	41.2	36	60	4	64	32	$50
Total		1,160	1,337	853	635.7	—	—	21	47	32	$375

Note. LTC = long-term care; CCH = chronic care hospital; FTE = full-time equivalent; Pre = preintervention; Post = postintervention; NWB = non–weight bearing; WB = weight bearing; Sup = supervised. Dash indicates data were not available.

facility (D8), (b) develop training programs for nursing personnel on proper use of equipment (D8), (c) determine appropriate transferring devices to be used with each patient and for each transfer (D8), (d) monitor equipment-use compliance (D8), and (e) address unforeseeable problems brought to its attention by employees (D8). Participation in the no-manual-lifting programs developed by the teams was mandatory, and adherence to the programs was monitored by key personnel (D6). On an ongoing basis, each team met monthly to discuss and resolve problems, address injuries, and monitor program effectiveness (D1).

Addressing barriers to implementing no-manual-lifting program. In health care facilities, barriers to providing and using lifting equipment may include cost (Collins et al., 1994); management cooperation, commitment, and visible support (Evanoff et al., 2003; Li et al., 2004); a reluctance to use mechanical devices for patient transfers (Garg & Owen, 1992; Li et al., 2004); lack of readily available patient-transferring devices and slings (Bell, 1987; Garg, Owen, & Carlson, 1992; Jensen, 1987; McGuire, Hanson, & Tigar, 1996); lack of clarity on which mechanical aid to use in the patient care plan (McGuire et al., 1996); lack of proper training (Bell, 1987; Garg et al., 1992; McGuire et al., 1996; Li et al., 2004; Takala & Kukkonen, 1987); employee buy-in (Garg & Owen, 1992); concerns about patient comfort and safety (Collins et al., 2004); and the time required to use the equipment (Collins et al., 2004; Garg et al., 1991a, 1991b; Garg & Owen, 1992).

When implementing the no-manual-lifting programs, we paid special attention to addressing the above barriers as well as included elements from the lead author's own experience (Garg et al., 1992; Garg & Owen, 1992). In this regard, key aspects of the implemented programs included (a) management commitment and participation, (b) empowerment of nursing personnel in equipment selection and program implementation, (c) evaluation of patients' transferring needs by nursing personnel, (d) laminated cards in each patient room specifying patient-handling devices to be used, (e) adequate patient-handling equipment for each nursing unit for easy access, (f) spare slings and parts in each facility to minimize equipment down time, (g) hands-on training of all nursing personnel, (h) monitoring use of patient-handling devices by key nursing personnel, (i) feedback

from key nursing personnel to those nursing personnel who needed help, (j) team approach to address patients' and family members' concerns about patient-handling devices, and (k) monthly meetings to discuss and resolve problems and concerns.

Management commitment. Management commitment included financial support for purchasing equipment, formation of participatory ergonomics teams, assignment of responsibility to a nursing coordinator to manage the ergonomics program, and show of visible support for the program by participating in participatory ergonomics teams from time to time. These teams consisted of 10 to 14 team members, mostly NAs (approximately 50% team members) and nurses. Participatory ergonomics teams also had 1 member each representing housekeeping, dietary, and maintenance. The teams met once per month. Although both the management and the employees believed that manual lifting and transferring of patients were the most hazardous tasks in their facilities, the participatory ergonomics teams also discussed slips and falls and unsafe conditions in dietary and housekeeping departments and recommended solutions to identified problems.

Equipment evaluation and selection. All seven nursing facilities invited different vendors to demonstrate their patient-handling equipment. The participatory ergonomics teams evaluated these devices. Nurses and NAs served as both patients and caregivers. The evaluation period ranged from 4 weeks to 3 months. The investigators trained 12 nursing personnel (hands-on training) in the use of these devices and prepared written instructions along with pictures and videos showing proper and improper uses of these devices in Facilities 1 to 4. In Facilities 5 to 7, vendors trained the participatory ergonomics team members in the use of selected patient-transferring devices, and the investigators provided additional training during postintervention as requested by those facilities.

Empowering ergonomics teams in equipment selection and use. In all seven nursing facilities, the participatory ergonomics teams were empowered to determine the brand(s) and quantity of patient-handling devices. In Facilities 1 to 4, patient-handling devices included portable battery-powered total-lift hoists for transferring non-weight-bearing patients, portable battery-powered sit-stand hoists for transferring partial-weight-bearing patients, walking belts with handles for transferring fully weight-bearing patients with the use of a pulling technique (Garg & Owen, 1992), shower chairs for toileting and showering, shower gurneys, a friction-reducing sheet for use under the draw sheet for repositioning in bed, friction-reducing sheet and walking belt for repositioning in wheelchair, and ramp-type weighing scales (Figure 1). Nursing Facilities 5 to 7 primarily used battery-operated total lift hoists and battery-operated sit-stand hoists. In addition, Facility 5 had a few ceiling-mounted hoists, slide boards, and slide transfer sheets; and Facility 6 had modern bathtubs with doors. All facilities ensured that each nursing unit would be self-sufficient in these devices when determining how many devices to order.

For each unit, one total-lift hoist, one sit-stand hoist, one friction-reducing sheet, and one shower chair were ordered for up to eight patients who needed to be transferred with the use of those devices. In addition, one walking belt with handles (small, medium, or large) was ordered for each patient who needed to be transferred with the use of a walking belt. NAs and nurses (participatory ergonomics team members) determined appropriate assistive devices for transferring both existing patients as well as new admissions. A laminated patient transfer card was prepared that showed all patient transfers and devices to be used for each transfer for each patient. Cards were stored in patients' rooms to provide easy reference to nursing personnel and to avoid decision making at the individual caregiver level.

