Int Arch Occup Environ Health (2014) 87:323–330
DOI 10.1007/s00420-013-0864-y

ORIGINAL ARTICLE

Association between perceived inadequate staffing and musculoskeletal pain among hospital patient care workers

Seung-Sup Kim · Cassandra A. Okechukwu · Jack T. Dennerlein · Leslie I. Boden · Karen Hopcia · Dean M. Hashimoto · Glorian Sorensen

Received: 17 August 2012 / Accepted: 21 February 2013 / Published online: 12 March 2013

Abstract
Objective To examine association between perceived inadequate staffing and musculoskeletal pain and to evaluate the role of work-related psychosocial and physical work factors in the association among hospital patient care workers.
Methods A cross-sectional study was conducted among 1,572 patient care workers in two academic hospitals. Perceived inadequate staffing was measured using the "staffing adequacy subscale" of Nursing Work Index, which is a continuous scale that averages estimates of staffing adequacy by workers in the same units. Musculoskeletal pain (i.e., neck/shoulder, arm, low back, lower extremity, any musculoskeletal pain, and the number of area in pain) in the past 3 months was assessed using a self-reported Nordic questionnaire. Multilevel logistic regression was applied to examine associations between perceived inadequate staffing and musculoskeletal pain, considering clustering among the workers in the same units.
Results We found significant associations of perceived inadequate staffing with back pain (OR 1.50, 95 % CI 1.06, 2.14) and the number of body area in pain (OR 1.42, 95 % CI 1.01, 2.00) after adjusting for confounders including work characteristics (job title, having a second job or not, day shift or not, and worked hours per week). When we additionally adjusted for physical work factors (i.e., use of a lifting device, and the amount of the time for each of five physical activities on the job), only the association between perceived inadequate staffing and back pain remained significant (OR 1.50, 95 % CI 1.03, 2.19), whereas none of the associations was significant for all of musculoskeletal pains including back pain (OR 0.96, 95 % CI 0.66, 1.41) when we additionally adjusted for work-related psychosocial factors (i.e., job demands, job control, supervisor support, and co-worker support) instead of physical work factors.
Conclusions Perceived inadequate staffing may be associated with higher prevalence of back pain, and work-

S.-S. Kim (✉)
Department of Healthcare Management, Korea University, Seoul, Republic of Korea
e-mail: ssk3@korea.ac.kr

C. A. Okechukwu · G. Sorensen
Department of Society, Human Development, and Health, Harvard School of Public Health, Boston, MA, USA

J. T. Dennerlein · D. M. Hashimoto
Department of Environmental Health, Harvard School of Public Health, Boston, MA, USA

J. T. Dennerlein
Department of Physical Therapy, Bouvé College of Health Sciences, Northeastern University, Boston, MA, USA

L. I. Boden
Department of Environmental Health, Boston University School of Public Health, Boston, MA, USA

K. Hopcia
College of Nursing, University of Illinois at Chicago, Chicago, IL, USA

D. M. Hashimoto
Occupational Health Services, Partners HealthCare System, Boston, MA, USA

G. Sorensen
Dana-Farber Cancer Institute, Center for Community-Based Research, Boston, MA, USA

related psychosocial factor may play an important role in the potential pathway linking staffing level to back pain among hospital workers.

Keywords Inadequate staffing · Musculoskeletal pain · Back pain · Hospital worker

Introduction

Staffing adequacy in hospitals continues to be a serious issue with detrimental consequences for the quality of care delivered in the United States (Kane et al. 2007; Lang et al. 2004; Weinstein et al. 2008). A growing number of studies and meta-analytic reviews show that inadequate staffing can degrade the quality of patient care and threaten patient safety (Christine et al. 2002; Needleman et al. 2002). A high patient-to-nurse ratio is related to an increase in patient mortality within 30 days of admission (Aiken et al. 2002) and neonatal mortality in preterm infants (Hamilton et al. 2007). Likewise, inadequate staffing is associated with an increase in pneumonia and urinary tract infection after major surgery (Christine et al. 2002; Kovner and Gergen 1998). In addition, inadequate staffing has been shown to increase nosocomial infection rates because it decreases patient care workers' hand-hygiene compliance and increases movement of patients and staff between hospital wards (Archibald et al. 1997; Clements et al. 2008; Fridkin et al. 1996).

