The Association of Socioeconomic Status and Psychosocial and Physical Workplace Factors With Musculoskeletal Injury in Hospital Workers

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Background *The combined effect of socioeconomic, organizational, psychosocial, and physical factors on work-related musculoskeletal disorders (WRMSDs) were studied in a heterogeneous, socioeconomically diverse sample (cases and their matched referents) of hospital workers.*
Methods *Cases were defined by a new acute or cumulative work-related musculoskeletal injury; referents were matched by job group, shift length, or at random. Information was obtained through telephone interviews and on-site ergonomics observation. Questionnaire items included sociodemographic variables, lost work time, work effectiveness, health status, pain/disability, and psychosocial working conditions using Effort Reward Imbalance (ERI) and Demand-Control (DC) models. Two multivariate models were tested: Model 1 included occupation as a predictor; Model 2 included education–income as a predictor.*
Results *Cases reported greater pain, disability, lost time, and decreased work effectiveness than the referents. Model 1 was statistically significant for neck/upper extremity injury (Chi-square = 19.3, P = 0.01), back/lower extremity injury (Chi-square = 14.0, P = 0.05), and all injuries combined (Chi-square = 25.4, P = 0.001). "Other Clinical" occupations (34% mental health workers) had the highest risk of injury (OR 4.5: 95%CI, 1.7–12.1) for all injuries. The ERI ratio was a significant predictor for neck and upper extremity (OR 1.5: 95%CI, 1.1–1.9) and all injuries (OR 1.3; 95%CI, 1.04–1.5), per SD change in score.*
Conclusions *In this study, the risk of WRMSDs was more strongly influenced by specific psychosocial and physical job-related exposures than by broad socioeconomic factors such as education and income.* Am. J. Ind. Med. 50:245–260, 2007. *© 2007 Wiley-Liss, Inc.*

KEY WORDS: work-related musculoskeletal disorders; socioeconomic status; hospitals; effort-reward imbalance; demand-control model; ergonomics; hospital occupations

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BACKGROUND

The personal and employer costs associated with work-related injuries and disability are notable [Leigh et al., 1997; Keogh et al., 2000; Pransky et al., 2000; Robinson et al., 2001; Gillen et al., 2004; Strunin and Boden, 2004]. Functional, economic, social, and quality of life outcomes associated with occupational injury and illness have become an increasingly important area for study [Centers for Disease Control, 2003, National Institute for Occupational Safety and Health (CDC/NIOSH), 2003; Dembe, 2001]. Research on socioeconomic status (SES) and health has shown consistent associations across a broad range of conditions and outcomes, including mortality [Marmot and Feeney, 1997; Marmot et al., 1997a,b; Stansfeld et al., 2003; Muntaner et al., 2004; Steenland et al., 2004; Ferrie et al., 2005; Langenberg et al., 2005; Shishehbor et al., 2006], but less is known about the relationship of socioeconomic status and injury. Although there is a strong association between socioeconomic status and injury mortality [Cubbin et al., 2000; Steenland et al., 2003], the relationship with regard to nonfatal injuries is less clear [Kelly and Miles-Doan, 1997]. For example, in one study, low educational attainment was a statistically significant risk for nonfatal work-related injuries only at the uppermost levels of severity (i.e., days of restricted activity), though employment in blue-collar occupations was a risk factor at every level of disability [Cubbin et al., 2000]. Conversely, in two studies, one addressing low back pain and the other, repetitive strain injuries, higher educational status was found to be a risk factor for musculoskeletal injury [Kerr et al., 2001a; Cole et al., 2005].

Hospital employees are at especially high risk for work-related musculoskeletal disorders (WRMSDs) due to the physically demanding nature of their work and the environment in which it is conducted. In particular, the prevalence of and risk factors for back and neck/shoulder pain—the most common WRMSDs—have been analyzed among nurses and nursing assistants in many countries and settings [Lagerstrom et al., 1995; Engels et al., 1996; Josephson et al., 1997; Engkvist et al., 2000; Yassi et al., 2001; Yip, 2001; Lipscomb et al., 2002; Evanoff et al., 2003; Salminen et al., 2003; Smedley et al., 2003a,b; Trinkoff et al., 2003; Eriksen et al., 2004; Violante et al., 2004; Cheung et al., 2006]. Most of these studies have focused on the physical demands of clinical care, such as lifting and transferring activities, while little attention has been paid to the strenuous activities of other hospital employees at risk for injury [Evanoff et al., 1999; Salminen et al., 2003; Kumar et al., 2003, 2004; Horkey and King, 2004].

Although the literature has been dominated by the study of physical risk factors for injury, several studies of nursing staff have assessed concomitant physical (including ergonomic) demands of work with workplace psychosocial factors such as schedule, shift, pace, tedium or boredom, or relationships with co-workers [Engels et al., 1996; Josephson et al., 1997; Engkvist et al., 2000; Yip, 2001; Lipscomb et al., 2002; Gunnarsdottir et al., 2003; Smedley et al., 2003a,b; Eriksen et al., 2004; Smith et al., 2004; Violante et al., 2004; Yip, 2004; Cheung et al., 2006]. Most of the studies of nursing staff used self-report survey measures to assess not only these psychosocial factors but also the physical demands or ergonomic characteristics of the work, and the injury outcome of interest. Notable exceptions have included direct observations of work tasks or ergonomic factors or confirmation of self-reported pain [Engels et al., 1994, 1996; Salminen et al., 2003].

Beyond the focused topics of workplace psychosocial factors, additional investigations have explored theoretical models of psychosocial stress factors as predictors of WRMSDs in hospital workers. The two most prominent theoretical models in the literature are the demand–control (DC) model [Theorell and Karasek, 1996; Karasek et al., 1998] and the effort–reward imbalance (ERI) model [Siegrist, 1996; Bosma et al., 1998a]. The DC model postulates that the combination of high psychological demands (e.g., time pressure) and low decision latitude (e.g., less influence, monotonous work) can cause health-disrupting psychophysiological stress reactions leading to a state conceptualized as ''job strain.'' The ERI model also proposes that such stress reactions are important but theorizes that they are caused by a combination of high effort (similar to psychological demands in the DC model) and low rewards in terms of compensation, respect, advancement prospects, and job security. While the concept of DC focuses more on decision making and physical demands in the workplace, the ERI additionally encompasses organizational components of the workplace such as fairness and justice. Hence, they measure related but different aspects of the work environment [Bosma et al., 1998a,b; Peter et al., 2002].