Program training, compliance, and continuous improvement. All seven nursing facilities adopted a no-manual-lifting policy and made use of patient-transferring devices mandatory. The staff development coordinators and the members of the participatory ergonomics teams were responsible for training both new and all other NAs and nurses, including director of nursing, in proper use of patient-transferring devices. Responsibilities were assigned for

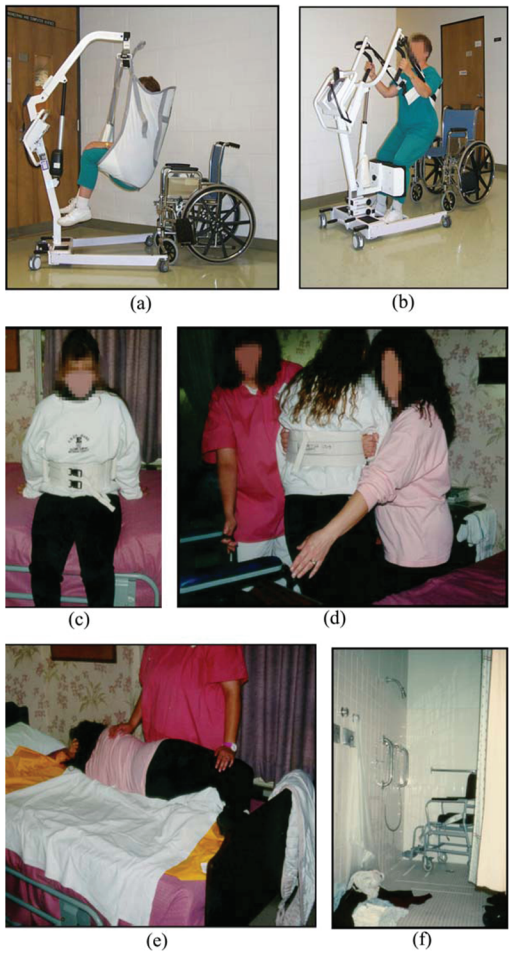

Figure 1. Patient-handling devices used during postintervention: (a) battery-powered total-lift hoist, (b) battery-powered sit-stand hoist, (c) walking belt with handles and snap-on buckles, (d) transferring patient with use of walking belt and pulling technique, (e) friction-reducing device under bedsheet to reposition patient in bed, (f) shower chair for showering and toileting patients.

storing devices, charging batteries, sling inspection, ordering spare parts, and performing maintenance on these devices. Key nursing members of the participatory ergonomics teams were responsible for random monitoring of patient transfers, providing feedback to NAs and nurses, and discussing unforeseeable problems with patient transfers in monthly meetings. All employees were encouraged to report any problem with patient handling or any other safety concern to the participatory ergonomics team.

A small minority of patients and their family members preferred manual lifting. They were informed that use of patient-handling devices was not an option, and a group of nursing personnel persuaded them in favor of patient-handling devices by emphasizing risks to patients and nursing personnel from a manual transfer.

Data Collection

All data were collected during intervention and postintervention. Nursing personnel from the participatory ergonomics teams obtained the signed consent forms from all nursing personnel and from those patients who were able to respond either in writing or verbally in Facilities 1 to 4. The response rate for the nursing personnel was 97% and 68% for those patients who were able to respond (overall response rate is unknown but estimated to be greater than 50%). Nursing Facilities 5 to 7 provided injury and cost data to the researchers, and no individual data were collected from either nursing personnel or patients.

During intervention, 12 NAs and nurses from the LTC facility formally evaluated different devices for transferring patients from bed to wheelchair and for repositioning in bed and then selected the devices that they liked the most. Those NAs and nurses served both as caregivers and patients (mean patient weight = 76.8 kg, range = 47.2 to 103.6 kg). They rated each device for stresses to low back and shoulders on the Borg CR-10 Scale (Borg, 1982), patient comfort on a 7-point comfort scale (1 = *extremely comfortable*, 7 = *extremely uncomfortable*; Corlett & Bishop, 1976) and patient safety on a 7-point scale similar to Corlett and Bishop's (1976) scale (1 = *extremely safe*, 7 = *extremely unsafe*). They also rated the manual transfer method using gait belt for lifting and transferring patients from bed to wheelchair and draw sheet for repositioning in bed. NAs and nurses were randomly assigned patient-transfer equipment to test, and perceived ratings were obtained.

The postintervention period began after the patient-transferring devices were placed for use

in the nursing facilities. Facilities 1 to 4 were visited 4 to 10 times per year, and Facilities 5 to 7 were visited 2 times per year by the first author. Postintervention data in Facilities 1 to 4 included transfer time measured with a wrist watch, ratings of perceived exertion for low back and shoulders on the Borg CR-10 Scale from nursing personnel, and ratings of perceived comfort (*comfortable*, *neither comfortable nor uncomfortable*, *uncomfortable*) and perceived safety (*safe*, *neither safe nor unsafe*, *unsafe*) from patients. Immediately after a patient transfer, NAs and nurses were asked to provide perceived exertion ratings on a questionnaire. Patients were asked to provide perceived comfort and safety ratings either on a form or verbally. Nursing team members of the participatory ergonomics teams collected these data after obtaining consents from NAs, nurses, and patients. Impacts of ergonomic interventions on nursing personnel who were older (age >50 years), pregnant, or with severe back problems were determined by identifying the number of nursing personnel in each of these categories who continued to perform patient transfers.

In each nursing facility, the preintervention period was defined as the time prior to the date patient-transferring devices were deployed in that facility. Intervention period was the time spent to evaluate and select devices. This time period ranged from 3 to 6 months and was considered part of the preintervention period as no patient-handling devices were provided to nursing employees. The postintervention period was defined as the time from when the patient-transferring devices were deployed to the time data collection ended. Since the seven nursing facilities implemented no-manual-lifting programs at different times and patient-transferring devices were deployed at different times in different facilities, pre- and postintervention time varied for each nursing facility.

Pre- and postintervention injury data were available for 38.9 months (range = 29 to 54 months) and 51.2 months (range = 36 to 60 months), respectively (Table 1). These data were obtained from OSHA logs and insurance records in Nursing Facilities 1 to 4. Nursing Facilities 5 to 7 analyzed their OSHA and insurance records and provided summary data to the research team. These data included patient-handling injuries, lost workdays, modified-duty days, and workers' compensation costs associated with patient-handling injuries. A patient-handling injury was defined as a musculoskeletal injury experienced during an act of lifting, transferring, repositioning in bed, boosting in wheelchair, or ambulating a patient. These data were also collected for non-patient-handling injuries experienced by any employee in the nursing facility. In addition, costs for patient-handling devices were provided by all seven nursing facilities.

Data Analysis

For each nursing facility, mean values for patient-handling injuries, lost workdays, modified-duty days, and workers' compensation costs were calculated per 100 nursing full-time-equivalent employees (FTEs) per year for both pre- and postintervention. A Poisson regression model was used to compute RRs and 95% CIs to compare post- and preintervention rates for (a) patient-handling injuries, (b) lost workdays, (c) modified-duty days, and (d) workers' compensation costs with the GENMOD procedure in SAS 9.2 (Collins et al., 2004; Nelson et al., 2006; SAS, 2008). Payback periods were determined by dividing the cost of equipment purchased by mean savings per year in workers' compensation costs (actual dollars, not adjusted for inflation) associated with patient-handling injuries. Separate analyses were performed for each nursing facility as well as for combined data from all seven facilities.