Despite mounting evidence linking inadequate hospital staffing to patients' outcomes, relatively little is known about the associations between inadequate staffing and workers' health outcomes. Since inadequate staffing could increase the psychological and physical demands and pace of patient care workers' jobs, it could place them at high risk for occupational injuries such as needlestick injuries and musculoskeletal disorders (MSDs) (Clarke 2007; Clarke et al. 2002). However, it is not clear whether inadequate staffing is associated with MSDs among hospital patient care workers despite their high prevalence of MSDs (Engels et al. 1996). In a qualitative interview study of 218 nurses who sustained a back injury at a Canadian tertiary care hospital, 30 (13.8 %) of the nurses cited inadequate staffing as the main cause of their injury (Yassi et al. 1995). Trinkoff et al. found a significant relationship between nursing home staffing levels and injury rates including MSDs in 445 nursing homes after adjusting for organizational characteristics, although the design of the study raises the possibility of ecological bias (Trinkoff et al. 2005). However, one empirical study of nurses, which analyzed the individual-level data, found no statistically significant association between staffing level and musculoskeletal injury and any injury among nurses in intensive care units (Stone and Gershon 2006).

Therefore, the goal of this study was to add to the evidence by testing the hypothesis that workers within units that perceive inadequate staffing have a higher prevalence of MSDs. In this study, we first estimated perceived inadequate staffing at the unit level using the average score of individual's perceived staffing level from patient care workers in the same units. Workload is usually shared among workers within the unit; therefore, this measure captures the collective experiences of the workers in a unit (Clarke et al. 2002; Hofmann and Mark 2006). We then examined the association between perceived inadequate staffing and musculoskeletal pain after adjusting for potential confounders. Finally, we sought to evaluate how the associations changed when we additionally adjusted for potential intermediate factors linking inadequate staffing to musculoskeletal pain: work-related psychosocial factors (i.e., job demands, job control, supervisor support, and co-worker support) and physical work factors (i.e., use of a lifting device, and the amount of time on the job for each of five physical activities).

Materials and methods

Study population

Our study sample was part of the "Be Well Work Well" study which was conducted by the Harvard School of Public Health Center for Work, Health and Wellbeing. The study included a cross-sectional survey of 2,000 randomly selected patient care workers in two large academic hospitals in the metropolitan Boston area between October 2009 and February 2010. The study was designed to evaluate associations between organizational policies and practices along with physical and psychosocial exposures on the job and workers' health behaviors and health outcomes.

Eligible participants included registered nurses, licensed practical nurses, and patient care/nursing assistants with direct patient care responsibilities. Patient care workers assigned to the "float" unit were eligible to participate in the survey but we excluded those in environmental services and physical medicine units (e.g., physical therapy, occupational therapy), traveling or contract nurses, and those who were on an extended absence greater than 12 weeks. We provided incentives in the form of $20 gift card for the workers who completed surveys. A detailed description about the eligibility of survey participants and the process of data collection is provided elsewhere (Sorensen et al. 2011). All workers provided signed informed consent, and all project materials and methods were approved by the Institutional Review Board of the Partners HealthCare.

From 1,572 patient care workers who participated in the survey, we excluded survey participants with missing

values for any covariates used in the analyses. As a result, we analyzed a total of 1,339 patient care workers in 105 units including 12 different types of units (i.e., emergency department, operating room, adult medical/surgical, adult intensive care, step-down, pediatric medical/surgical, pediatric/neonatal intensive care, psychiatry, obstetrics/postpartum, float pool, ambulatory units, and orthopedics).

