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Musculoskeletal pain among critical-care nurses by availability and use of patient lifting equipment: An analysis of cross-sectional survey data

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ABSTRACT

Background: Patient handling is a major risk factor for musculoskeletal injuries among nurses. Lifting equipment is a main component of safe patient handling programs that aim to prevent musculoskeletal injury. However, the actual levels of lift availability and usage are far from optimal.
Objective: To examine the effect of patient lifting equipment on musculoskeletal pain by level of lift availability and lift use among critical-care nurses.
Design and participants: A cross-sectional postal survey of a random sample of 361 critical-care nurses in the United States.
Methods: The survey collected data on low-back, neck, and shoulder pain, lift availability, lift use, physical and psychosocial job factors, and sociodemographics. Musculoskeletal pain was assessed by three types of measures: any pain, work-related pain, and major pain. Multivariable logistic regressions were used to examine the associations between musculoskeletal pain and lift variables, controlling for demographic and job factors.
Results: Less than half (46%) of respondents reported that their employer provided lifts. Of 168 nurses who had lifts in their workplace, the level of lift availability was high for 59.5%, medium for 25.0%, and low for 13.7%; the level of lift use was high for 32.1%, medium for 31.5%, and low for 31.5%. Significant associations were found between lift availability and work-related low-back and shoulder pain. Compared to nurses without lifts, nurses reporting high-level lift availability were half as likely to have work-related low-back pain (OR = 0.50, 95% CI 0.26–0.96) and nurses reporting medium-level lift availability were 3.6 times less likely to have work-related shoulder pain (OR = 0.28, 95% CI 0.09–0.91). With respect to lift use, work-related shoulder pain was three times less common among nurses reporting medium-level use (OR = 0.33, 95% CI 0.12–0.93); any neck pain was three times more common among nurses reporting low-level use (OR = 3.13, 95% CI 1.19–8.28).
Conclusions: Greater availability and use of lifts were associated with less musculoskeletal pain among critical-care nurses. These findings suggest that for lift interventions to be effective, lifts must be readily available when needed and barriers against lift use must be removed.

What is already known about the topic?

- Patient handling is a major risk factor for musculoskeletal injuries among nurses.

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- Use of mechanical patient lifting equipment can reduce the risk of musculoskeletal injury from patient handling.

What this paper adds

- Lift provision was associated with a lower prevalence of work-related shoulder pain. The strongest protective effect was observed among nurses reporting medium levels of lift availability and lift use.
- A protective effect for work-related low back pain was observed only among nurses with high-level lift availability. Less neck pain was associated with higher levels of lift use.
- Lift provision and greater lift availability and use appear to improve job control and reduce psychosocial job strain.
- Work-related pain showed higher sensitivity than non-specific pain measures and is therefore recommended as an outcome measure in intervention studies.

1. Introduction

Unsafe patient handling is a major risk factor for musculoskeletal injuries among nurses (Waters et al., 2006). Each year, more than 10,000 nurses in the United States experience work-related musculoskeletal disorders resulting in lost work days and nurses rank among the top five occupations for musculoskeletal disorders (Bureau of Labor Statistics, 2010). Injuries from patient handling tasks account for 31–66% of all musculoskeletal injuries among healthcare workers (D'Arcy et al., 2012; Kim et al., 2012; Pompeii et al., 2009).

Use of mechanical patient lifting equipment can reduce the risk of musculoskeletal injury from patient handling. Biomechanical and lift intervention studies have shown significant reductions in biomechanical stress, musculoskeletal discomfort, injury rates, and workers compensation costs (Engst et al., 2005; Evanoff et al., 2003; Li et al., 2004; Yassi et al., 2001; Zhuang et al., 2000). Eliminating risky manual lifting and promoting the use of adequate lifting equipment have become a key component of safe patient handling policies internationally (American Nurses Association, 2012b; Australian Nursing Federation, 2012; Workers Compensation Board of British Columbia, 2006). Since 2005, 10 states in the United States have enacted safe patient handling legislation that requires provision of patient lifting equipment to prevent musculoskeletal injury among healthcare workers (American Nurses Association, 2012b).

Providing lifts to nurses is the first step in ensuring safe patient handling, and having a lift readily available and having nurses actually use the lift are key to the success of lift interventions. However, lifts are not available in many healthcare settings. Even in settings where lifts are provided, actual lift availability and usage is far from optimal (Lee et al., 2010; Trinkoff et al., 2003). A 2011 survey by the American Nurses Association (2012a) showed that while two thirds of respondents had patient lift and transfer devices available, less than one third reported using the devices frequently.