To determine whether ergonomic interventions involving patient-handling devices were primarily responsible for reduced injury rates, mean post- and preintervention patient-handling injuries per year were compared with mean post- and preintervention non-patient-handling injuries per year with the use of chi-square tests (SAS, 2008). Similar chi-square tests were performed for lost workdays, modified-duty days, and workers' compensation costs per year for each nursing facility as well as for the combined data from all seven facilities.

Perceived exertion, comfort, and safety ratings for the selected devices (postintervention devices) were compared with manual patient-transferring

methods (preintervention techniques) during intervention (equipment selection) with the use of paired *t* tests. Descriptive statistics were calculated for postintervention transfer times, ratings of perceived exertion, and patient comfort and safety ratings.

RESULTS

Pre- and Postintervention Patient-Handling Injuries, Lost Workdays, Modified-Duty Days, and Workers' Compensation Costs

Pre- and postintervention patient-handling injuries, lost workdays, modified-duty days, and workers' compensation costs per 100 FTEs per year are summarized in Table 2. Compared with preintervention data, postintervention data showed significant improvements in injuries, lost workdays, modified-duty days, and workers' compensation costs associated with patient-handling activities ($p < .001$). Overall, postintervention patient-handling injuries on the combined data from seven nursing facilities decreased by 59.8% (RR = 0.36, 95% CI [0.28, 0.49], $p < .001$), lost workdays by 86.7% (RR = 0.16, 95% CI [0.13, 0.18], $p < .001$), modified-duty days by 78.8% (RR = 0.25, 95% CI [0.22, 0.28], $p < .001$), and workers' compensation costs by 90.6% (RR = 0.12, 95% CI [0.09, 0.15], $p < .001$) (Table 2).

Postintervention patient-handling injury rates were significantly lower in six out of seven nursing facilities ($p < .05$, RR = 0.21 to 0.61), and lost workdays rates were lower in all seven facilities ($p < .001$, RR = 0.00 to 0.50) (Table 2). Modified days and workers' compensation costs were available from five and six nursing facilities, respectively. Modified days rates significantly decreased in four nursing facilities ($p < .001$, RR = 0.04 to 0.20) and increased in one nursing facility (RR = 1.17, 95% CI [0.95, 1.45], $p = .15$). Workers' compensation cost rates were significantly lower in all six nursing facilities ($p < .001$, RR = 0.00 to 0.47) (Table 2).

Payback Period

Complete data (patient-handling devices cost and workers' compensation costs) were available for six nursing facilities. The mean cost for the patient-transferring devices purchased by these six nursing facilities was $53,571 (range = $45,000 to $62,000; Table 1). The mean savings in workers' compensation costs associated with patient-transferring injuries for these six nursing facilities was $71,822 per year (Table 2). The mean of payback periods for the six facilities was 15 months (range = 5 to 31 months).

Comparison of Patient-Handling Injuries With Non-Patient-Handling Injuries

Injuries, lost workdays, modified-duty days, and workers' compensation costs per year for non-patient-handling injuries are summarized in Table 3. Chi-square tests on the combined data from seven nursing facilities showed that when compared with non-patient-handling activities, overall postintervention patient-transferring injuries, lost workdays, modified-duty days, and workers' compensation cost per year showed significant decreases from preintervention levels ($p < .001$; Table 3). Postintervention injuries from non-patient-handling activities remained practically unchanged, and modified-duty days and workers' compensation costs increased. Lost workdays decreased but to a much lesser extent than did those associated with patient-handling activities. Regarding individual nursing facilities, when compared with non-patient-handling activities, postintervention patient-transferring injuries per year showed significant decreases from preintervention levels in four out of seven nursing facilities ($p \leq .04$), lost workdays per year in five out of seven ($p \leq .007$), modified-duty days in five out of five ($p < .001$), and workers' compensation costs in five out of five ($p < .001$) (Table 3).

Perceived Exertion, Comfort, and Safety Ratings

Postintervention perceived exertion ratings for low back and shoulder from nursing personnel and comfort and safety ratings from patients are summarized in Table 4. Nursing personnel rated the perceived stresses to low back and shoulder between *very light* and *light*. Overall, three out of four patients found the devices comfortable and safe. Among the four patient-handling devices, walking belt with handles was rated as

TABLE 2: Summary of Pre- and Patient-Handling Injuries per 100 Full-Time-Equivalent Nursing Personnel per Year

Nursing Facility	Injury Rate				Lost Workdays Rate				Modified Duty Days Rate				Workers' Compensation Cost Rate ($ x1,000)			
	Pre	Post	RR [95% CI]	*p*	Pre	Post	RR [95% CI]	*p*	Pre	Post	RR [95% CI]	*p*	Pre	Post	RR [95% CI]	*p*
1	33.5	7.0	0.21 [0.09, 0.47]	<.001	237.8	118.7	.50 [.40, .62]	<.001	486.8	18.0	0.04 [0.02, 0.06]	<.001	104.4	49.2	.47 [.34, .66]	<.001
2	37.6	14.3	0.38 [0.21, 0.70]	.002	80.3	4.5	.06 [.22, .15]	<.001	324.8	67.6	0.21 [0.16, 0.20]	<.001	160.5	2.9	.02 [.01, .06]	<.001
3	22.4	5.1	0.23 [0.09, 0.60]	.003	219.3	3.0	.01 [.00, .04]	<.001	237.5	55.6	0.23 [0.18, 0.31]	<.001	118.9	1.1	.01 [.00, .06]	<.001
4	20.2	7.2	0.36 [0.15, 0.84]	.018	88.7	16.9	.20 [.12, .34]	<.001	291.2	46.7	0.16 [0.12, 0.22]	<.001	130.0	13.5	.10 [.06, .18]	<.001
5	19.4	8.6	0.44 [0.20, 0.99]	.047	180.8	.7	.01 [.00, .04]	<.001	—	—	—	—	79.6	.1	.00 [.00, .39]	.021
6	24.5	15.0	0.61 [0.32, 1.16]	.135	138.1	19.0	.14 [.09, .22]	<.001	—	—	—	—	—	—	—	—
7	21.8	9.7	0.45 [0.21, 0.95]	.036	145.6	7.3	.05 [.02, .11]	<.001	155.3	182.0	1.17 [0.95, 1.45]	.146	17.9	6.1	.34 [.14, .86]	.022
Total	24.4	9.8	0.37 [0.28, 0.49]	<.001	150.5	19.6	.16 [.13, .18]	<.001	296.6	62.8	0.25 [0.22, 0.28]	<.001	108.6	10.2	.12 [.09, .15]	<.001

Note. Pre = preintervention; Post = postintervention; RR = risk ratio of post versus pre; CI = confidence interval. Dash indicates data are not available.