Measures

Perceived inadequate staffing

Perceived staffing adequacy was measured by four questions from the staffing adequacy subscale of the Nursing Work Index-Revised questionnaire (Aiken and Patrician 2000), which is commonly used to measure the professional nursing practice environment and has been shown to have a high reliability and validity (Aiken and Patrician 2000; Vahey et al. 2004). The questions were as follows: in the last year on your unit, how often has there been: (1) enough patient care workers to get the work done? (2) enough registered nurses to provide necessary patient care? (3) adequate support services to allow patient care staff to spend time with patients? (4) enough time to discuss patient care problems with other staff? For each question, five ordinal answers were available (1: always, 2: often, 3: sometimes, 4: rarely, 5: never). The Cronbach's alpha among four questions was 0.84. We opted to use a unit level aggregation of responses as the exposure variable for several reasons. First, patient care workers usually share workload with others on the unit (Clarke et al. 2002; Hofmann and Mark 2006; Mark et al. 2007). Also, the NWI-R was developed to measure staffing adequacy as an organizational attribute instead of an individual-level trait (Aiken and Patrician 2000). To calculate unit level staffing adequacy, we first calculated the average score of responses for the four questions for each worker. Then, we estimated an average of the resulting score among workers in the same units. The average score for each of the 105 units could have ranged from 1 to 5, but the actual distribution ranged from 1.25 to 3.75 with the higher score indicating inadequate staffing level on the unit.

Musculoskeletal pain in the past 3 months

Musculoskeletal pain was assessed for the past 3 months based on the Standardized Nordic Questionnaire for musculoskeletal symptoms (Kuorinka et al. 1987; Trinkoff et al. 2006). Specifically we asked, "During the past 3 months, have you had pain or aching in any of the areas shown on the diagram?" The areas were lower back, shoulder, neck, wrist or forearm, knee, ankle or feet, and none of the above. We combined responses for the neck and shoulder into a single neck/shoulder area, and the responses for the knees, ankle, and feet were grouped into a single lower extremity body area. We then created an ordinal variable of the number of body areas in pain (0–4) by summing the responses. We also created a variable of any musculoskeletal pain to assess whether worker had a pain at least one body part (coded as 1) with those who did not have any pain (coded as 0) as referent.

Potential confounders

We considered individual demographic variables, occupational conditions (i.e., job title, hours worked per week, and shift work), and BMI, which may be associated with both perceived staffing adequacy and musculoskeletal pains, as potential confounders (Camerino et al. 2010; Dex and Bond 2005; Eriksen et al. 2004; Trinkoff et al. 2006). All potential confounders were included as categorical dummy variables: age (18–24, 25–34, 35–44, 45–54, 55–64, >65 years); race (Hispanic, White, Black, and mixed race/others); job title (staff nurse, patient care associate, and others including assistant nurse manager, clinical nurse specialist, and operational coordinator); shift work (working only on daytime or not) (Camerino et al. 2010; Eriksen et al. 2004).; hours worked per week (<30, 30–34, 35–39, 40–44, >45 h) (Dex and Bond 2005; Trinkoff et al. 2006); having a second job or not; and BMI (<25, 25–29.9, ≥30 kg/m^2).

Work-related psychosocial factors and physical work factors

We assessed work-related psychosocial factors and physical work factors to understand their role in the association between perceived inadequate staffing and musculoskeletal pain. Four different work-related psychosocial factors were measured using a modified the Job Content Questionnaire (Karasek et al. 1998; Karasek 1979; Landsbergis et al. 2002): psychological demands (5 items) and decision latitude (9 items) (Ariens 2001; Grönlund 2007), supervisor support (2 items), and co-worker support (3 items) (Eriksen et al. 2004; Pisarski et al. 2008). Each of four work-related psychosocial factors was included in the data analysis as a continuous variable.

Six different physical work factors were measured: the amount of the time on the job for each of five physical activities and use of a lifting device. Five different physical activities on the job were assessed using questions asking patient care workers to "estimate how much of a typical shift you spend: (a) sitting, (b) standing, (c) walking, (d) lifting and carrying, (e) pushing and pulling" (Reis et al. 2005). The five-point scale response (all, more than half, about half, less than half, and none) was included as a categorical variable with response "all" as a reference in

the data analysis. Use of a lifting device was measured using a question "In general, when a patient needs to be moved, how often do you use a lifting device?" was used to assess use of a lifting device. Workers could answer in a five ordinal scale from "never" to "always" or "not applicable," indicating that they do not move patient on their job and their response was included as a categorical variable with response "never" as a referent group.