The purpose of this study was to investigate the effect of lifts on musculoskeletal pain by level of lift availability and lift use. As there are discrepancies between lift provision and actual lift availability and use, the intervention effect may differ by the actual levels of lift availability and lift use. However, this difference has not yet been explored in intervention or observational studies. Three lift variables examined in this study have different characteristics. Lift provision is a purely organizational level variable, determined by whether or not it is provided by the employer. The level of lift availability is primarily an organizational level variable determined by the number and proper maintenance of lifts in the workplace, but may also be affected in part by individual factors such as age, gender, or work status of the nurse. For example, when there is a conflicting demand for these devices, male nurses may give priority of use to their female nurse colleagues. The level of lift use measures actual utilization for patient handling when needed; both organizational and individual factors play roles in the level of actual use (Koppelaar et al., 2011; Rickett et al., 2006).

2. Methods

2.1. Study design and population

This study analyzed data from a cross-sectional survey conducted in 2006 among critical-care nurses in the United States (Lee et al., 2010). The original study mailed the survey to 1000 nurses randomly selected from the American Association of Critical-Care Nurses (AACN) membership list; the response rate was 42%. Among initial respondents, the study identified 361 nurses who met the eligibility criteria. Inclusion criteria were critical-care nurses currently employed as staff or charge nurses in hospitals and who performed patient handling tasks. Our broad definition of critical-care nurses included nurses working in intensive care units (ICUs) and other settings such as step-down units, trauma units, telemetry units, emergency departments, operating or recovery rooms, cardiac catheterization labs, and flight nurses. Among ICUs, this study excluded neonatal ICUs because lifts are not necessary for neonatal patient handling. The study sample included nurses on sick or disability leave ($n = 13$). This secondary analysis study, using data without personal identifiers, received an exemption of review by the Committee on Human Research at the University of California, San Francisco.

2.2. Study variables and measures

The outcome variables of this study were pain in the low back, neck, or shoulders. Respondents were asked whether in the past 12 months they had pain, aching, stiffness, burning, numbness, or tingling in each body region shown on body diagrams. The question for low back pain also included an option for pain radiating into the leg. Respondents who had pain were asked to answer subsequent questions on pain frequency, duration, and severity. These answers were used to define *major pain* as pain with at least moderate intensity and either with at

Table 1
Sample characteristics by lift provision and availability level ($n = 361$).

Variable	Total		Lift provided on the unit[c]			Lift availability[c]		
	N[a]	Mean ± SD or %[b]	No ($n = 193$)[d]	Yes ($n = 168$)	P	High ($n = 100$)	Medium ($n = 42$)	Low ($n = 23$)
Personal factors								
Age (years)	357	47.3 ± 8.8	46.7 ± 9.3	47.9 ± 8.1	.194	48.5 ± 8.4	48.5 ± 6.2	44.3 ± 9.3
Gender (female)	333	92.8	91.7	94.0	.409	96.0	85.4	100
Race (white)	297	82.7	79.7	86.2	.102	85.9	85.7	87.0
Marital status (married)	268	74.2	70.8	78.6	.093	75.0	83.3	82.6
BMI (kg/m^2)	358	26.4 ± 5.7	26.2 ± 5.5	26.7 ± 5.9	.411	26.9 ± 6.1	26.7 ± 5.6	26.7 ± 5.7
Workplace/employment factors								
Total years in nursing	360	22.5 ± 9.3	21.8 ± 9.5	23.3 ± 9.1	.126	24.2 ± 9.3	23.0 ± 8.0	20.7 ± 9.8
Type of hospital								
Non-profit community	197	54.9	49.7	60.7	.184	66.0	54.7	43.5
Profit community	57	15.9	17.3	14.3		11.0	16.7	26.1
University medical center	66	18.4	19.9	16.7		17.0	14.3	21.7
Other (*e.g.*, government)	39	10.8	13.1	8.3		6.0	14.3	8.7
Work setting								
Urban	169	48.0	53.5	41.8	.086	37.8	54.8	34.8
Suburban	139	39.5	34.8	44.9		50.0	28.6	52.2
Rural	44	12.5	11.8	13.3		12.2	16.7	13.0
Type of unit (ICU)	294	81.4	76.2	87.5	**.006**	88.0	88.1	82.6
Work status (full time)	270	75.2	73.3	77.4	.371	83.0	71.4	69.6
Work schedule (day)	212	58.9	59.6	58.1	.773	53.5	64.3	60.9
Work hour per shift	345	11.6 ± 1.6	11.7 ± 1.6	11.6 ± 1.7	.748	11.6 ± 1.7	11.8 ± 1.6	11.4 ± 1.7
Physical workload								
No. of patient lifts/transfers	358	6.8 ± 7.3	6.3 ± 5.8	7.4 ± 8.7	.174	7.4 ± 9.2	6.2 ± 5.2	9.4 ± 11.6
Physical workload index	345	30.7 ± 11.0	31.8 ± 10.8	29.4 ± 11.1	**.045**	28.9 ± 12.0	28.7 ± 10.5	33.0 ± 8.1
Psychosocial factors								
Psychological demand	358	37.2 ± 5.8	37.2 ± 5.8	37.2 ± 5.8	.933	36.7 ± 5.9	37.3 ± 5.6	39.4 ± 5.5
Job control	360	73.5 ± 8.7	72.6 ± 8.6	74.6 ± 8.8	**.035**	75.8 ± 9.4	72.6 ± 7.6	72.8 ± 7.6
Job strain	358	0.51 ± 0.10	0.52 ± 0.11	0.51 ± 0.10	.189	0.49 ± 0.10	0.52 ± 0.10	0.54 ± 0.07
Effort	341	15.7 ± 4.8	15.7 ± 4.8	15.7 ± 4.9	.999	15.4 ± 4.9	16.2 ± 5.1	15.6 ± 4.1
Reward	351	48.4 ± 7.3	48.3 ± 7.4	48.5 ± 7.3	.838	48.3 ± 7.6	49.3 ± 6.8	47.9 ± 6.0
Effort-reward imbalance ratio	337	0.63 ± 0.33	0.63 ± 0.33	0.64 ± 0.33	.892	0.63 ± 0.35	0.63 ± 0.29	0.62 ± 0.25
Safety climate	360	38.1 ± 7.9	37.0 ± 7.9	39.4 ± 7.7	**.004**	39.9 ± 7.5	38.5 ± 8.2	39.0 ± 7.1
Lift team availability								
Yes	26	7.2	5.2	9.5	.115	10.0	9.5	8.7
Use of lifts or transfer aids[e]								
High (always or most of the time)	54	–	–	33.8	–	44.8	22.5	9.5
Medium (often or occasionally)	53	–	–	33.1		31.2	37.5	33.3
Low (rarely or never)	53	–	–	33.1		24.0	40.0	57.2