The two models have been tested extensively with regard to cardiovascular disease [Belkic et al., 2004; van Vegchel et al., 2005]. More recently, psychosocial risk factors have been evaluated as risk factors for WRMSDs and modest effects have been documented [Davis and Heaney, 2000; Ariens et al., 2001; Kerr et al., 2001b; Joksimovic et al., 2002; Bongers et al., 2002; Rugulies and Krause, 2005]. Most of these studies, however, have limited capacity to adjust for potential additive or interactive effects of physical workload. Moreover, where these models or other models of psychosocial stress have been used to study musculoskeletal or sickness/absence outcomes in the health care sector, the focus primarily has been on nursing staff [Bourbonnais and Mondor, 2001; Lipscomb et al., 2002; Salminen et al., 2003; Gunnarsdottir et al., 2003; Eriksen et al., 2004; Jhun et al., 2004; Lavoie-Tremblay et al., 2005; Cheung et al., 2006].

To address these limitations and to test the hypothesis that injury and its associated health gradients are associated with socioeconomic status, including occupation, a case-control study of hospital workers was conducted studying the combined effect of socioeconomic, workplace organizational, psychosocial, and ergonomic factors. A questionnaire that included information on education and income and both demand–control and effort–reward imbalance measures was administered to both cases and referents. Additionally, direct observation of workplace activities in a wide variety of occupations was conducted. The Gradients of Occupational Health in Hospital Workers (GROW) study provided an opportunity to assess the combined contribution of psychosocial and physical exposures for workplace injury in a socioeconomically diverse workforce, albeit in one industrial sector.

METHODS

Study Overview

Data are from an ongoing longitudinal, case-control investigation. This study used a multi-pronged, mixed methodology approach to evaluating injuries in two hospital settings. This was designed to follow injured hospital workers (cases) with acute and cumulative WRMSDs of the trunk, neck, and upper and lower extremities. The study included a referent cohort of non-injured employees. Information from subjects was obtained by structured telephone interviews and data on exposure through on-site ergonomics observations, respondent self-assessment of the safety climate [Dedobbeleer and Beland, 1991; Gillen et al., 2002], and collection of saliva samples for salivary cortisol analysis. For the current analysis, data from the structured telephone interviews and the ergonomics observations is presented. A summary of key study instruments and methodology, with details of the core structured questionnaire and the ergonomics assessments, has been previously reported. The qualitative arm of the study has also been separately described [Rugulies et al., 2004b; Gordon et al., 2005; Janowitz et al., 2006].

Recruitment and Follow-Up

Eligible participants were recruited from a study base of approximately 6,000 hospital workers at two institutional sites, including nurses and other health care professionals, technical workers, administrators, clerical, and skilled and unskilled craft workers. Only physicians were excluded from the eligible participant pool. Cases were defined by a new presentation of an acute or cumulative musculoskeletal injury that was evaluated and determined to be work-related by physician and nurse practitioner colleagues who worked at each site's employee health clinic. Injuries that were eligible for workers' compensation were considered work-related. Cases were classified according to the primary injury site as noted by the treating clinician if cases presented with more than one injury. Referents were matched by job group, shift length, or at random, yielding a 3:1 ratio to cases. Job-matched controls were selected from a list, provided by each site's human resources department, of potential cases with job titles and/or job codes that were consistent with the list of categories we requested. Shift length matches were based on the usual length of shift that employees worked—either 8 or 12 hr in length. Following recruitment, cases and referents were followed prospectively for a period averaging 24 months. There were two waves to this study; this report covers the first wave, which took approximately 28 months to complete.

Questionnaire Content and Administration

All participants completed a structured telephone-based interview. It included items on general job information, sociodemographic variables, lost work time due to any cause during the 4 weeks prior to interview, psychosocial working conditions, work family balance, job satisfaction, co-morbid medical conditions, health-related lifestyle issues (e.g., smoking status, exercise patterns), general health status, and musculoskeletal pain and disability. Injury questions ascertaining musculoskeletal pain and disability particular to the anatomical location of the reported injury of the case were included for cases and their matched referents.

Sociodemographics, Health Status, and Health Behaviors

Questionnaire items addressing demographics and socioeconomic status included age, gender, race/ethnicity, and educational attainment (no college degree, associate degree, bachelor degree, or post-graduate degree). Annual household income was ascertained in $40,000 increments up to a category of $120,000 and greater. Occurrence of physician-diagnosed co-morbid conditions such as asthma, hypertension, and diabetes was assessed using a short check list and several open-ended questions. In addition, we asked about current and former smoking status and alcohol use.

Health-Related Quality of Life, Musculoskeletal Pain, and Disability Measures

Short form—12, physical component score

General health status was determined using the Physical Component Score (PCS) of the SF-12 [Ware et al., 1996], a shortened version of the Short-Form 36 [Ware et al., 1993;

Ware, 2000]. Scores on the PCS range from 0 to 100 with higher scores indicating better functioning.

Roland Morris scale for low back symptoms

The 24-item Roland Morris Scale was used to assess low back symptoms and pain. Except for the first question, which assesses pain, the remaining dichotomous items assess pain-related restrictions in daily life. This instrument has been used in previous studies and has demonstrated satisfactory psychometric properties [Roland, 1983; Kerr et al., 2001b; Hogg-Johnson and Cole, 2003; Licciardone et al., 2003].

Von Korff neck pain assessment

Neck symptoms were assessed using 11-items from the Saskatchewan Health and Back Pain Survey, a population-based study of the determinants of spinal pain [Cote et al., 2000]. Four items evaluate past and current neck pain, while seven measure severity of neck pain and the extent of disability resulting from pain. The instrument has been shown to have adequate psychometric properties when grading the severity of chronic pain [Von Korff et al., 1990, 1992].

Disability of the arm, shoulder, and hand (DASH)

The DASH is a widely used instrument that has been extensively evaluated for its psychometric properties [Navsarikar et al., 1999; Atroshi et al., 2000; Beaton et al., 2001; SooHoo et al., 2002]. A shortened version, the 11-item Quick-DASH [Beaton et al., 2005], was used to assess upper extremity symptoms. Two of the items measure pain while the remaining nine measure functional limitations in daily life secondary to symptoms.