Statistical analyses

The analysis took the hierarchical data structure where patient care workers were nested within units into account. We applied multilevel logistic regression with a random intercept at the unit level to examine the relationship of perceived inadequate staffing with musculoskeletal pain (i.e., pain in neck/shoulder, arm, low back, lower extremity, and any musculoskeletal pain) in the past 3 months considering clustering among workers in the same units. For the association between perceived inadequate staffing and the number of body areas in pain, we applied multilevel ordinal logistic regressions considering an ordinal scale of the variable. We confirmed that the proportional odds assumption for the ordinal logistic regression was not violated. All analyses were performed using STATA/SE version 11.0 (StataCorp, College Station, TX).

Results

Among 1,339 hospital patient care workers, 90.2 % were female, 81.5 % were non-Hispanic white, and 73.0 % were staff nurses (Table 1). Most patient care workers did not have a second job (85.4 %) and worked a shift other than a regular day shift (71.3 %). Table 2 displays the distribution of self-reported musculoskeletal pain in the past 3 months. The highest prevalence of musculoskeletal pain was for the self-reported low back pain (53.7 %), and the lowest prevalence was for the arm pain (10.8 %).

We found significant associations of perceived inadequate staffing with back pain (OR 1.49, 95 % CI 1.04, 2.13) and the number of body area in pain (OR 1.42, 95 % CI 1.02, 1.99) after adjusting for confounders including work characteristics (job title, having a second job or not, day shift or not, and worked hours per week). When we additionally adjusted for physical work factors (i.e., use of a lifting device, and the amount of time on the job for each of five physical activities), only the association between perceived inadequate staffing and low back pain remained significant (OR 1.50, 95 % CI 1.03, 2.19), whereas the association between perceived inadequate staffing and the number of body areas in pain was attenuated and became non-significant (OR 1.34, 95 % CI 0.95, 1.90). However,

Table 1 Distribution of study population by key covariates ($N = 1{,}339$)

Characteristics	Distribution	
	N	%
Gender		
Male	131	9.8
Female	1,208	90.2
Age (years)		
18–24	97	7.2
25–34	365	27.3
35–44	322	24.1
45–55	358	26.7
55–64	183	13.7
≥65	14	1.1
Race		
Hispanic	50	3.7
White, non-hispanic	1,091	81.5
Black, non-hispanic	125	9.3
Other	73	5.5
Education		
Grade 12/GED or less	55	4.1
1–3 years of college	309	23.1
Baccalaureate degree	737	55.0
Graduate degree	238	17.8
Job title		
Staff nurse	978	73.0
Patient care associate	86	6.4
Others	275	20.5
Hours worked per week		
<30	315	23.5
30–34	161	12.0
35–39	392	29.3
40–44	414	30.9
>45	57	4.3
Having a second job		
Yes	195	14.6
No	1,144	85.4
Having only day shift (%)		
Yes	954	71.3
No (also night shift)	385	28.8
BMI (kg/m^2)		
18–24.9	657	49.1
25–29.9	400	29.9
≥30	282	21.1
	Mean (SD)	Min–Max
Perceived inadequate staffing		
Individual level	2.28 (0.69)	1.00–5.00
Unit level[a]	2.28 (0.33)	1.25–3.75

[a] The average score of perceived inadequate staffing using the responses of individual workers in the same units

Table 2 Distribution of self-reported musculoskeletal pain among hospital patient care workers ($N = 1,339$)

Characteristics	Distribution	
	N	%
Neck/shoulder pain	577	43.1
Arm pain	144	10.8
Low back pain	719	53.7
Lower extremity	503	37.6
Any musculoskeletal pain	1,004	75.0
Number of areas in pain		
0	335	25.0
1	372	27.8
2	375	28.0
3	207	15.5
4	50	3.7

when we adjusted for work-related psychosocial factors (i.e., job demands, job control, supervisor support, and co-worker support) instead of physical work factors in addition to other confounders, all of the associations between perceived inadequate staffing and musculoskeletal pain including back pain (OR 0.96, 95 % CI 0.66, 1.41) were attenuated and became non-significant (Table 3).