TABLE 3: Comparison of Patient-Handling and Non-Patient-Handling Injuries, Lost Workdays, Restricted Workdays, and Workers' Compensation Costs per Year

Nursing Facility		Injuries				Lost Days				Modified Days				Workers' Compensation ($ x1,000)			
		PT	Non-PT	RR [95%CI]	*p*	PT	Non-PT	RR [95%CI]	*p*	PT	Non-PT	RR [95%CI]	*p*	PT	Non-PT	RR [95%CI]	*p*
1	Pre	18.6	11.6	—	—	132.0	24.4	—	—	270.2	58.8	—	—	58	7	—	—
	Post	3.9	15.2	0.3 [0.12, 0.80]	.005	65.9	28.1	0.6 [0.45, 0.86]	.007	10.0	53.9	0.1 [0.04, 0.14]	<.001	27	16	0.5 [0.30, 0.67]	<.001
2	Pre	24.0	13.2	—	—	51.2	4.8	—	—	207.2	36.8	—	—	102	2	—	—
	Post	9.1	21.0	0.4 [0.24, 0.83]	.005	2.9	36.0	0.1 [0.02, 0.19]	<.001	43.1	85.0	0.3 [0.18, 0.33]	<.001	2	38	0.0 [0.00, 0.08]	<.001
3	Pre	22.2	20.7	—	—	217.1	14.9	—	—	235.1	174.0	—	—	118	71	—	—
	Post	5.0	23.5	0.4 [0.15, 0.80]	.003	3.0	98.0	0.0 [0.00, 0.05]	<.001	55.0	194.0	0.4 [0.28, 0.46]	<.001	1	38	0.0 [0.00, 0.17]	<.001
4	Pre	25.1	42.0	—	—	104.0	52.0	—	—	362.0	180.0	—	—	162	29	—	—
	Post	9.0	38.0	0.6 [0.30, 0.97]	.03	21.0	9.0	1.3 [0.56, 2.34]	.72	58.0	76.0	0.5 [0.34, 0.63]	<.001	17	49	0.2 [0.09, 0.25]	<.001
5	Pre	20.3	8.0	—	—	189.7	18.0	—	—	—	—	—	—	—	—	—	—
	Post	9.0	3.7	1.0 [0.36, 2.65]	.96	0.7	26.0	0.0 [0.00, 0.07]	<.001	—	—	—	—	—	—	—	—
6	Pre	36.0	20.3	—	—	203.0	302.0	—	—	—	—	—	—	—	—	—	—
	Post	22.0	16.2	0.9 [0.52, 1.40]	.53	28.0	27.0	1.5 [0.89, 2.44]	.13	—	—	—	—	—	—	—	—
7	Pre	9.0	15.0	—	—	60.0	248.0	—	—	64.0	9.0	—	—	7	43	—	—
	Post	4.0	16.0	0.6 [0.25, 1.44]	.21	3.0	109.0	0.16 [0.05, 0.48]	<.001	75.0	159.0	0.6 [0.49, 0.67]	<.001	3	28	0.6 [0.21, 1.95]	.39
Total	Pre	155.2	130.8	—	—	957.0	664.1	—	—	1,138.5	458.6	—	—	447	152	—	—
	Post	62.0	133.6	0.6 [0.44, 0.72]	<.001	124.5	333.1	0.3 [0.29, 0.42]	<.001	241.1	567.9	0.3 [0.28, 0.36]	<.001	50	169	0.2 [0.14, 0.25]	<.001

Note. Pre = preintervention; Post = postintervention; PT = patient handling; Non-PT = non–patient handling; RR = risk ratio of post versus pre; CI = confidence interval. Dash indicates data are not available.

TABLE 4: Summary of Percentages of Patients Feeling Comfortable and Safe and Perceived Exertion Ratings for Nursing Personnel During Postintervention

		Resident Comfort and Safety Ratings							Nursing Personnel Perceived Exertion Ratings[a]					
Device	*n*	Comfort			Safety			*n*	Low Back			Shoulder		
		Comfortable (%)	Neither/ Nor (%)	Uncom-fortable (%)	Safe (%)	Neither/ Nor (%)	Unsafe (%)		*M*	*SD*	Range	*M*	*SD*	Range
Total lift	200	72.0	21.0	7.0	70.0	24.0	6.0	214	1.5	1.41	0–5	1.3	1.28	0–5
Sit-stand lift	129	64.4	30.2	5.4	63.5	31.8	4.7	138	1.3	1.30	0–5	1.0	1.12	0–4
Walking belt with handles	114	79.8	17.6	2.6	83.3	14.9	1.8	114	1.0	1.14	0–5	0.8	1.01	0–4
Friction-reducing sheet	61	55.7	41.0	3.3	59.0	41.0	0.0	61	1.6	1.35	0–5	1.6	1.29	0–5
Total	504	69.8	25.0	5.2	70.0	26.0	4.0	527	1.4	1.34	0–5	1.2	1.21	0–5

[a]Borg CR-10 ratings (Borg, 1982).

TABLE 5: Transfer Times for Patient-Handing Devices During Postintervention (in minutes)

		Transfer Time		
Device	*n*	Mean	Standard Deviation	Range
Total lift	121	3.94	3.94	1.00–8.50
Sit-stand lift	80	2.86	2.86	0.70–7.50
Walking belt	84	1.31	1.31	0.17–3.50
Friction-reducing sheet	44	2.33	1.73	0.30–6.30

comfortable and safe by the largest percentage of patients (≥80%) and friction-reducing sheet by the smallest percentage of patients (≤59%) (Table 4). There were frequent comments made by the nursing personnel either on their perceived exertion ratings form or to the research team, such as "improved patient care," "equipment user-friendly," "reduced stress," "I go home without my back being sore," and "We are a lot less tired at the end of the day."

Postintervention transfer times for total lift, sit-stand lift, walking belt with handles, and the friction-reducing device are summarized in Table 5. On average, the walking belt required the least amount of time and the total lift the most time for patient transfers.