Western Ontario and McMaster Universities osteoarthritis index (WOMAC) questionnaire

A shortened version of the WOMAC (21-items) was used to measure lower extremity symptoms [Bellamy et al., 1988; Roos et al., 1999a,b; Hogg-Johnson and Cole, 2003]. Four items assess pain or stiffness in the hips, knees, ankles, and feet, while the remaining 17 items measure restrictions in daily activities secondary to those symptoms.

Psychosocial Exposures at Work

The demand–control model (DC)

Job strain was measured using the 14-item version of the Job Content Questionnaire (JCQ), including five questions on psychological demands, and nine on job control (made up of six items on skill latitude and three items on decision authority). All responses are constructed using a 4-point Likert scale ranging from "strongly agree" to "strongly disagree." A summary score is calculated by taking the ratio of the psychological demands subscale to the job control subscale. The psychometric properties of the scales have been extensively tested in previous studies [Landsbergis et al., 1994, 2000; Karasek et al., 1998]. Although a categorical quadrant classification of the DC model has been the most commonly used analytical technique in the past, our use of the ratio of demands to latitude model is a newer approach increasingly used in studies of job strain. This alternative model has been shown to be an effective analytic strategy for use with the DC model. Potential DC scores range from 0.125 (lowest levels of demands and highest level of control) to 2.0 (highest level of demand and lowest level of control). Among our subjects, internal consistency for the DC battery as measured by Cronbach's α was 0.77.

Effort–reward imbalance model (ERI)

Effort–reward imbalance (ERI) was measured using the 17-item ERI-Questionnaire, containing six items on extrinsic effort and 11 items on reward. The psychometric properties of the scales have been reported in prior work and are satisfactory [Landsbergis et al., 2000; Siegrist et al., 2004]. Respondents determine if a potential stressor is present, and, if present, what degree of distress this causes them, if any. All responses are constructed using a 4-point Likert scale ranging from "not at all distressed" to "very distressed." Effort and reward, scored separately, are used to create a ratio, with a correction factor for the higher number of items on the reward scale [Siegrist, 1996; Siegrist and Marmot, 2004]. Among our respondents, internal consistency measured by Cronbach's α for the ERI effort component of the battery yielded $\alpha = 0.72$ and for the ERI reward $\alpha = 0.80$.

Occupational Job Categories

Thirteen distinct occupational categories were created, including eight non-nursing and five nursing groupings. These were based on a combination of factors including status in the organization, education/licensing, amount and type of patient contact, and amount and type of physical labor. For analysis purposes, the 13 categories were further collapsed into six groups: administrator and professional, nursing, other clinical, clerical, technical, and support positions. The "other clinical" occupations category included 34% mental health, 29% nursing-related, and 15% rehabilitation occupations, among others (Appendix 1).

Measurement of Physical Workload

Ergonomics observations

All study participants were eligible to take part in an 1-hr ergonomics observation. This was scheduled during the normal work day and was conducted by trained observers under the supervision of the study ergonomist (IJ). Methods of observation have been reported previously [Janowitz et al., 2006]. The observations incorporated the assessment tool developed for the Rapid Entire Body Assessment [Hignett and McAtamney, 2000], which was augmented with additional items related to sedentary positions and computer tasks derived from the University of California Computer Checklist [Janowitz et al., 2002]. The scoring system developed for the GROW study produced two scores—one for the neck/upper extremities (Upper Body Assessment—University of California {UBA-UC}) and one for the back and lower extremities (Lower Body Assessment—University of California {LBA-UC}).

The ergonomics measures were recorded every 2 min, resulting in approximately 30 observations for each subject assessment. In summarizing these scores, we were not interested in a peak or an average score for each individual, but rather the cumulative risk of high physical strain working positions. Therefore, for both UBA-UC and LBA-UC, variables were created that represented the proportion of an individual subject's observations that were at or above the 90th percentile of all such observations across all subjects. A 90% cut off point was used to capture the most extreme conditions and postures observed. The differences in ergonomics scores between the occupational health groups, as measured by the mean sum of squares, were much larger than the differences within groups (all P values < 0.001). A third measure estimated the proportion of the assessment period that was spent using a computer.

Job tasks in these settings vary greatly from day to day or even hour to hour. Therefore, rather than assigning scores for individual subjects, the scores are summarized for all individuals in a given occupational category (as detailed above). Thus, there are 13 possible values for UBA-UC, LBA-UC, and computer tasks. The values were applied to all study participants, including those who did not participate in the ergonomics assessments.

Data Analysis

Cases were compared with pooled referents and the subcategories of referents by age (using the Wilcoxon rank sum test for the dichotomous comparison {cases vs. all referents} and the Kruskal–Wallis test for the three-way comparison, by education and income (Chi-square test for trend), and gender, race/ethnicity, comorbidity status, and smoking status (Chi-square test). Differences were assessed between cases and pooled referents on measures of physical functioning and disability—the SF-12 PCS, Roland Morris, DASH, von Korff disability, and WOMAC physical functioning scores [Roland, 1983; Bellamy et al., 1988; Ware et al., 1995; Germann et al., 1999; Beaton et al., 2005] using the Wilcoxon rank sum test, and differences in number of lost work days between cases and referents by injury type using the Kruskal–Wallis test. SF-12 scores for this sample were compared against population mean scores [Ware et al., 1995] using a one-sample *t*-test. In addition, analysis of variance was used to test for differences in mean scores among job groups for continuous scores such as the Effort Reward Imbalance [Siegrist, 1996]. Logistic regression analysis was used to estimate odds ratios (ORs) for injury beginning with simple models. Predictor variables studied individually included education, household income, occupation (six categories), ERI and Job Strain, and the three ergonomics summary measures (i.e., UBA-UC, LBA-UC, and percent time on computer activities). Models were tested for all subjects and then re-estimated based on the injury type of the index case and matched referents (aggregated as neck/upper extremity and back/lower extremity). For continuous independent variables, the OR for injury associated with a standard deviation change in the independent variable was calculated.