Discussion

We found that perceived inadequate staffing would be associated with musculoskeletal pain (i.e., back pain and the number of body areas in pain) in the past 3 month, after adjusting for confounders including work characteristics (job title, having a second job or not, day shift or not, and worked hours per week).The association between perceived inadequate staffing and back pain was robust when we additionally adjusted for physical work factors (i.e., use of a lifting device, and the amount of time on the job for each of five physical activities), whereas the association was almost completely attenuated and became non-significant when we additionally adjusted for work-related psychosocial factors (i.e., job demands, job control, supervisor support, and co-worker support). These findings suggest that work-related psychosocial stress may play an important role in the pathway linking perceived inadequate staffing to low back pain.

The observed significant associations between perceived inadequate staffing and back pain and the number of body area in pain are supported by the findings from one qualitative study (Yassi et al. 1995) and one ecological study (Trinkoff et al. 2005) that reported the potential association between understaffing and musculoskeletal pain among patient care workers. However, our study is different from a previous study of health care workers, which reported no statistically significant association between low staffing level and MSDs (i.e., any reported injury or disability to the upper or lower back, neck, and feet) (Stone and Gershon 2006). One possible reason for this discrepancy is that the previous study assessed MSD as self-reported injury or disability which may represent more severe health condition than self-reported pain.

Our finding suggests that work-related psychosocial stress may play an important role in the association

Table 3 Association between perceived inadequate staffing[a] and self-reported musculoskeletal pain during the past week among hospital patient care workers

Self-reported musculoskeletal disorders	Unadjusted ($N = 1,399$)		Adjusted[b] ($N = 1,399$)		Adjusted + physical work factors[c] ($N = 1,288$)		Adjusted + psychosocial factors[d] ($N = 1,248$)	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Neck/shoulder pain	1.33	(0.92, 1.93)	1.30	(0.89, 1.92)	1.24	(0.82, 1.88)	1.07	(0.70, 1.63)
Arm pain	1.25	(0.72, 2.15)	1.38	(0.82, 2.32)	1.19	(0.66, 2.12)	1.00	(0.56, 1.77)
Low back pain	1.49*	(1.04, 2.13)	1.50*	(1.06, 2.14)	1.50*	(1.03, 2.19)	0.96	(0.66, 1.41)
Lower extremity	1.15	(0.77, 1.73)	1.21	(0.79, 1.84)	1.10	(0.70, 1.73)	0.99	(0.63, 1.54)
Any musculoskeletal pain	1.36	(0.90, 2.07)	1.36	(0.88, 2.09)	1.20	(0.77, 1.87)	0.93	(0.57, 1.51)
Number of area in pain	1.42*	(1.02, 1.99)	1.42*	(1.01, 2.00)	1.34	(0.95, 1.90)	1.01	(0.70, 1.47)

OR odds ratio, *CI* confidence interval

* $p < 0.05$

[a] The average score of perceived inadequate staffing using the responses of individual workers in the same units, ranged from 1.25 to 3.75

[b] Adjusted: adjusted for age, race, gender, job title, having a second job or not, day shift or not, worked hours per week, and BMI

[c] In addition to the adjusted model, additionally adjusted for physical work factors including use of a lifting device, and the amount of time on the job for each of five physical activities (i.e., sitting, standing, walking, lifting and carrying, pushing and pulling)

[d] In addition to the adjusted model, additionally adjusted for work-related psychosocial factors (i.e., job demands, job control, supervisor support, co-worker support)

between perceived inadequate staffing and musculoskeletal pain, particularly low back pain. Because we adjusted for four different work-related psychosocial factors simultaneously, we examined how the association between perceived inadequate staffing and back pain is changed when we adjusted for each of four work-related psychosocial factors separately as a post hoc analysis. We observed the greatest attenuation in the association between perceived inadequate staffing and back pain when we adjusted for job demand (OR 1.10, 95 % CI 0.75, 1.60) in addition to potential confounders (i.e., age, race, gender, job title, having a second job or not, day shift or not, worked hours per week, and BMI) although the other three psychosocial factors attenuated more than 20 % of the observed associations. These findings could be supported by the previous findings reported the importance of work-related psychosocial factors, particularly job demand, on musculoskeletal pain (Eriksen et al. 2004). Lang et al. reviewed 23 longitudinal studies across different industries including health care, clerical, and manufacturing and found that psychosocial work stressors had significant effects on the development of musculoskeletal problems (Lang et al. 2012). Further study is required to examine the role of work-related psychosocial factors in the relationship linking inadequate staffing to other occupational health outcomes among patient care workers, such as needlestick injuries (Clarke 2007; Clarke et al. 2002), burnout (Aiken et al. 2002), and assault by patients (Lanza et al. 1997).