During the intervention phase, a comparison of patient transfers with the use of selected patient-handling devices with manual method of transfer showed that all devices were rated as less stressful on the low back ($p < .001$), shoulders ($p \leq .008$), and wrists ($p \leq .005$) (Table 6). Patients rated total lift and sit-stand lift as more comfortable ($p \leq .007$) and safe ($p \leq .010$) and walking belt with handles as safer ($p < .001$) than manual lifting method (Table 6). The friction-reducing device was found neither significantly more comfortable nor safer than the draw sheet ($p \geq .10$).

Impact on Staffing Level and on Older and Pregnant Workers and Those With Severe Back Problems

The ergonomics programs neither required nor resulted in any increase in nursing staff in any of the seven facilities. Postintervention,

TABLE 6: Comparison of Patient Comfort and Safety and Nursing Aides' Perceived Exertion Ratings for Patient-Handling Devices With Manual Method of Transfer

		Patient Comfort and Safety Ratings					Perceived Exertion Ratings					
		n	Comfort[a]		Safety[b]		*n*	Low Back[c]		Shoulder[c]		Wrist[c]	
Transfer Type	Device		*M*±*SD* (Range)	*p*	*M*±*SD* (Range)	*p*		*M*±*SD* (Range)	*p*	*M*±*SD* (Range)	*p*	*M*±*SD* (Range)	*p*
	Manual[d] (gait belt)	6	3.8±0.98 (3.0–5.0)	•••	3.7±0.82 (3.0–5.0)	•••	12	4.6±1.62 (2.0–7.0)	•••	3.9±1.73 (1.0–7.0)	•••	4.2±1.75 (1.0–6.0)	•••
Bed to wheelchair	Total lift[e]	6	2.3±0.82 (1.0–3.0)	.007	2.0±0.63 (1.0–3.0)	.004	12	1.8±0.72 (0.5–3.0)	<.001	1.9±0.87 (0.5–3.0)	.008	1.5±0.88 (0.5–3.0)	<.001
	Sit-stand lift[e]	6	2.7±0.82 (2.0–4.0)	<.001	2.3±0.82 (1.0–3.0)	.010	12	1.7±0.92 (0.5–4.0)	<.001	1.6±0.67 (1.0–3.0)	<.001	1.6±0.51 (1.0–2.0)	<.001
	Walking belt with handles[e]	6	2.7±0.52 (2.0–3.0)	.058	2.5±0.55 (2.0–3.0)	<.001	12	2.6±0.9 (1.0–4.0)	<.001	2.6±0.9 (1.0–4.0)	.001	2.7±1.23 (1.0–4.0)	<.001
Repositioning in bed	Draw sheet[d]	6	2.7±0.82 (2.0–4.0)	•••	2.3±0.52 (2.0–3.0)	•••	12	4.0±1.57 (0.0–7.0)	•••	3.8±2.42 (0.0–9.0)	•••	3.3±2.43 (0.0–9.0)	•••
	Friction-reducing device[e]	6	2.0±0.63 (1.0–3.0)	.102	1.8±0.75 (1.0–3.0)	.203	12	0.8±0.89 (0.0–3.0)	<.001	0.8±0.69 (0.0–2.0)	.003	0.6±0.74 (0.0–2.0)	.005

Note. Ratings provided during equipment selection)

[a]Rated on 7-point comfort scale whereby 1 = *extremely comfortable* and 7 = *extremely uncomfortable*.

[b]Rated on 7-point safety scale whereby 1 = *extremely safe* and 7 = *extremely unsafe*.

[c]Rated on Borg CR-10 Scale (Borg, 1982).

[d]Preintervention device.

[e]Postintervention device.

•••Comparison group for paired *t* test.

eight out of nine NAs continued their employment well into their pregnancies. Similarly, in one nursing facility, all seven NAs >50 years of age and three NAs >60 years of age were able to continue their employment. In all seven facilities, there were seven nurses and NAs diagnosed with herniated disc and/or degenerative spine disease, and two of these underwent surgeries prior to intervention. All seven had permanent restrictions (no lifting >20 kg, no repetitive lifting and bending). Postintervention, all seven nurses and NAs performed their regular duties, including all patient transfers.

Other Factors Affecting Injury Reporting

All seven nursing facilities indicated that their patient acuity levels were going up (although the actual acuity rates over time are unknown). For example, data provided by Nursing Facility 5 showed that the patient case mix index (CMI) for postintervention Years 1, 2, 3, 4, and 5 was 0.92, 0.88, 1.11, 1.11, and 1.24, respectively. A CMI of <1.0 for an LTC facility indicates that medical care is required, 1.0 represents an average LTC patient, and >1.0 indicates that the patient is more complex. In addition, Nursing Facilities 2 and 4 each converted one of their units with patients requiring minimum care into acute care units.

There were no changes from pre- to postintervention in injury reporting policy, nursing personnel's workload, or nurse-to-patient ratio at any of the facilities. Staffing levels (number of nurses and nursing aides) showed day-to-day fluctuations because of sick leave, vacation, and turnover, but there were no material changes in staffing levels from pre- to postintervention at any of the facilities. The no-manual-lifting programs neither required nor resulted in an increase in nursing staff in any of the seven facilities. Furthermore, these programs did not affect employee turnover rates. Although the turnover rate in one of the nursing facilities (Facility 7) decreased from 150% preintervention to 40% postintervention, the other six facilities did not experience any improvement in turnover rates. The turnover rate in Facilities 1 to 4 was approximately 80% and in Facility 6 was 130% during both pre- and postintervention. The turnover rate for Facility 5 was not available.

DISCUSSION

This study demonstrates that ergonomics programs implemented in seven nursing facilities with participatory ergonomics teams and modern patient-handling devices were highly successful in reducing number of injuries, lost workdays, modified-duty days, and workers' compensation costs associated with patient-handling activities, in spite of indications that patient acuity level might have been increasing during postintervention. This study adds to the growing body of evidence that modern patient-handling devices are effective in reducing patient-handling injuries, particularly when implemented as part of a comprehensive ergonomics program (Charney et al., 2006; Collins et al., 2004; Evanoff et al., 2003; Garg & Owen, 1992; Li et al., 2004; Lynch & Freund, 2000; Nelson et al., 2006; Owen et al., 2002).