Further, those variables associated with the studied outcomes in the simple models were considered for analysis in multivariate models using a cut-off of $P < 0.20$. Some of the potential study variables selected by this criterion, however, were highly collinear. To address this, the variable with the greatest explanatory power from the simple modeling was included in the multivariate analysis. For example, since ERI and DC scores were modestly correlated, only ERI scores were included in multivariate models. For each of the three injury models (all injuries, neck/upper extremity, back/lower extremity), two multivariate models were estimated. The first model included occupational category, ERI score, and percent strain UB-UC score for upper body injuries, or percent high strain LB-UC score for lower body and all injuries. Job-matched referents were excluded from this model. The second model included all cases and referents, and the following independent variables: a combination of education and income (a sum of the two scores, divided into quintiles), ERI score, and percent high strain UB-UC or LB-UC (as above).

The GROW study design was balanced for the ratio of cases to referents in each hospital, with the result that site, by definition, could not be associated with case/referent status (the dependent variable for the logistic regression models). To address the possibility of clustering of effects by hospital site, conditional logistic regression models were used, conditioned on hospital site. This approach was chosen rather than a mixed model that treated hospital site as a random effects term, because of the limitations of a dichotomous variable (hospital site #1 vs. hospital site #2) serving as a random term. Because the results of the conditional logistic regressions were nearly identical to the unconditional regressions, only the unconditional regression models are presented, all of which contain a fixed effect for hospital site in addition to the variables described above. All analyses were conducted using the statistical software program, SAS version 9.1 [SAS Institute, Inc., Cary, NC].

RESULTS

Demographics, Response Rate, and Reliability Analysis

Details of subject recruitment are presented in Figure 1. There were 664 subjects (59% of eligible pool) who completed the interview; 497 (75% of those interviewed) completed the ergonomics observation. Overall recruitment for cases and referents was similar between the two hospital sites studied.

The mean age of subjects was 45 ± 10 years; the majority was female (72%) and the largest ethnic group (<40%) was White, non-Hispanic (Table I). There were no statistically significant differences between cases and referents with regard to age, gender, race/ethnicity, education level, or annual family income. Co-morbid health conditions were common. Approximately one-fourth of the participants reported clinician-diagnosed hypertension, while asthma and diabetes were reported by 14% and 6% respectively. Current smoking in this population was relatively infrequent, reported by only 72 subjects (11%).

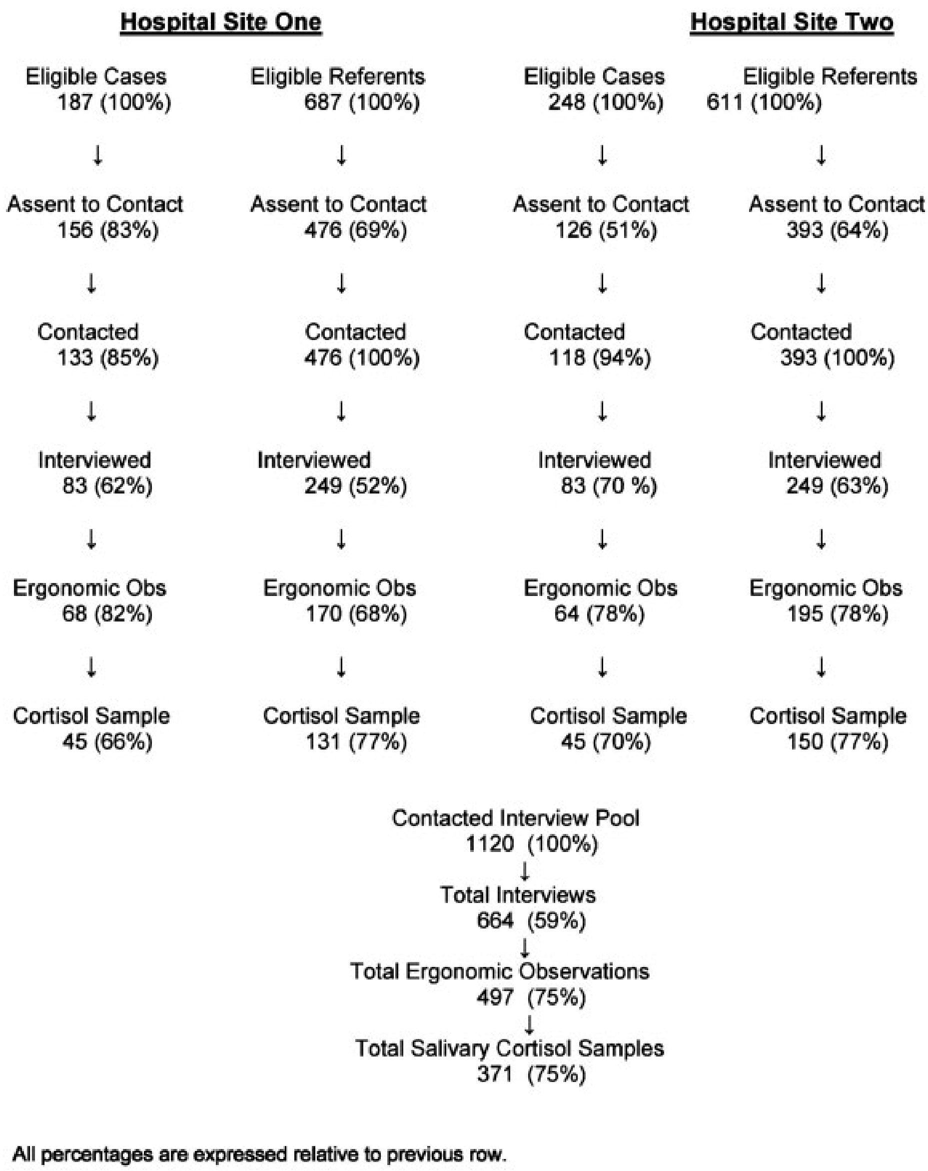

FIGURE 1. Subject recruitment flow.