[a] Total N varies by variable due to missing data.
[b] Column percent.
[c] Presented data are mean ± SD or column %.
[d] Included "don't know" answers ($n = 5$).
[e] Presented numbers and percentages are for those who were provided lifts.

least one week duration or at least monthly frequency. This definition was adopted from a study by Trinkoff et al. (2003). Respondents who had pain were also asked whether they thought the pain was caused or made worse by working. This self-assessed work-relatedness was used to define *work-related pain* as noted by other researchers (Krause et al., 2005; Scherzer et al., 2005). As such, the pain outcome variables constituted *any pain*, *major pain*, and *work-related pain* for low back, neck, or shoulders.

The independent variables included lift provision, level of lift availability, and level of lift use. Lift provision was determined by the question, "Does your workplace provide mechanical lifting devices on the unit where you work?" Those who answered "no" or "don't know" were assigned to the group without lifts. The levels of lift availability and lift use were assessed by the questions, "If lifting devices are provided, how often are they actually available when you need them?" and "If the patient is physically dependent, I use a lifting device or transfer aid." The latter statement included lifts and transfer aids together, but for a concise description, we use the term "lift use" in this paper. The last two items were answered using a six-category response format ranging from always to never. These categories were combined to create three categories: *high* (always/most of the time), *medium* (often/occasionally), and *low* (rarely/never).

Covariates included personal factors, workplace and employment factors, physical workload, and psychosocial work factors. Personal factors included age, gender, race, marital status, and body mass index (BMI). Workplace and employment factors included type of hospital, work setting, type of unit, years worked in nursing, work status, work schedule, work hours per day, and availability of lift team. Physical workload was assessed by the number of patient lifts or transfers per shift and the modified Physical Workload Index Questionnaire (Hollmann et al., 1999; Janowitz et al., 2006). The Physical Workload Index Questionnaire included 19 items asking about the average frequency of body postures and lifting, pushing, pulling, or carrying of loads during a work day with a 5-point response scale, ranging from never to very often. Psychosocial work factors included job demand, job control, effort, reward, and safety climate. The Job Content Questionnaire subscales were used to measure job demand (five items) and job control (nine items) (Karasek et al., 1998); job strain was calculated as the ratio of demand to control. The Effort-Reward Imbalance (ERI) Questionnaire was used to measure effort (six items) and reward (11 items); an ERI ratio was calculated as the ratio of effort to reward with a correction factor applied to resolve the number difference in the two scales (Siegrist et al., 2004). Safety climate was measured by an 11-item questionnaire assessing the employee's perceptions about management commitment for worker safety, safety communication with supervisors and coworkers, and work environment related to safety (Felknor et al., 2000).

2.3. Statistical analysis

Data were analyzed using the SAS program version 9.2 (SAS Institute, Cary, NC). Prevalence rates of any pain, work-related pain, and major pain were calculated for low back, neck, and shoulders. For musculoskeletal pain questions using a skip format, inconsistent responses between steps were found among 16 respondents (4.4%); for example, answering *no* to symptom experience and then providing answers to the next step questions for severity, frequency, and duration. In these cases, we used the initial answer and disregarded subsequent answers. For missing data in multi-item measures, case mean substitution was used for respondents who answered at least 75% of the items of a scale. Missing data for physical workload index were not replaced because the index is calculated by a formula with different weights for each item (Hollmann et al., 1999).