Overall, the greater reductions in lost workdays (86%) and workers' compensation costs (84%) as compared with injuries (62%) associated with patient-handling activities suggest that postintervention injuries were less severe and/or that injured nursing personnel were able to return to their employment earlier because of availability of patient-handling devices. This observation is consistent with other studies (Evanoff et al., 2003; Garg & Owen, 1992; Owen et al., 2002) that have also reported greater reduction in lost workdays as compared with injuries. Relatively, short payback periods from this study suggest that patient-handling devices are an economically efficient way of reducing injuries and injury costs in nursing facilities. Longer transfer times observed during use of patient-handling devices was not a concern to nursing personnel and are consistent with those reported by Garg et al. (1991b).

Nursing Facilities 1 to 4 showed greater reduction in patient-transfer injuries than did Facilities 5 to 7 (Table 3). For Facilities 1 to 4, comprehensive ergonomics programs and interventions were developed by the principal investigator on the basis of lessons learned from previous studies (Garg et al., 1992; Garg & Owen, 1992). Facilities 5 to 7 developed their own ergonomics programs. In addition, Facilities 1 to 4 were visited more frequently than

Facilities 5 to 7 during postintervention follow-up. It is possible that the comprehensive ergonomics programs and more frequent follow-up visits to Facilities 1-4 led to greater reductions in patient-transfer-related injuries in those facilities.

Intangible benefits of the ergonomics program and patient-handling devices used in this study included the following: (a) nursing personnel believed they were less tired at the end of their work shifts, and their backs were less sore (postintervention perceived exertion ratings); (b) most of the NAs in their 50s and 60s were able to continue their employment; (c) pregnant NAs were able to continue to work well into their pregnancies; and (d) managers believed there was an increase in employee morale and a decrease in absence rate.

Strengths of this study include addressing of barriers in effective implementation of patient-handling devices (discussed later), adoption of a no-manual-lifting policy to encourage use of the devices, implementation of patient-handling devices in the entire nursing facility to avoid temporary exposure to manual lifting when assigned to a different unit in the facility, use of multiple patient-handling devices to address different levels of care required by patients, relatively long pre- and postintervention observation periods for capturing improvements in injury measures, and frequent visits to nursing facilities by the research team members to collect data and assist the nursing facilities in resolving unforeseeable problems. It is possible that the postintervention improvements in injury statistics shown in this study are greater than those reported in prior studies because of these detailed methods that addressed most of the issues raised by previous studies.

One potential limitation of this study is the pre- and postintervention study design without an external control group. Because of the pre- and postintervention study design, we cannot be certain that the observed postintervention decreases in number of injuries, lost workdays, modified-duty days, and workers' compensation costs resulted from ergonomic interventions. However, it is unlikely that these decreases were attributable to Hawthorne effect. First, the effect magnitudes (decreases in postintervention from preintervention) are large in all four injury statistics: 59.8% decrease in patient-handling injuries, 86.7% in lost workdays, 78.8% in modified-duty days, and 90.6% in workers' compensation costs. Second, consistent with the recommendations of Nelson et al. (2006), both pre- and postintervention periods were fairly long, 37 months (range = 29 to 54 months) and 51 months (range = 36 to 60 months), respectively. Last, when treating non-patient-handling activities as an internal control, overall postintervention patient-transferring injuries per year, lost workdays per year, modified-duty days, and workers' compensation cost per year showed significant decreases from preintervention levels.

Injury rates excluded minor injuries that did not meet OSHA criteria for reporting and may have resulted in underestimates of injuries. Underreporting of injuries on OSHA logs is a widely recognized problem (Li et al., 2004). High turnover rates in nursing personnel might have affected estimation of injury rates, as it was difficult to accurately determine FTEs. Another limitation of this study is that it did not account for confounders, such as psychosocial and work organization factors, that might have affected our results.

Barriers in Effective Implementation of Patient-Handling Devices

On the basis of a systematic review of patient-handling studies, Koppelaar, Knibbe, Miedema, and Burdorf (2009) identified four major issues in effective implementation of patient-handling devices: (a) employee motivation, (b) convenience and easy accessibility, (c) supportive management climate, and (d) patient-related factors. Other barriers to effective implementation of patient-handling devices include lack of mandatory no-manual-lifting policy (Charney, 2006; Li et al., 2004), provision of patient-handling devices in selected units and not the entire nursing facility (Nelson et al., 2006), inadequate or not readily available devices (Bell, 1987; Garg et al., 1992; Jensen, 1987; Owen et al., 2002), inadequate training of nursing personnel on patient-handling devices (Bell, 1987; Garg et al., 1992; Jensen, 1987;

Owen et al., 2002), concerns for patient safety (Collins et al., 2004; Garg et al., 2002; Li et al., 2004), and longer transfer time with devices than with manual methods (Bell, 1987; Garg et al., 1992, Jensen, 1987; Li et al., 2004). The nursing facilities participating in this study recognized these and other barriers prior to interventions and were able to address them, demonstrating that it is possible to overcome most or all of these barriers.

Use of walking belt with handles with a pulling technique (instead of lifting) might have partially addressed the issue of increased transfer time, as the belt required the smallest amount of time among all devices used in this study. Garg and Owen (1992) also reported that the increased transfer time associated with patient-handling devices was not a problem. Empowering employees in selection of patient-handling devices, assessing patient-handling needs, training, and monitoring compliance may have contributed to nursing personnel buy-in and effectiveness of the program. Making each nursing unit self-sufficient in patient-handling devices provided easy and quick access to these devices.

Participation of representatives from housekeeping, dietary, maintenance, and administration probably created greater safety awareness throughout the nursing facilities (such as storing of spare batteries and critical replacement parts, sling inspections for fraying straps, and cleaning and mopping of slippery floors). This participation resulted in timely repair of beds, patient-handling devices, and other equipment when they broke down. Postintervention perceived exertion ratings, comments from nursing personnel, and patient comfort and safety ratings, consistent with other studies (Garg & Owen, 1992; Owen et al., 2002), indicate that both nursing personnel and patients had a positive reaction to the ergonomics program and to the patient-handling devices.

CONCLUSION

This study demonstrated that the implementation of patient-handling devices along with a comprehensive ergonomics program was effective in reducing patient-handling injuries, lost workdays, modified-duty days, and workers' compensation costs in seven nursing facilities. The impact was greater on lost workdays and workers' compensation cost than on number of injuries. Perceived stresses to low back and shoulders among nursing personnel were low. A vast majority of patients found the patient-handling devices comfortable and safe. Future studies should include an external control group to better quantify efficacy of patient-handling devices in injury reduction.

ACKNOWLEDGMENTS

This research was partially supported by a Centers for Disease Control and Prevention (National Institute for Occupational Safety and Health) grant (Contract No. 460/CCU512089-2).