TABLE I. Demographic Data Among 664 Interview Subjects by Study Status

	Study status			
		Referent categories		
Characteristic	**Cases (n = 166)**	**Job match (n = 166)**	**Shift match (n = 166)**	**Random (n = 166)**
Age in years, mean ± SD	46 ± 9	45 ± 10	46 ± 10	46 ± 11
Female, n (%)	127 (77)	108 (65)	123 (74)	122 (73)
Race/ethnicity, n (%)				
White, non-Hispanic	61 (37)	61 (37)	74 (45)	64 (39)
Hispanic	27 (16)	29 (17)	24 (14)	25 (15)
Asian/Pacific Islander	45 (27)	51 (31)	48 (29)	41 (25)
African American	20 (12)	12 (7)	12 (7)	22 (13)
Mixed/other/unknown	13 (8)	13 (8)	8 (5)	14 (8)
Educational level, n (%)[a]				
No college degree	34 (20)	35 (21)	38 (23)	39 (24)
Associate degree	43 (26)	30 (18)	31 (19)	28 (17)
Bachelor degree	62 (37)	66 (40)	63 (38)	65 (40)
Post-graduate degree	27 (16)	35 (21)	32 (20)	32 (20)
Annual family income, n (%)[b]				
≤$40,000	24 (15)	17 (10)	18 (11)	27 (17)
>$40,000 to $80,000	73 (45)	76 (46)	71 (43)	65 (41)
>$80,000 to $120,000	44 (27)	50 (30)	48 (29)	42 (26)
>$120,000	22 (14)	23 (14)	27 (16)	26 (16)
Co-morbid conditions, n (%)				
Hypertension	39 (23)	46 (27)	33 (20)	34 (20)
Asthma	25 (15)	20 (12)	18 (11)	28 (17)
Diabetes	10 (6)	11 (7)	4 (2)	11 (7)
Smoking status, n (%)				
Current	20 (12)	22 (13)	22 (13)	8 (5)
Former	43 (26)	48 (29)	47 (28)	50 (30)

No statistically significant ($P < 0.05$) differences between cases and pooled referents [Wilcoxon rank sum (age), chi-square test for trend (education, income), and chi square] or among the three categories of referents [Kruskal–Wallis (age) and chi-square].
[a]Educational level missing for 4 subjects.
[b]Income missing for 11 subjects.

Health Status and Injury/Disability Characteristics

For each of the four groups stratified by injury type, there were statistically significant differences between cases and referents for injury-specific pain and disability scores. All of these differences were in the expected direction (for the WOMAC physical functioning score, a lower score indicated greater dysfunction; for the others, higher scores indicate greater pain or disability). Although each measure is scaled differently, for the Roland Morris (back), DASH (upper extremity), and von Korff scores, the difference between cases and referents was approximately one standard deviation (SD); for the WOMAC, it was approximately two-thirds of the SD.

There were statistically significant differences between the SF-12 physical component scores (PCS) of cases and pooled referents for each type of injury and for all injuries combined (Table II). The mean PCS score for all injured cases (41 ± 10) was lower than population normative values [Ware et al., 1995]. PCS scores were similar for male cases (mean 41.0 ± 9.1, $n = 39$) and female cases (40.4 ± 10.0, $n = 124$) and both differed significantly from gender-stratified population normative values ($P < 0.0001$ for each).

Self-reported work effectiveness was significantly lower among all cases compared to referents ($81 \pm 27\%$ compared to $92 \pm 14\%$, $P < 0.05$). In stratified analyses, work effectiveness was lower for each of the four types of injury analyzed, although this difference was not statistically

TABLE II. Health Status by Injury Type Among Cases Versus Pooled Referents

Injury Type	Health status measure	Cases mean ± SD	Referents mean ± SD
		(n = 50)	(n = 150)
Back	SF-12 physical component score	39 ± 9	49 ± 9*
	Work effectiveness	72 ± 33	92 ± 13*
	Lost work days**	5.2 ± 6.8	0.8 ± 2.3*
	Roland Morris score	8.4 ± 6.3	2.7 ± 4.3*
		(n = 74)	(n = 222)
Upper extremity	SF-12 physical component score	41 ± 10	48 ± 10*
	Work effectiveness	85 ± 23	92 ± 15*
	Lost work days**	2.3 ± 4.2	1.1 ± 3.4*
	DASH score	34 ± 23	13 ± 18*
		(n = 18)	(n = 54)
Neck	SF-12 physical component score	41 ± 11	50 ± 8*
	Work effectiveness	84 ± 25	92 ± 16
	Lost work days**	4.0 ± 6.4	0.6 ± 1.7*
	von Korff disability score	31 ± 36	11 ± 19*
		(n = 24)	(n = 72)
Lower extremity	SF-12 physical component score	42 ± 11	49 ± 9*
	Work effectiveness	85 ± 25	92 ± 11
	Lost work days**	2.5 ± 5.0	0.6 ± 1.1
	WOMAC physical functioning score	63 ± 35	83 ± 27*
		(n = 166)	(n = 498)
All subjects‡	SF-12 physical component score	41 ± 10	49 ± 9*
	Work effectiveness	81 ± 27	92 ± 14*
	Lost work days**	3.4 ± 5.6†	0.9 ± 2.7*

*$P < 0.05$, cases versus referents, Wilcoxon rank sum test.
†$P < 0.05$, cases by injury type, Kruskal–Wallis test.
‡SF-12 PCS missing for 9 subjects (3 cases; 6 referents), work effectiveness missing for 10 subjects (4 cases; 6 referents) and lost work days for 4 subjects (1 case; 3 referents).
**Lost work days due to any cause during the 4-week time period preceding the interview.

significant among the neck-injury stratum (the smallest group). Cases with low back injuries reported the lowest work effectiveness (72 ± 33%). The pattern for lost work days in the 4 weeks previous to interview was similar to that for decreased work effectiveness, with a greater number of lost days among all cases compared to referents (3.4 ± 5.6 vs. 0.9 ± 2.7 days). In the stratified analysis, all differences by case-referent status remained statistically significant except for lower extremity injuries. Among the injured cases, there were statistically significant differences in the number of lost work days among the four injury groups ($P < 0.05$), with cases with back injuries reporting the most lost work time.

Risk Factors for Injury—Simple Logistic Regression Models

Table III presents the results of simple logistic regression analyses for a series of predictors each modeled separately. There was no consistent relationship of education or income to injury. For neck or upper extremity injury, the overall logistic regression model for education was significant ($P < 0.05$) and those with associate degrees were at higher injury risk (OR 2.3; 95%CI, 1.03–4.5) compared to those with graduate degrees. The education model, however, was not statistically significant either for back/lower extremity injuries or for all injuries combined. Similarly, for neck/upper extremity and all injuries, there was a gradient in point estimates of risk associated with lower income, but this was not statistically significant.