Descriptive statistics were used to summarize the study sample by lift variables. Differences in means or proportions of covariates by lift provision were examined using *t*-tests or chi-square tests. Within nurses who were provided lifts, the correlation between lift availability and lift use was examined by Spearman's rank correlation. Multiple logistic regression analyses examined the associations between the three lift variables and the three types of pain in the low back, neck, and shoulders. All covariates were assessed first for confounding. Confounders were defined as variables showing a change of 5% or more in odds ratios (OR). As a lift team is also an effective intervention for injury prevention (Nelson and Baptiste, 2006), we conducted additional analyses on the effect of lift team. In these analyses, nurses without lift teams had 1.2–2.6 times higher ORs for all low back pain outcomes and any and

Table 2
Associations between prevalence of musculoskeletal pain and provision of lift.

Type of pain	Total	Nurses with pain	Nurses with pain by lift provision[b], *N* (%)			
	N[a]	*N* (%)	Lift provided ($n = 152$)[a]	No lift provided ($n = 182$)[a]	Adj. OR[c]	95% CI
Low back pain						
Any pain	359	272 (75.8)	118 (77.6)	137 (75.7)	0.91	0.47–1.76
Work-related pain[d]	358	222 (62.1)	91 (60.3)	115 (63.5)	0.62	0.35–1.12
Major pain[e]	358	97 (27.1)	38 (25.2)	52 (28.7)	0.82	0.44–1.54
Neck pain						
Any pain	351	221 (63.0)	96 (64.4)	109 (61.9)	1.13	0.65–1.99
Work-related pain[d]	348	139 (39.9)	58 (38.9)	70 (40.2)	0.95	0.53–1.70
Major pain[e]	347	100 (28.8)	36 (24.5)	58 (33.3)	0.68	0.37–1.25
Shoulder pain						
Any pain	352	165 (46.9)	68 (46.6)	85 (47.5)	0.81	0.46–1.40
Work-related pain[d]	351	112 (31.9)	41 (28.3)	62 (34.6)	**0.47**	**0.25–0.91**
Major pain[e]	351	66 (18.8)	23 (15.9)	37 (20.7)	0.84	0.41–1.75

[a] Total N varies due to missing data of pain variables.
[b] The analyses excluded nurses with a lift team in their workplace ($n = 26$).
[c] Analyses controlled for age, the number of patient lifts/transfers, and the following variables demonstrating confounding effect (≥5% change in OR):
- Any low back pain: race, setting, effort-reward imbalance (ERI).
- Work-related low back pain: race, setting, work hour, ERI.
- Major low back pain: type of hospital, setting, ERI.
- Any neck pain: type of hospital, ERI, safety climate.
- Work-related neck pain: setting.
- Major neck pain: ERI.
- Any shoulder pain: work hour, ERI.
- Work-related shoulder pain: gender, race, type of hospital, work hour, physical workload index, ERI.
- Major shoulder pain: type of hospital, shift, physical workload index, ERI.

[d] Pain caused or worsened by work.
[e] Pain with at least moderate intensity that occurred at least monthly or lasted at least one week.

Table 3
Associations between prevalence of musculoskeletal pain and the level of lift availability ($n = 331$).

Type of pain	Level of lift availability[a]	Nurses with pain/prevalence N (%)	Adj. OR[b]	95% CI
Low back pain				
Any pain	Not provided	137 (75.7)	1.00	
	Low	19 (90.5)	1.71	0.35–8.32
	Medium	32 (84.2)	2.73	0.72–10.3
	High	65 (72.2)	0.65	0.32–1.34
Work-related pain	Not provided	115 (63.5)	1.00	
	Low	16 (76.2)	0.98	0.31–3.12
	Medium	26 (70.3)	1.29	0.50–3.33
	High	47 (52.2)	**0.50**	**0.26–0.96**
Major pain	Not provided	52 (28.7)	1.00	
	Low	5 (23.8)	0.69	0.22–2.23
	Medium	11 (29.7)	0.93	0.36–2.43
	High	20 (22.2)	0.85	0.41–1.79
Neck pain				
Any pain	Not provided	109 (61.9)	1.00	
	Low	15 (71.4)	2.01	0.65–6.22
	Medium	25 (65.8)	1.44	0.59–3.50
	High	55 (62.5)	0.98	0.52–1.86
Work-related pain	Not provided	70 (40.2)	1.00	
	Low	11 (52.4)	1.49	0.55–4.05
	Medium	14 (36.8)	1.04	0.44–2.43
	High	32 (36.4)	0.78	0.40–1.53
Major pain	Not provided	58 (33.3)	1.00	
	Low	6 (28.6)	0.72	0.25–2.12
	Medium	8 (21.6)	0.69	0.26–1.79
	High	22 (25.3)	0.71	0.35–1.43
Shoulder pain				
Any pain	Not provided	85 (47.5)	1.00	
	Low	8 (40.0)	0.63	0.22–1.77
	Medium	16 (43.2)	0.90	0.39–2.08
	High	43 (50.0)	0.90	0.48–1.68
Work-related pain	Not provided	62 (34.6)	1.00	
	Low	6 (30.0)	0.62	0.20–1.97
	Medium	7 (19.4)	**0.28**	**0.09–0.91**
	High	27 (31.4)	0.63	0.29–1.36
Major pain	Not provided	37 (20.7)	1.00	
	Low	3 (15.8)	0.75	0.18–3.12
	Medium	4 (10.8)	0.69	0.21–2.28
	High	15 (17.4)	0.99	0.42–2.35