KEY POINTS

- The use of patient-handling devices within a comprehensive ergonomics program reduces patient-transferring injuries, lost workdays, modified-duty days, and workers' compensation costs.
- Nursing personnel rate perceived stresses to shoulder and low back as "fairly light" when using patient-transferring devices.
- Patients find patient-transferring devices comfortable and safe.
- Increase in transfer time when using patient-transferring devices is not a barrier to successful use of these devices.

REFERENCES

Bell, F. (1987). Ergonomic aspects of equipment. *International Journal of Nursing Studies*, *24*, 331–337.

Borg, G. A. V. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, *14*, 377–381.

Brophy, M. O., Achimore, L., & Moore-Dawson, J. (2001). Reducing incidence of low-back injuries reduces cost. *AIHA Journal*, *62*, 508–511.

Bureau of Labor Statistics. (2007). *Nonfatal occupational injuries and illnesses requiring days away from work, 2006: News* (USDL-07-1741). Washington, DC: U.S. Department of Labor.

Bureau of Labor Statistics. (2009). *Nonfatal occupational injuries and illnesses requiring days away from work, 2007: News* (USDL-08-1716). Washington, DC: U.S. Department of Labor.

Byrns, G., Reeder, G., Guang, J., & Pachis, K. (2004). Risk factors for work-related low back pain in registered nurses, and potential obstacles in using mechanical lifting devices. *Journal of Occupational and Environmental Hygiene*, *1*, 11–21.

Charney, W. (2000). Reducing back injury in nursing: A case study using mechanical equipment and a hospital lift team. *Journal of Healthcare Safety, Compliance & Infection Control*, *4*, 117–120.

Charney, W., Simmons, B., Lary, M., & Metz, S. (2006). Zero lift programs in small rural hospitals in Washington state:

Reducing back injuries among health care workers. *AAOHN Journal*, *54*, 355–358.

Cohen, A. (1994). Worker participation approaches and issues. In C. C. Gjessing, T. F., Schoenborn, & A. Cohen (Eds.), *Participatory ergonomics interventions in meatpacking plants* (DHHS [NIOSH] Publication No. 94-124, pp. 9–46). Cincinnati, OH: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

Collins, J. W., Wolf, L., Bell, J., & Evanoff, B. (2004). An evaluation of a "best practices" musculoskeletal injuries prevention program in nursing homes. *Injury Prevention*, *10*, 206–211.

Corlett, E. N., & Bishop, R. P. (1976). A technique for assessing postural discomfort. *Ergonomics*, *19*, 175–182.

Daynard, D., Yassi, A., Cooper, J. E., Tate, R., Norman, R., & Wells, R. (2001). Biomechanical analysis of peak and cumulative spinal loads during simulated patient-handling activities: A substudy of a randomized controlled trial to prevent lift and transfer injury of health care workers. *Applied Ergonomics*, *32*, 199–214.

Engkvist, I., Hjelm, E. W., Hagberg, M., Menckel, E., Ekeenvall, L., & PROSA Study Group. (1998). The accident process preceding overexertion back injuries in nursing personnel. *Scandinavian Journal of Work Environment and Health*, *24*, 367–375.

Engst, C., Chhokar, R., Miller, A., Tate, R. B., & Yassi, A. (2005). Effectiveness of overhead lifting devices in reducing the risk of injury to care staff in extended care facilities. *Ergonomics*, *48*, 187–199.

Evanoff, B., Wolf, L., Aton, E., Canos, J., & Collins, J. (2003). Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the workplace. *American Journal of Industrial Medicine*, *44*, 451–457.

Feldstein, A., Valanis, B., Vollmer, W., Stevens, N., & Overton, C. (1993). The back injury prevention project pilot study: Assessing the effectiveness of back attack, an injury prevention program among nurses, aides, and orderlies. *Journal of Occupational Medicine*, *35*, 114–120.

Garg, A., & Owen, B. D. (1992). Reducing back stress to nursing personnel: An ergonomic intervention in a nursing home. *Ergonomics*, *35*, 1353–1375.

Garg, A., & Owen, B. D. (1994). Prevention of back injuries in health care workers. *International Journal of Industrial Ergonomics*, *14*, 315–333.

Garg, A., Owen, B. D., Beller, D., & Banaag, J. (1991a). A biomechanical and ergonomic evaluation of patient transferring tasks: Bed to wheelchair and wheelchair to bed. *Ergonomics*, *34*, 289–312.

Garg, A., Owen, B. D., Beller, D., & Banaag, J. (1991b). A biomechanical and ergonomic evaluation of patient transferring tasks: Wheelchair to shower chair and shower chair to wheelchair. *Ergonomics*, *34*, 407–419.

Garg, A., Owen, B.D., & Carlson, B. (1992). An ergonomics evaluation of nursing assistants' job in a nursing home. *Ergonomics, 35*, 979–995.

Guthrie, P. F., Westphal, L., Dahlman, B., Berg, M., Behnam, K., & Ferrel, D. (2004). A patient lifting intervention for preventing the work-related injuries of nurses. *Work*, *22*, 79–88.

Haines, H., Wilson, J. R., Vink, P., & Koningsveld, E. (2002). Validating a framework for participatory ergonomics (the PEF). *Ergonomics*, *45*, 309–327.

Hartvigsen, J., Lauritzen, S., Lings, S., & Lauritzen, T. (2005). Intensive education combined with low tech ergonomic intervention does not prevent low back pain in nurses. *Occupational Environmental Medicine*, *62*, 13–17.

Hegmann, K. T., & Garg, A. (2004). *Home healthcare: Reducing musculoskeletal hazards. Final report* (NIOSH [CDC] Grant No. U50/CCU 300860). Cincinnati, OH: CDC/NIOSH.

Hignett, S. (1996). Work-related back pain in nurses. *Journal of Advanced Nursing*, *23*, 1238–1246.

Jensen, R. (1987). Disabling back injuries among nursing personnel: Research needs and justifications. *Research in Nursing and Health*, *10*, 29–38.

Jensen, L.D., Gonge, H., Jors, E., Ryom, P., Foldspang, A., Christensen, M., Vesterdorf, A., & Bonde, J. P. (2006). Prevention of low back pain in female eldercare workers: Randomized control work site trial. *Spine*, *31*, 1761–1769.

Johnsson, C., Carlsson, R., & Lagerström, M. (2002). Evaluation of training in patient handling and moving skills among hospital and home care personnel. *Ergonomics*, *45*, 850–865.