The Effort Reward Imbalance (ERI) measure was significantly associated with upper extremity/neck and all injuries, while the DC score was not a significant risk factor for any of the injury outcomes. Percent time in high strain positions for both lower and upper extremity, as assessed by the LB-UC and UB-UC ergonomics assessment scores, were both associated with greater risk of lower back injury, while

TABLE III. Risk Factors for Injury Among 649 Subjects by Injury Type

Risk Factor	Neck/upper extremity OR (95%CI)	Back/lower extremity OR (95%CI)	All injuries OR (95%CI)
	(n = 357)	(n = 292)	(n = 649)
Educational level			
High school/some college	0.6 (0.3–1.5)*	1.8 (0.8–4.2)	1.1 (0.6–1.9)
Associate degree	2.2 (1.03–4.5)	1.4 (0.6–3.3)	1.8 (1.0–3.1)
Bachelor's degree	1.2 (0.6–2.4)	1.1 (0.5–2.5)	1.2 (0.7–2.0)
Graduate degree (Referent)	1.0	1.0	1.0
Annual family income, n (%)			
<$40,000	1.7 (0.7–3.9)	1.0 (0.3–2.9)	1.4 (0.7–2.7)
>$40,000 to $80,000	1.3 (0.6–2.7)	1.0 (0.4–2.4)	1.2 (0.7–2.0)
>$80,000 to $120,000	1.2 (0.5–2.5)	1.0 (0.4–2.4)	1.1 (0.6–1.9)
>$120,000 (referent)	1.0	1.0	1.0
Effort reward ratio**	1.3 (1.1–1.7)**	1.1 (0.9–1.4)	1.2 (1.03–1.4)
Job strain score**	1.2 (0.95–1.5)	1.1 (0.8–1.4)	1.1 (0.9–1.3)
Ergonomics assessments†			
% High strain UB-UC**	0.9 (0.7–1.1)	1.6 (1.2–2.1)*	1.2 (0.98–1.4)
% High strain LB-UC**	0.9 (0.7–1.2)	1.5 (1.2–2.1)*	1.1 (0.96–1.4)
% Computer time**	1.0 (0.8–1.3)	0.5 (0.4–0.7)*	0.8 (0.7–0.97)
	(n = 266)	(n = 201)	(n = 484)
Job group‡			
Nurses	1.4 (0.6–3.5)	2.3 (0.9–5.8)	2.6 (1.2–5.9)*
Other clinical	3.4 (1.2–9.7)	4.0 (1.4–11.9)	5.4 (2.2–13.3)
Technical	2.8 (0.9–8.7)	3.2 (0.98–10.6)	4.4 (1.7–11.4)
Support	1.0 (0.3–3.7)	4.3 (1.3–14.3)	3.2 (1.2–8.7)
Clerical	2.5 (1.01–6.5)	1.0 (referent)	2.8 (1.2–6.7)
Administrators/professionals	1.0 (referent)	(Not in model)	1.0 (referent)

*Model chi-square P-value < 0.05.
**OR expressed per SD change in observed predicted variable.
†Ergonomics scores assigned based on mean observed value by occupational substrata. High strain defined as 90th percentile upper body (UB-UC) or lower body (LB-UC) scores. Computer time refers to the proportion of the assessment period spent on computer-related tasks (see Methods).
‡Analysis excludes job-match referents. There were no cases with back/lower extremity injuries in the administrators occupation group.

percent time spent on computer tasks was protective. The latter was the only ergonomic factor in the analysis of all injuries that was significantly protective (OR 0.8; 95%CI, 0.7–0.97). Excluding job-matched referents from the univariate analyses for education, income, psychosocial work factors, and ergonomically-assessed exposures did not substantively impact any of these OR point estimates (data not shown).

The analysis of occupational risk excluded job-matched referents (Table III). The occupational model was statistically significant (model Chi square $P < 0.05$) only for all injuries combined. In that model, each job category was associated with increased risk relative to the administrators/professional group. The highest point estimate of risk was associated with "other clinical" occupations. For back and lower extremity injury, administrators were excluded from the model due to the lack of any observed events. In that analysis, both other clinical positions (OR 4.0; 95%CI, 1.4–12) and support workers (OR 4.3; 95%CI, 1.3–14) had a significantly elevated risk of injury relative to clerical workers.

Risk Factors for Injury—Multiple Logistic Regression Models

Multiple logistic regression analyses were carried out for lower extremity/back, upper extremity/neck, and all injuries combined (Table IV). Two models were tested: Model 1 that includes occupation as a risk factor and excludes job-matched referents, and Model 2 that includes education-income as a risk factor and does not exclude job-matched

TABLE IV. Multiple Logistic Regression Analysis: Risk Factors for Injury by Injury Type