[a] Not provided ($n = 182$), low ($n = 21$), medium ($n = 38$), high ($n = 90$). Total N varies due to missing data of pain variables.
[b] Analyses controlled for age, the number of patient lifts/transfers, and the following variables demonstrating confounding effect ($\geq$5% change in OR):
- Any low back pain: years in nursing, gender, race, BMI, type of hospital, setting, full time, shift, work hour, physical workload index (PWI), job strain, effort-reward imbalance (ERI).
- Work-related low back pain: years in nursing, gender, race, type of hospital, setting, full time, work hour, PWI, job strain, ERI.
- Major low back pain: race, BMI, type of hospital, setting, work hour, PWI, job strain, ERI, safety climate.
- Any neck pain: race, setting, unit, work hour, PWI, ERI, safety climate.
- Work-related neck pain: gender, race, marital status, type of hospital, setting, shift, job strain, ERI, safety climate.
- Major neck pain: gender, unit, shift, work hour, PWI, job strain, ERI, safety climate.
- Any shoulder pain: years in nursing, setting, shift, work hour, PWI, job strain, ERI.
- Work-related shoulder pain: gender, race, type of hospital, setting, full time, shift, work hour, PWI, job strain, ERI, safety climate.
- Major shoulder pain: marital status, type of hospital, setting, shift, work hour, PWI, job strain, ERI, safety climate.

significant neck pain than nurses with lift teams, after controlling for lift provision and other confounders. Considering such effects and also that the study sample included only a small number of nurses with lift teams ($n = 26$), we restricted multivariable analyses to nurses without lift teams in order to examine only effects associated with lifting equipment. Multivariable models were adjusted *a priori* by age and the number of patient lifts or transfers. Other covariates were added only if a confounding effect was determined empirically. Initially, age and years in nursing were highly correlated ($r = 0.80$) and thus, multicollinearity was of concern. For combinations where years in nursing presented confounding in the initial examination, we conducted two analyses including and excluding years in nursing in the final models. We found only minor differences between the findings, and therefore, we kept years in nursing in those final models. For the level of lift availability and lift use variables, nurses who were not provided lifts were used as the reference group. ORs and 95% confidence intervals (CIs) were calculated.

3. Results

3.1. Study sample

The study sample ($n = 361$) characteristics are presented in Table 1. The typical respondent was female, White, married, working in a non-profit community hospital and ICU, at a full-time job on the day shift. Of the sample, 168 (46.5%) reported that their employer provided lifts; among these nurses, lifts were available always to 33 (19.6%), most of the time to 67 (39.9%), often to 19 (11.3%), occasionally to 23 (13.7%), rarely to 21 (12.5%), and never to 2 (1.2%) [missing $n = 3$]. The 168 nurses reported using a lift or transfer aid for physically dependent patient handling as follows: 22 (13.1%) always, 32 (19.0%) most of the time, 13 (7.7%) often, 40 (23.8) occasionally, 41 (24.4%) rarely, and 12 (7.1%) never (missing $n = 8$). Personal factors, workplace and employment factors, physical workload, and psychosocial work factors were compared between nurses with lifts and nurse without lifts and by the level of lift availability. Personal factors showed no significant differences ($p < 0.05$) between comparison groups for lift variables. Nurses whose workplaces provided lifts were significantly more likely to be ICU nurses and have a lower physical workload index score and higher job control and safety climate scores. The level of lift use was significantly correlated with lift availability (rho = 0.31, $p < 0.0001$).

3.2. Musculoskeletal pain by lift provision, availability and use

Tables 2–4 present the prevalence rates of low back, neck, and shoulder pain by lift provision and by the levels of lift availability and lift use; the relationships between lift variables and pain are presented by ORs with 95% CIs from multivariable analyses. Among the sample, low back pain was the most commonly reported pain type. Almost two-thirds of respondents reported work-related low back pain while about one-third reported work-related neck and shoulder pain (Table 2).