Koppelaar, E., Knibbe, J. J., Miedema, H. S., & Burdorf, A. (2009). Determinants of implementation of primary preventive interventions on patient handling in healthcare: A systematic review. *Occupational and Environmental Medicine*, *66*, 353–360.

Lagerström, M., & Hagberg, M. (1997). Evaluation of a 3-year education and training program for nursing personnel at a Swedish hospital. *AAOHN Journal*, *45*, 83–92.

Lagerström, M., Hansson, T., & Hagberg, M. (1998). Work-related low-back problems in nursing. *Scandinavian Journal of Work and Environmental Health*, *24*, 449–464.

Li, J., Wolf, L., & Evanoff, B. (2004). Use of mechanical patient lifts decreased musculoskeletal symptoms and injuries among health care workers. *Injury Prevention*, *10*, 212–216.

Lynch, R. M., & Freund, A. (2000). Short-term efficacy of back injury intervention project for patient care providers at one hospital. *AIHA Journal*, *61*, 290–294.

Marras, W. S., Davis, K. G., Kirking, B. C., & Bertsche, P. K. (1999). A comprehensive analysis of low-back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. *Ergonomics*, *42*, 904–926.

McGuire, M. J., Hanson, M., & Tigar, F. (1996). A study of nurses' attitudes towards mechanical aids. *Nursing Standard*, *11*, 37–42.

Miller, A., Engst, C., Tate, R. B., & Yassi, A. (2006). Evaluation of the effectiveness of portable ceiling lifts in a new long-term care facility. *Applied Ergonomics*, *37*, 377–385.

Myers, D, Silverstein, B., & Nelson, N. A. (2002). Predictors of shoulder and back injuries in nursing home workers: A prospective study. *American Journal of Industrial Medicine*, *41*, 466–476.

Nelson, A., Fragala, G., & Menzel, N. (2003). Myths and facts about back injuries in nursing. *American Journal of Nursing*, *103*, 32–40.

Nelson, A., Matz, M., Chen, F., Siddharthan, K., Lloyd, H., & Fragala, G. (2006). Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *International Journal of Nursing Studies*, *43*, 717–733.

Owen, B. D. (1989). The magnitude of low back problems in nursing. *Western Journal of Nursing Research*, *11*, 234–242.

Owen, B. D., & Fragala, G. (1999). Reducing perceived physical stress while transferring residents. *AAOHN Journal*, *47*, 316–323.

Owen, B. D., & Garg, A. (1993). Back pain isn't part of the job. *American Journal of Nursing*, *93*, 48–51.

Owen, B. D., Keene, K., & Olson, S. (2002). An ergonomic approach to reducing back/shoulder stress in hospital nursing

personnel: A five-year follow up. *International Journal of Nursing Studies*, *39*, 295–302.
Retsas, A., & Pinikahana, J. (2000). Manual handling activities and injuries among nurses: An Australian hospital study. *Journal of Advanced Nursing*, *31*, 875–883.
SAS. (2008). *SAS Version 9.2 (TS2M2)*. Cary, NC: SAS Institute.
Schibye, B., Faber Hansen, A., Hye-Knudsen, C. T., Essendrop, M., Bocher, M., & Skotte, J. (2003). Biomechanical analysis of the effect of changing patient-handling technique. *Applied Ergonomics*, *34*, 115–123.
Silverstein, B. (2006). Barrier to zero lift in nursing homes. In *Proceedings of the 6th Annual Safe Patient Handling and Movement Conference* (n.p.). Clearwater Beach, FL.
Skotte, J. H., Essendrop, A. F., & Hansen, B. (2002). A dynamic 3D biomechanical evaluation of the load on the low back during different patient-handling tasks. *Journal of Biomechanics*, *35*, 1357–1366.
Smedley, J., Egger, P., Cooper, C., & Coggon, D. (1997). Prospective cohort study of predictors of incident low back pain in nurses. *British Medical Journal*, *314*, 1225–1228.
Takala, E. P., & Kukkonen, R. (1987). The handling of patients on geriatric wards: A challenge for on the job training. *Applied Ergonomics*, *18*, 17–22.
Ulin, S. S., Chaffin, D., Patellos, C. L., Blitz, S. G., Emerick, C. A., Lundy, F., & Misher, L. (1997). A biomechanical analysis of methods used for transferring totally dependent patients. *Spinal Cord Injury Nursing*, *14*, 19–27.
Vasihadou, A., Karvolntzis, G. G., Soumilas, A., Roumehotis, D., & Theodosopoulou, E. (1995). Occupational low-back pain in nursing staff in a Greek hospital. *Journal of Advanced Nursing*, *21*, 125–130.
Videman, T., Rauhala, H., Asp, S., Lindström, K., Cedercreutz, G., Kämppi, M., Tola, S., & Troup, J. D. G. (1989). Patient-handling skill, back injuries, and back pain: An intervention study in nursing. *Spine*, *14*, 148–156.
Village, J., Frazer, M., Cohen, M., Leyland, A., Park, I., & Yassi, A. (2005). Electromyography as a measure of peak and cumulative workload in intermediate care and its relationship to musculoskeletal injury: An exploratory ergonomic study. *Applied Ergonomics*, *36*, 609–618.
Waters, T. R., Collins, J., Galinsky, T., & Caruso, C. (2006). NIOSH research efforts to prevent musculoskeletal disorders in the healthcare industry. *Orthopaedic Nursing*, *25*, 380–389.
Waters, T. R., Putz-Anderson, V., Garg, A., & Fine, L. J. (1993). Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics*, *36*, 749–776.
Winkelmolen, G. H. M., Landeweerd, J. A., & Drost, M. R. (1994). An evaluation of patient lifting techniques. *Ergonomics*, *37*, 921–932.
Yassi, A., Cooper, J. E., Tate, R. B., Gerlach, S., Muir, M., Trottier, J., & Massey, K. (2001). A randomized controlled trial to prevent patient lift and transfer injuries of health care workers. *Spine*, *26*, 1739–1747.
Yassi, A., Khokhar. J., Tate, R., Cooper, C., & Vallentype, S. (1995). The epidemiology of back injuries in nurses at a large Canadian tertiary care hospital: Implications for prevention. *Journal of Occupational Medicine*, *45*, 215–220.
Zhuang, Z., Stobbe, T. J., Hsiao, H., Collins, J. W., & Hobbs, G. R. (1999). Biomechanical evaluation of assistive devices for transferring residents. *Applied Ergonomics*, *30*, 285–294.

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Date received: May 24, 2011
Date accepted: January 12, 2012