Several limitations of this study should be noted. Worker-reported assessments of inadequate staffing would be less likely to reflect actual staffing levels compared to nurse-to-patient ratio from administrative data in previous studies (Aiken et al. 2002; Clarke et al. 2002). However, several studies reported that the nurse–patient ratio may have weakness as a measure of sufficient staffing because sufficient nurse–patient ratio could be different based on several factors including characteristics of the patient or nurse in the unit (Kane 2004; Unruh 2008). Therefore, a nurse–patient ratio that is considered as sufficient staffing on one unit could not be applied to another unit. We assessed inadequate staffing using a standardized questionnaire, the staffing adequacy subscale of the Nursing Work Index-Revised questionnaire (Aiken and Patrician 2000), which was developed explicitly to assess nursing practice environment. Although this aggregate self-reported measure of inadequate staffing is more likely to be influenced by worker's perception compared to the nurse–patient ratio, our measure may capture aspects of inadequate staffing not measured by the nurse–patient ratio from administrative data (Unruh 2008). Future studies need to examine how worker-perceived inadequate staffing is related to the nurse–patient ratio and how these two different measures can be used to understand the association between inadequate staffing and occupational health outcome among patient care workers.

In addition, because of the cross-sectional survey design, we cannot rule out the possibility of a reverse causation. For example, there could be a recall bias such that workers who were injured or had musculoskeletal pain were more likely to report an unfavorable staffing level at their unit during last year. Another possibility is that workers with musculoskeletal pain might perceive the same staffing level as inadequate compared to those without because of their functional limitation. However, because perceived inadequate staffing was assessed as the average score of patient care workers' reporting within each unit, the potential bias caused by individual reporting would not fully explain the association we observed. Furthermore, this cross-sectional evidence can provide motivation to examine these associations in prospective cohorts.

As a final limitation, our findings about the non-significant role of physical work factors in the association between perceived inadequate staffing and back pain should be interpreted cautiously. Although we assessed use of a lifting device and the amount of the time on the job for each of the five physical activities and also applied multilevel modeling to consider different physical workloads between units, there could be physical exposures related to musculoskeletal pains that were not considered in this research. Previous studies reported other physical exposures such as self-reported awkward posture (Trinkoff et al. 2003b) or biomechanical factors such as higher peak lumbar shear or higher cumulative lumbar disc compression (Grieco et al. 1998; Kerr et al. 2001) as significant risk factors for musculoskeletal pain.

There are also strengths in this study. First, we examined the association of unit-level perceived inadequate staffing with musculoskeletal pains, which have been cited as top safety concern among nurses (Trinkoff et al. 2003a; 2006). Second, we investigated the association after adjustment for potential confounders such as hours worked per week, having a second job or not and job title.

Little is known about inadequate staffing and its association with patient care workers' health outcomes although safe work environment could be one step to improve patient safety (Burström and Fredlund 2001; Sorensen et al. 2011). This study found that perceived inadequate staffing is associated with low back pain and the number of body areas in pain in the past 3 months among hospital patient care workers. In addition, our findings suggest that work-related psychosocial factors may play an important role in the pathway linking staffing level to low back pain among hospital workers. More research studies of adequate staffing, particularly with a prospective study design, are required in order to make hospitals safer places for both workers and patients.