Nurses whose workplaces provided lifts less commonly reported work-related pain in the low back and shoulders and major pain in all three body regions than nurses without lifts (Table 2). A statistically significant association was found only for work-related shoulder pain (OR = 0.47, 95% CI 0.25–0.91).

With respect to the level of lift availability, significant associations were found for work-related low back pain and work-related shoulder pain (Table 3). Compared to those without lifts, nurses reporting high-level lift availability were 50% less likely to have work-related low back pain (OR = 0.50, 95% CI 0.26–0.96) and nurses reporting medium-level lift availability were 72% less likely to have work-related shoulder pain (OR = 0.28, 95% CI 0.09–0.91); however, no clear dose-response relationships were observed by availability level.

For the level of lift use, significant associations were found for work-related shoulder pain and any neck pain (Table 4). Compared to those without lifts, nurses reporting medium-level lift use were three times less likely to have work-related shoulder pain (OR = 0.33, 95% CI 0.12–0.93) and nurses reporting low-level lift use were three times more likely to report any neck pain (OR = 3.13, 95% CI 1.19–8.28). In additional analysis for neck pain, nurses reporting low-level lift use had significantly higher odds of any neck pain than nurses reporting medium or high level lift use. For work-related low back pain, the finding was not statistically significant, but ORs decreased by the level of lift use, indicating a dose-response relationship.

4. Discussion

This study investigated the effect of patient lifting equipment on musculoskeletal pain by level of lift availability and lift use among U.S. critical-care nurses, using three types of pain outcome measures. The information on the type of lift equipment was not available in this study, but most lifts available to the study participants are likely to be floor-based lifts, given the fact that the survey data were collected in 2006. The study sample presented high prevalence of musculoskeletal symptoms in the low back, shoulder, and neck. Significant protective effects were observed for work-related shoulder pain consistently across all three lift variables. A significant protective effect was observed also for work-related low back pain among nurses reporting a high-level of lift availability, but the protective effect of lift use on work-related low back pain was not significant. Low-level lift use was associated with higher odds of any neck pain compared to nurses reporting medium or high levels of lift use as well as nurses who were not provided lifts.

Our study findings suggest that the most beneficial effects of lifts may be seen in preventing work-related shoulder pain. This finding is interesting because back injury prevention is the primary goal in lift interventions (Marras et al., 2009; Santaguida et al., 2005) and the strongest protective effect of lifts was expected for the low back. Only a few studies have examined the effect of patient lift intervention on shoulders (Li et al., 2004; Trinkoff et al., 2003; Yassi et al., 2001) and these studies reported beneficial effects in line with our study findings. In a study by Yassi et al. (2001), significant reductions of work-related shoulder pain and low back pain were found among intervention groups provided with mechanical lifts and other transfer aids compared to the control group using usual practices. In a study by Li et al. (2004), musculoskeletal comfort scores in the shoulders and upper arms significantly increased six months after providing lifts and training; however, the largest increases in comfort were found for the low and upper back. Another study by Trinkoff et al. (2003) also suggested a protective effect on shoulders among nurses with lifts, but the finding was not statistically significant (OR = 0.66, 95% CI 0.33–1.31). The definition for pain used by Trinkoff et al. (2003) was equivalent to our major pain measure.

Our study also found significant protective effects of lifts on work-related low back pain among nurses with

Table 4
Associations between prevalence of musculoskeletal pain and the level of lift equipment use ($n = 327$).

Type of pain	Level of lift equipment use[a]	Nurses with pain/prevalence N (%)	Adj. OR[b]	95% CI
Low back pain				
Any pain	Not provided	137 (75.7)	1.00	
	Low	40 (81.6)	1.40	0.51–3.85
	Medium	38 (79.2)	1.22	0.47–3.14
	High	36 (75.0)	0.87	0.37–2.04
Work-related pain	Not provided	115 (63.5)	1.00	
	Low	34 (69.4)	0.97	0.43–2.19
	Medium	29 (60.4)	0.72	0.33–1.58
	High	24 (51.1)	0.52	0.25–1.09
Major pain	Not provided	52 (28.7)	1.00	
	Low	12 (24.5)	0.67	0.28–1.58
	Medium	12 (25.5)	0.77	0.32–1.82
	High	10 (20.8)	0.74	0.31–1.80
Neck pain				
Any pain	Not provided	109 (61.9)	1.00	
	Low	39 (81.3)	**3.13**	**1.19–8.28**
	Medium	29 (60.4)	0.94	0.44–2.04
	High	24 (52.2)	0.79	0.37–1.68
Work-related pain	Not provided	70 (40.2)	1.00	
	Low	22 (45.8)	0.99	0.46–2.13
	Medium	19 (39.6)	1.00	0.46–2.19
	High	14 (30.4)	0.75	0.34–1.65
Major pain	Not provided	58 (33.3)	1.00	
	Low	15 (31.3)	0.91	0.41–2.04
	Medium	9 (18.8)	0.59	0.24–1.43
	High	11 (24.4)	0.68	0.28–1.63
Shoulder pain				
Any pain	Not provided	85 (47.5)	1.00	
	Low	23 (47.9)	0.97	0.45–2.12
	Medium	22 (50.0)	0.88	0.40–1.93
	High	20 (41.7)	0.61	0.28–1.30
Work-related pain	Not provided	62 (34.6)	1.00	
	Low	16 (33.3)	0.74	0.31–1.78
	Medium	11 (25.6)	**0.33**	**0.12–0.93**
	High	11 (22.9)	0.37	0.14–1.00
Major pain	Not provided	37 (20.7)	1.00	
	Low	6 (12.5)	0.52	0.16–1.67
	Medium	8 (18.6)	1.38	0.51–3.70
	High	7 (14.6)	0.95	0.32–2.86