Risk factor	Multivariate model 1* OR (95%CI)	Multivariate model 2† OR (95%CI)
	Neck/UE (n = 266)	Neck/UE (n = 357)
Job group		
Nurses	1.8 (0.6–5.4)	
Other clinical	4.1 (1.3 12.5)	
Technical	4.1 (0.9–18.6)	
Support	2.3 (0.2–23.3)	
Clerical	2.8 (1.1–7.2)	
Administrators/professionals (Referent)	1.0	
Educational level × income level quintiles‡		
Score 1–3		1.2 (0.5–2.7)
Score 4		1.5 (0.7–3.5)
Score 5		2.0 (0.9–4.4)
Score 6		1.4 (0.7–3.2)
Score 7–8 (referent)		1.0
Effort reward ratio**	1.5 (1.1–1.9)	1.3 (1.04–1.6)
Percent high strain UB-UC**	0.8 (0.5–1.4)	0.9 (0.7–1.1)
Model Chi-square, DF, *P*-value	19.3, 8, 0.01	10.9, 7, 0.14
	Back/LE (n = 201)	Back/LE (n = 292)
Job group		
Nurses	1.0 (0.3–3.6)	
Other clinical	1.7 (0.4–7.1)	
Technical	1.4 (0.3–5.8)	
Support	0.4 (0.03–6.1)	
Clerical (referent)	1.0	
Administrators/professionals	(Not in model)	
Educational level × income level score‡		
Score 1–3		1.3 (0.5–3.0)
Score 4		0.6 (0.2–1.6)
Score 5		0.7 (0.3–1.5)
Score 6		0.7 (0.3–1.7)
Score 7–8 (Referent)		1.0
Effort reward ratio**	1.1 (0.8–1.5)	1.1 (0.9–1.4)
Percent high strain LB-UC**	2.0 (0.99–3.9)	1.5 (1.2–2.0)
Model Chi-square, DF, *P*-value	14.0, 7, 0.05	15.8, 7, 0.03
	All injuries (n = 484)	All injuries (n = 649)
Job Group		
Nurses	2.1 (0.8–5.3)	
Other Clinical	4.5 (1.7–12.1)	
Technical	3.2 (1.1–9.0)	
Support	1.5 (0.3–8.8)	
Clerical	3.1 (1.3–7.3)	
Administrators/professionals (Referent)	1.0	
Educational level × income level score‡		
Score 1–3		1.3 (0.7–2.3)
Score 4		1.1 (0.6–1.9)
Score 5		1.2 (0.7–2.1)
Score 6		1.0 (0.6–1.9)
Score 7–8 (Referent)		1.0

TABLE IV. (*Continued*)

Risk factor	Multivariate model 1* OR (95%CI)	Multivariate model 2† OR (95%CI)
Effort reward ratio**	1.3 (1.04–1.5)	1.2 (1.03–1.4)
Percent high strain LB-UC**	1.3 (0.8–2.0)	1.1 (0.96–1.4)
Model Chi-square, DF, *P*-value	25.4, 8, 0.001	9.2, 7, 0.24

All models include indicator variable for hospital site.
*Model 1 excludes job match referents and does not include education × income score as a predictor.
†Model 2 includes all referents and does not include occupation as a predictor.
‡Education × income score calculated by adding 1 point each for the 4 levels of education and income shown in Table III, and grouping the resulting score by (approximate) quintiles.
**OR expressed per SD change in observed predicted variable.

referents. Model 1 was statistically significant for neck and upper extremity injury, back and lower extremity injury, and all injuries combined (model Chi-square $P < 0.05$). In these analyses, the other clinical occupational category demonstrated the most consistent association with increased risk (although the 95%CI was wider for back and lower extremity injury). In Model 1, the ERI ratio was a significant predictor for neck and upper extremity and all injuries.

Model 2 had less predictive power for each of the dependent variables analyzed, reflected in lower model Chi square values; only in the case of back and lower extremity injuries was the overall model significant ($P = 0.03$). In that model, percent high strain as measured by the LB-UC was a statistically significant risk factor (OR 1.5; 95%CI, 1.2–2.0 per SD change in score). This was similar to the estimated effect in Model, 1 although the LB-UC was not statistically significant in that analysis (OR 2.0; 95%CI, 0.99–3.9). Similarly, the estimated risk for all injuries associated with the ERI ratio (OR 1.2; 95%CI, 1.03–1.4) was similar in Model 2 compared to Model 1.

DISCUSSION

In this study, we evaluated the combined effect of factors that we predicted would be associated with work-related musculoskeletal injury in a heterogeneous, sociodemographically diverse group of hospital workers in two settings. Socioeconomic status was examined, as measured by education and income, as well as organizational, psychosocial, and physical factors, including on-site ergonomics observations.

Socioeconomic Status as a Risk Factor for Injury and Associated Health Gradients

Injured workers in this study reported persistent symptomatology, pain, and decreased effectiveness at work weeks after first seeking treatment, underscoring that injury and its after-effects constitute a prolonged and complex phenomenon. Although it had been hypothesized that socioeconomic status (SES) would be an important risk factor for injury, neither educational level nor income appeared to provide substantive and consistent explanatory power in the injury models tested. In contrast, occupational group and work-related physical and social-organizational factors were indeed associated with injury risk, independent of SES insofar as it was captured by education and income. Thus, in this analysis, the three core measures most commonly used to measure SES—income, education, and occupation—appeared to act in a markedly divergent manner. This is important because in many studies, it is almost impossible to tease out the linked inter-relationships among income, education, and occupation. This study, by basing itself in one industry, while assessing injury and its associated health gradients across a range of occupations that are heterogeneous in working conditions and associated risks, provides a unique perspective from which to analyze the effect of SES.

Magnitude of the Observed Health Gradient

One explanation for these findings could be that the injuries studied did not result in adverse health effects of a substantive enough nature, either in degree or duration, to be associated with decrements in health. Arguing against this, the injured cases differed from their non-injured counterparts by multiple measures using validated instruments relevant to health status. Most directly, this was manifest through significantly lower SF-12 PCS scores and four different body-part-specific musculoskeletal measures. This study also documented substantial differences between injured cases and referents in self-reported work effectiveness, presenteeism (defined as working while ill or injured) and sickness/absence (the latter from any cause, not solely injury)—all indirect measures of health gradients. Impaired presenteeism has been directly linked to musculoskeletal problems [Meerding et al., 2005] and lost time from painful conditions [Allen et al., 2005]. In addition, higher levels of presenteeism have been found in the health and education sectors [Aronsson et al., 2000; Aronsson and Gustafsson, 2005; Dew et al., 2005].

Range of Occupations

Including a narrow range of occupations and associated education and income levels is another factor that could otherwise blunt an SES-related health gradient. For example, a hospital-based study restricted to nursing personnel alone might face this limitation. This study, however, differs from most research conducted in the hospital industry in that it captured a broad range of occupations. This was reflected in the results of the injury risk modeling. For all injuries combined, when compared to administrators, three separate occupational groups (other clinical, technical, and clerical positions) were each associated with statistically significant elevated risks for injury. Subjects grouped into "other clinical positions" (34% mental health occupations) demonstrated a fourfold elevated risk for all injuries combined and were the only group to have a statistically significant elevated risk for neck/upper extremity injuries. Consistent with the heterogeneity of occupations studied, there was also a wide range of educational backgrounds and spread of incomes. Nonetheless, this cohort, by definition, was 100% employed. Thus, it did not include persons at the poverty level; moreover, in general, the educational level was high. These factors could have limited our ability to observe an SES effect based on income-education.