Acknowledgments This work was supported by a grant from the National Institute for Occupational Safety and Health (U19 OH008861) for the Harvard School of Public Health Center for Work, Health and Wellbeing. This study would not have been accomplished without the participation of Partners HealthCare System and leadership from Dennis Colling, Sree Chaguturu, and Kurt Westerman. The authors would like to thank Partners Occupational Health Services including Marlene Freeley for her guidance, as well as Elizabeth Taylor, Elizabeth Tucker O'Day, and Terry Orechia. We also thank individuals at each of the hospitals including Jeanette Ives Erickson and Jacqueline Somerville in Patient Care Services leadership, and Jeff Davis and Julie Celano in Human Resources. Additionally, we wish to thank Charlene Feilteau, Mimi O'Connor, Margaret Shaw, Eddie Tan and Shari Weingarten for assistance with supporting databases. We also thank Chris Kenwood of NERI for his statistical and programming support, Evan McEwing, Project Director, and Linnea Benson-Whelan for her assistance with the production of this manuscript. Our thanks also go to Anne M. Stoddard for her comments about data analyses.

Conflict of interest Dr. Hashimoto is employed by Partners HealthCare System, and the two studied hospitals are Partners hospitals. There is no other possible conflict of interests to report.

References

Aiken LH, Patrician PA (2000) Measuring organizational traits of hospitals: the Revised Nursing Work Index. Nurs Res 49(3): 146–153

Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH (2002) Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA 288(16):1987–1993

Archibald LK, Manning ML, Bell LM, Banerjee S, Jarvis WR (1997) Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric cardiac intensive care unit. Pediatr Infect Dis J 16(11):1045–1048

Ariens G (2001) Psychosocial risk factors for neck pain: a systematic review. Am J Ind Med 39(2):180–193

Burström B, Fredlund P (2001) Self rated health: is it as good a predictor of subsequent mortality among adults in lower as well as in higher social classes? J Epidemiol Commun Health 55(11): 836–840

Camerino D, Sandri M, Sartori S, Conway PM, Campanini P, Costa G (2010) Shiftwork, work-family conflict among Italian nurses, and prevention efficacy. Chronobiol Int 27(5):1105–1123

Christine K, Cheryl J, Chunliu Z, Peter JG, Jayasree B (2002) Nurse staffing and postsurgical adverse events: an analysis of administrative data from a sample of U.S. hospitals, 1990–1996. Health Serv Res 37(3):611–629

Clarke SP (2007) Hospital work environments, nurse characteristics, and sharps injuries. Am J Infect Control 35(5):302–309

Clarke SP, Sloane DM, Aiken LH (2002) Effects of hospital staffing and organizational climate on needlestick injuries to nurses. Am J Public Health 92(7):1115–1119

Clements A et al (2008) Overcrowding and understaffing in modern health-care systems: key determinants in meticillin-resistant *Staphylococcus aureus* transmission. Lancet Infect Dis 8(7): 427–434

Dex S, Bond S (2005) Measuring work-life balance and its covariates. Work Employ Soc 19(3):627–637

Engels JA, van der Gulden JW, Senden TF, van't Hof B (1996) Work related risk factors for musculoskeletal complaints in the nursing profession: results of a questionnaire survey. Occup Environ Med 53(9):636–641

Eriksen W, Bruusgaard D, Knardahl S (2004) Work factors as predictors of intense or disabling low back pain; a prospective study of nurses' aides. Occup Environ Med 61(5):398–404

Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR (1996) The role of understaffing in central venous catheter-associated bloodstream infections. Infect Control Hosp Epidemiol 17(3): 150–158

Grieco A, Molteni G, Vito GD, Sias N (1998) Epidemiology of musculoskeletal disorders due to biomechanical overload. Ergonomics 41(9):1253–1260

Grönlund A (2007) More control, less conflict? Job demand-control, gender and work-family conflict. Gend Work Organ 14(5): 476–497

Hamilton KE, Redshaw ME, Tarnow-Mordi W (2007) Nurse staffing in relation to risk-adjusted mortality in neonatal care. Arch Dis Child Fetal Neonatal Ed 92(2):F99–F103

Hofmann DA, Mark B (2006) An investigation of the relationship between safety climate and medication errors as well as other nurse and patient outcomes. Pers Psychol 59(4):847–869

Kane RL (2004) Commentary: nursing home staffing—more is necessary but not necessarily sufficient. Health Serv Res 39(2): 251–256