[a] Not provided ($n = 182$), low ($n = 49$), medium ($n = 48$), high ($n = 48$). Total N varies due to missing data of pain variables.
[b] Analyses controlled for age, the number of patient lifts/transfers, and the following variables demonstrating confounding effect (≥5% change in OR):
- Any low back pain: race, type of hospital, setting, full time, work hour, physical workload index (PWI), job strain, effort-reward imbalance (ERI).
- Work-related low back pain: race, setting, full time, work hour, PWI, ERI.
- Major low back pain: BMI, type of hospital, setting, unit, work hour, ERI, safety climate.
- Any neck pain: race, setting, unit, work hour, PWI, job strain, ERI, safety climate.
- Work-related neck pain: race, setting, full time, work hour, ERI, safety climate.
- Major neck pain: gender, setting, unit, shift, work hour, PWI, ERI, safety climate.
- Any shoulder pain: race, type of hospital, setting, full time, shift, work hour, PWI, ERI.
- Work-related shoulder pain: gender, race, BMI, type of hospital, setting, full time, shift, work hour, PWI, job strain, ERI.
- Major shoulder pain: BMI, type of hospital, setting, shift, work hour, PWI, job strain, ERI, safety climate.

high-level lift availability and any neck pain among higher level lift users. Protective, although not significant, effects for low back pain were suggested also by lift provision and greater lift use. Similarly, Trinkoff et al. (2003) found that nurses with lifts had significantly less back pain (OR = 0.53, 95% CI 0.29–0.97) and neck pain (OR = 0.45, 95% CI 0.22–0.89). In our study, risk of any neck pain was shown to be lower among higher level lift users, but higher among low-level users compared to nurses without lifts. The greater risk among low-level users may reflect that nurses who were not provided lifts may perform less heavy lifting tasks than nurses who were provided lifts; thus low-level lift use may be worse than working with no lifts provided for these nurses in terms of ergonomic risks. More investigation is needed to understand why this pattern is prominent for neck pain.

This study found significant findings for only a few exposure and outcome categories. This may be due to low statistical power of this study using a relatively modest sample size. Alternatively, this may reflect the fact that lifting equipment is just one component of safe patient handling programs. As reported in the literature, best practices for musculoskeletal injury prevention use an array of multifaceted approaches such as lift equipment, zero-lift policy, training, ergonomic risk assessment, and peer safety leaders (Collins et al., 2004; Nelson and Baptiste, 2006; Nelson et al., 2006). Thus, negative findings in this study may conversely suggest the need for comprehensive safe patient handling programs for intervention success.

Our study findings suggest the utility of work-related pain as an outcome measure specifically suitable for use in intervention studies because of its relatively high sensitivity compared to non-specific pain measures. Among the five significant associations between musculoskeletal pain and lift variables, four were found for work-related pain (in the low back and shoulders). Work-related pain, however, has not been a common choice as a pain measure in intervention or prevalence studies. According to a systematic review of back injury intervention studies among nurses (Dawson et al., 2007), seven out of eight studies that evaluated patient handling devices or ergonomics training assessed pain as the outcome measure, and only one study asked about work-related pain and it was the only study that found a significant reduction in pain (Yassi et al., 2001). Employing an outcome measure with an adequate sensitivity and specificity should be an important consideration in intervention studies. As any pain and major pain include both work-related and non-work-related pain, they can be considered less sensitive measures than work-related pain in evaluating work-related interventions. Indeed, our study findings supported that using the specific measure of work-related pain has an advantage in capturing the effect of lift intervention. Also, from a management perspective, reduction in work-related pain serves as a major 'early warning indicator', with the potential to reduce liability and associated direct and indirect costs for employers. The utility of work-related pain as an outcome measure should continue to be evaluated in future research.