Occupational Factors Independent of Other SES Measures

A more likely explanation for the divergence in injury risk associated with occupation compared to income and education can be explained by attributes of work that operate independently of these other SES components. Specifically, the attributes that emerge from this analysis are psychosocial and ergonomic work factors. Psychosocial workplace factors were measured using each of the two dominant paradigms in this area of research: the demand–control (DC) and the effort reward imbalance (ERI) models. Study findings indicate that ERI demonstrated a stronger and more consistent effect than did the DC with regard to risk factors for injury. The observation of risk associated with ERI has been associated with poor employee health in many studies [van Vegchel et al., 2005]. In the current study, this risk was driven largely by upper extremity and neck injuries, an association that has also been reported in a study of public transit workers using the DC model [Rugulies and Krause, 2005].

Ergonomics data from this study suggest that these factors, too, may help explain the link between work-related variables and injury risk (with its associated health gradients), specifically, for injuries of the back and lower extremities. In a setting such as the hospital sector in which patient lifting is a key factor in back injury and is specific to certain occupational groups, the divergence between education and income (on the one hand) and job-associated risk (on the other) may be particularly prominent, consistent with our study findings.

Limitations

Despite its innovative design, this study has limitations that could temper interpretation of the results. Given the cross-sectional design and self-reported nature of the responses to questionnaire items, common method variance may have introduced bias [Podsakoff et al., 2003]. However, the addition of a direct ergonomics assessment to the protocol enhances the credibility of the self-reported nature of the data generally. For example, modest correlations were found between subjects' self-assessment of percent time spent in high strain postures and our determinations from 1-hr observation periods [Janowitz et al., 2006].

Another potential study limitation derives from our lack of data on non-participants at initial recruitment. This does not allow a comparison of responders and non-responders in terms of occupational or demographic factors. An additional limitation may arise from the inclusion of job-matched controls, even though these were grouped rather broadly. The potential impact of including job-matched referents was addressed by conducting a second analysis (Model 1) excluding those subjects. However, the inclusion of other referents who may have had prior injuries (given the high injury rates of hospital workers) also could have biased the results toward the null.

Assessing the social structure of work following injury, without having a baseline assessment prior to the event, could also lead to reporting bias. Were this to be the case, subjects might report poorer working conditions (e.g., greater effort reward imbalance or greater demands with less decision latitude) due to perceptions on the part of the employee regarding the etiology of the injury they experienced. Such a systematic effect, thus, would lead to finding a similar association with injury for both self-reported measures and for both upper and lower body injury, a pattern not observed in this study. Thus the specificity of the relationship between ERI and injury, in particular with upper extremity and neck injuries, argues against reporting bias as a driving force explaining the observed observation.

In addition, psychosocial work factors that were not included in this study because they were *not* measured by either the ERI or the DC models might also be of importance. For example, the Copenhagen Psychosocial Questionnaire contains additional constructs, such as demand for hiding emotions and meaningfulness of work, which may offer a more comprehensive measurement of the psychosocial work environment of hospital workers [Kristensen et al., 2005; Aust et al., 2006]. Others as well have argued that job demands, as defined in the original model, may not fully capture the complexities of working with patients or clients in health care settings [de Jonge et al., 1999; Polanyi and Tompa, 2004].

Finally, in studying injuries leading to WRMSDs alone, only one potential source of morbidity leading to a gradient in health status was analyzed. It may be that other chronic conditions, for example, hypertension or diabetes, may manifest SES-related health gradients among hospital workers in which education and income play a greater role in concert with occupation. Further analysis of the baseline and follow-up waves of data collection will provide an opportunity to test causal pathways and may be amenable to alternative analytic strategies, such as structural equation modeling.

CONCLUSIONS

In this study, occupation was a key risk factor for WRMSDs, but not two other key measures of socioeconomic status (SES)—education and income. This finding may be seen as contrary to the widely held view that SES effects on health are ubiquitous, persistent, and transcend heterogeneous disease and injury categories [Adler et al., 1994; Marmot and Feeney, 1997; Marmot et al., 1997a,b; Ferrie et al., 2002; Lorant et al., 2003; Rugulies et al., 2004a; Siegrist and Marmot, 2004; Ferrie et al., 2005; Mackenbach, 2006]. We believe, however, that this observation is consistent with the overarching paradigm of SES-related health gradients, and that it helps place the general phenomenon in the context of specific work-related attributes that, in this study, were more powerful risk factors than income or education decontextualized. Thus, in this sample of health care workers, it appears that the qualities inherent in the ''job'' itself matter more than other socioeconomic factors per se, recognizing that any given occupation in a hospital setting represents a set of job-specific exposures encompassing both physical and psychosocial factors.

Further research can help develop more sensitive, valid, and precise exposure measurements for use in worksite studies that may even better explain job-specific risk. Presuming that such exposures would be amenable to corrective action [Shannon et al., 2001; Aust and Ducki, 2004; Kristensen, 2005], such research will be crucial in the primary prevention of injuries.

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APPENDIX1

Occupational Categories

Primary occupational categories	Subcategories
Managerial and professional positions (n = 74)	Management-level positions (high level administrators and directors),
	Non-health-related professionals (e.g., analysts, planners, computer programmers)
Nursing positions (n = 246)	Nurse administrators and instructors
	Inpatient critical care wards (includes RNs and LVNs)
	Inpatient non-critical care wards (includes RNs and LVNs)
	Outpatient (includes RNs and LVNs)
	Nurse practitioners, clinical nurse specialists, public health nurses, and home health nurses
Other clinical positions (n = 93)	Health care professionals (e.g., occupational therapists, physical therapists, psychotherapists, social workers, audiologists)
	Para-professionals in health fields (e.g., nursing and medical assistants, P/T aides, mental health workers)
Technical positions (n = 57)	Technicians and technologists (e.g., radiology technologists, laboratory workers, medical technologists)
Clerical positions (n = 139)	Clerical workers without patient contact (includes data entry and other clerical duties)
	Clerical workers with patient contact (unit clerks, admitting clerks, eligibility worker)
Support personnel (n = 55)	Support personnel (e.g., physical plant, housekeeping, supply/distribution, food service)