Kane RL, Shamliyan TA, Mueller C, Duval S, Wilt TJ (2007) The association of registered nurse staffing levels and patient outcomes: systematic review and meta-analysis. Med Care 45(12):1195

Karasek RA Jr (1979) Job demands, job decision latitude, and mental strain: implications for job redesign. Adm Sci Q 24(2):285–308

Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B (1998) The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 3(4):322–355

Kerr M et al (2001) Biomechanical and psychosocial risk factors for low back pain at work. Am J Public Health 91(7):1069–1075

Kovner C, Gergen PJ (1998) Nurse staffing levels and adverse events following surgery in U.S. hospitals. J Nurs Scholarsh 30(4): 315–321

Kuorinka I et al (1987) Standardized Nordic Questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 18:233–237

Landsbergis PA, Schnall PL, Pickering TG, Schwartz JE (2002) Validity and reliability of a work history questionnaire derived from the Job Content Questionnaire. J Occup Environ Med 44(11):1037–1047

Lang TA, Hodge M, Olson V, Romano PS, Kravitz RL (2004) Nurse–patient ratios: a systematic review on the effects of nurse staffing on patient, nurse employee, and hospital outcomes. J Nurs Adm 34(7–8):326–337

Lang J, Ochsmann E, Kraus T, Lang JWB (2012) Psychosocial work stressors as antecedents of musculoskeletal problems: a systematic review and meta-analysis of stability-adjusted longitudinal studies. Soc Sci Med 75(7):1163–1174

Lanza ML, Kayne HL, Gulliford D, Hicks C, Islam S (1997) Staffing of inpatient psychiatric units and assault by patients. J Am Psychiatr Nurses Assoc 3(2):42–48

Mark BA et al (2007) Does safety climate moderate the influence of staffing adequacy and work conditions on nurse injuries? J Safety Res 38(4):431–446

Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K (2002) Nurse-staffing levels and the quality of care in hospitals. N Engl J Med 346(22):1715–1722

Pisarski A, Lawrence SA, Bohle P, Brook C (2008) Organizational influences on the work life conflict and health of shiftworkers. Appl Ergon 39(5):580–588

Reis JP, Dubose KD, Ainsworth BE, Macera CA, Yore MM (2005) Reliability and validity of the occupational physical activity questionnaire. Med Sci Sports Exerc 37:2075–2083

Sorensen G et al (2011) The role of the work context in multiple wellness outcomes for hospital patient care workers. J Occup Environ Med 53(8):899–910

Stone PW, Gershon RR (2006) Nurse work environments and occupational safety in intensive care units. Policy Polit Nurs Pract 7(4):240–247

Trinkoff AM, Brady B, Nielsen K (2003a) Workplace prevention and musculoskeletal injuries in nurses. J Nurs Adm 33(3):153–158

Trinkoff AM, Lipscomb JA, Geiger-Brown J, Storr CL, Brady BA (2003b) Perceived physical demands and reported musculoskeletal problems in registered nurses. Am J Prev Med 24(3): 270–275

Trinkoff AM, Johantgen M, Muntaner C, Le R (2005) Staffing and worker injury in nursing homes. Am J Public Health 95(7): 1220–1225

Trinkoff AM, Le R, Geiger-Brown J, Lipscomb J, Lang G (2006) Longitudinal relationship of work hours, mandatory overtime, and on-call to musculoskeletal problems in nurses. Am J Ind Med 49(11):964–971

Unruh L (2008) Nurse staffing and patient, nurse, and financial outcomes. Am J Nurs 108(1):62–71

Vahey DC, Aiken LH, Sloane DM, Clarke SP, Vargas D (2004) Nurse burnout and patient satisfaction. Med Care 42(2 Suppl):II57–II66

Weinstein RA, Stone PW, Pogorzelska M, Kunches L, Hirschhorn LR (2008) Hospital staffing and health care-associated infections: a systematic review of the literature. Clin Infect Dis 47(7):937

Yassi A, Khokhar J, Tate R, Cooper J, Snow C, Vallentype S (1995) The epidemiology of back injuries in nurses at a large Canadian tertiary care hospital: implications for prevention. Occup Med 45(4):215–220