By using three different lift variables, our study could more comprehensively evaluate the potential effects of lift implementation. For work-related shoulder pain, lift provision reduced the odds of pain by 53%, and lift availability and lift use lift use were associated with higher reductions of pain of up to 72%. A similar pattern was observed for work-related low back pain. In a study by D'Arcy et al. (2012) that investigated a lifting-related musculoskeletal injury among nursing assistants, the odds of injury reporting was 41% lower among those who reported that lifts were always available. Taken together, these findings suggest that a high level of lift availability and consistent use are crucial in making lift intervention successful, above and beyond simply purchasing lifting equipment.

In addition to the main study findings above, our study was able to examine the psychosocial impact of lift interventions among nurses by comparing self-reported psychosocial job characteristics by lift variables. While there were no significant differences in psychological demand or effort scores, job control was significantly higher among nurses who were provided with lifts than nurses who were not. This finding may suggest that the provision of lifting equipment positively impacts nurses' control over job tasks, or alternatively that the provision of lifting equipment by the employer is the result of the nurses' high control over their working conditions. Driessen et al. (2011) found that a participatory, ergonomic intervention significantly increased job control. Improved job control reduces job strain—which has implications for musculoskeletal, cardiovascular, and mental health outcomes (Sultan-Taieb et al., 2011). Our study also showed that the safety climate score was significantly higher among nurses with lifts than nurses without lifts. This finding suggests that safety climate is enhanced by workplace intervention programs and/or that a positive safety climate results in provision of lifting equipment. This finding also suggests that the placement and maintenance of injury prevention programs are well reflected in workers' perceptions about overall workplace safety.

Our study has several strengths. First, we used multiple pain outcome measures, including a measure for work-related pain. This has significant implications regarding the potential for justifying the capital and training expenses that the provision of lifts entails. On the other hand, conducting multiple comparisons by the use of multiple outcomes can raise a concern about increasing the Type I error. However, making adjustments for multiple comparisons to control the Type I error increases the Type II error (Rothman, 1990). Rothman (1990) argued as "adjustment for multiple comparisons shields some observed associations from more intensive scrutiny" and addressed that not making such adjustments leads to fewer errors of interpretation for observed data. Thus, our approach in this study, which did not adjust for multiple comparisons, is a legitimate means for exploring the effect of lifts on different body regions from several angles. Second, in contrast to most other studies, we adjusted for a comprehensive set of confounding factors, including organizational and psychosocial job factors. Further, this study used a nationwide random sample and a relatively homogenous group of critical-care nurses, and had the ability to reach and include nurses on sick or disability leave. This sampling method may have improved the accuracy of prevalence estimates and the generalizability of results.

Our study also has several limitations, requiring cautious interpretation. First, this evaluation was based on data from an observational study using a cross-sectional design; thus, temporal relationships for causality are not established. Lifting equipment provision might not be the result of new musculoskeletal pain during the last 12 months. However, as this study did not exclude recurrent pain and chronic pain that lasted longer than a year, we cannot exclude for such cases the alternative situation of lift provision preceded by musculoskeletal pain and its influence on the study findings. In addition, awareness of lift availability and lift use may be affected by musculoskeletal pain experience. Second, there may be residual confounding. However, the comprehensive control of confounders in our study and the magnitude of the observed effect sizes practically rule out residual confounding as an alternative explanation for our findings. Third, self-report of both exposures and outcomes may have led to reporting and misclassification bias. On one hand, if subjects with pain had a strong tendency to "blame" unavailability of lifts as a cause for their work-related pain, this could lead to an overestimation of risks. On the other hand, if subjects made non-differential recall errors, this would lead to an underestimation of effects. Similarly, because the original study did not collect data on the types and ease of use of lifts and the exact biomechanical loads during lifting were not assessed, this non-differential misclassification of exposures would lead to an underestimation of effects. While misclassification could cast doubt on the non-significant findings, the strong and statistically significant findings of our study need to be considered as strong evidence for true associations observed despite relatively crude exposure assessments. Fourth, the modest response rate of 42% limits the generalizability of the study findings and is not sufficient to rule out response bias as described above. Finally, the relatively small sample size limited statistical power in identifying more statistical significant associations as well as precision of estimation. Especially for smaller categories, we obtained wide confidence intervals.

5. Conclusions

This study investigated the effects of patient lifting equipment on musculoskeletal pain for multiple levels of lift availability and actual use. Overall findings point to the following conclusions: (a) lifts appear to have the strongest potential for reducing work-related pain in the shoulders, and (b) consistent actual availability of lifts and removal of barriers against lift use among nurses may be important co-determinants for the prevention potential of lift interventions. The findings of this study can be used to generate specific hypotheses to be tested in future studies. Longitudinal studies are especially needed to determine the causal effect and the level of effectiveness of lift interventions. Future studies should include work-related pain as a relatively sensitive outcome measure and need to consider the levels of lift availability and actual use in evaluating the effectiveness of lift interventions.

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