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Do nurse and patient injuries share common antecedents? An analysis of associations with safety climate and working conditions

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ABSTRACT

Background: Safety climate and nurses' working conditions may have an impact on both patient outcomes and nurse occupational health, but these outcomes have rarely been examined concurrently.

Objective: To examine the association of unit-level safety climate and specific nurse working conditions with injury outcomes for both nurses and patients in a single hospital.

Research design: A cross-sectional study was conducted using nursing-unit level and individual-level data at an urban, level-one trauma centre in the USA. Multilevel logistic regressions were used to examine associations among injury outcomes, safety climate and working conditions on 29 nursing units, including a total of 723 nurses and 28 876 discharges.

Measures: Safety climate was measured in 2004 using the Safety Attitudes Questionnaire (SAQ). Working conditions included registered nursing hours per patient day (RNHPPD) and unit turnover. Patient injuries included 290 falls, 167 pulmonary embolism/deep vein thrombosis (PE/DVT), and 105 decubitus ulcers. Nurse injury was defined as a reported needle-stick, splash, slip, trip, or fall (n=78). Working conditions and outcomes were measured in 2005.

Results: The study found a negative association between two SAQ domains, Safety and Teamwork, with the odds of both decubitus ulcers and nurse injury. RNHPPD showed a negative association with patient falls and decubitus ulcers. Unit turnover was positively associated with nurse injury and PE/DVT, but negatively associated with falls and decubitus ulcers.

Conclusions: Safety climate was associated with both patient and nurse injuries, suggesting that patient and nurse safety may actually be linked outcomes. The findings also indicate that increased unit turnover should be considered a risk factor for nurse and patient injuries.

BACKGROUND

Increasing attention is being paid to the impact of organisational safety climate and working conditions on healthcare outcomes.[1–3] Safety climate refers to 'shared employee perceptions of the priority of safety at their unit and organisation at large, especially in situations where safety competes with other performance facets such as speed of care or its quality'.[2] Working conditions include an array of factors such as adequacy of resources, qualities of management and staffing characteristics.[1 4 5]

Meaningful safety climate findings have emanated from investigating employee perceptions in single hospital studies because employee perceptions reflect their immediate work environment.[6–8] Safety climate is local, demonstrating more variability within a hospital than between hospitals.[8]

Meta-analytic studies have contributed to the understanding of safety climate's systemic role in healthcare processes and outcomes. These studies suggest the importance of organisational-level factors, including safety climate, on individual safety behaviour.[9–12] Other previous research has explored relationships among safety climate and/or working conditions and nurse occupational injuries,[5 6 13] patient injuries,[4 14 15] and nurse and patient injuries together.[16] A detailed summary of these studies is presented in supplementary online appendix 1. The study by Hofmann and Mark found that a unit's safety climate is an important predictor of nurse occupational safety (back injuries) as well as patient outcomes (medication errors, urinary tract infections)

and was the only study to include both nurse and patient outcomes.[16]

This study extends the literature by examining a single hospital to investigate the extent to which the same organisational characteristics (working conditions and safety climate) predict injuries for both patients and the nurses who care for them, an important question given that nurses constitute the largest workforce in healthcare.[17]

METHODS

Study design

The study was cross-sectional with a longitudinal aspect in that safety climate data were assessed in 2004 while injury outcomes were collected in 2005. This study investigated whether unit-level working conditions and safety climate were predictors of both individual-level nurse and patient injuries. All study activities were approved by the investigators' institutional review board. Health Insurance Portability and Accountability Act approval was given by the hospital.

This study was conducted at a large, urban, level-one trauma centre with Magnet nursing status in the USA.[18] In 2005, the hospital had approximately 1900 total beds and 48 000 discharges. To be included, nursing units had to have a 60% or greater safety climate survey response rate among registered nurses, available turnover data, and information on hours of direct nursing care. Twenty-nine of 46 (63%) direct care inpatient nursing units satisfied these criteria. The 29 units included 19 medical, five surgical, four medical/surgical and one rehabilitation unit. These units encompassed paediatrics, general medicine, psychiatry, neurology, oncology, gynaecology and general surgery. The smallest of these units had a total of three nurses on staff and the largest 65, with a mean of 25 nurses on staff per unit. Multiple attempts were made to attain a 60% response rate on each unit, and the survey designer felt it critical to exclude units with less than 60% response rate. Among the 29 units included in this study, the response rate varied from 60% to 100%, with an average response rate of 76%.

The 60% response rate threshold is of particular value in a safety climate study because research on non-response bias has found that non-respondents show lower organisational commitment and job satisfaction, and greater intention to quit.[19] Such findings suggest that Safety Attitudes Questionnaire (SAQ) non-respondents may have different safety perceptions than respondents, and a higher response rate threshold reduces the risk of non-response bias. A recent meta-analysis of response rates in 2037 studies conducted from 1995 to 2008 found that for personally distributed surveys of non-managerial employees (as with the nurses in this study) average response rates are fairly high, with a 69% response rate at the 50th percentile of all surveys analysed.[20] This finding further supports the appropriateness of the 60% minimum response rate in the study design, as well as the utility of the 76% average response rate among included units.

Explanatory variables

Safety climate: the safety attitudes questionnaire

The SAQ elicits healthcare workers' safety climate perceptions. The SAQ has been described previously.[21–23] The hospital administered the SAQ to its employees in 2004, and the Department of Risk Management provided the resultant data. The 36-item survey uses a five-point Likert scale to elicit staff attitudes. Responses to questions within each domain are averaged and converted to a 100-point scale. A high score indicates greater agreement that a positive safety climate exists on a given unit. All average domain scores were rescaled (divide by a factor of 10) and interpreted as a 10-point change in the average domain score. The SAQ domains and questions are presented in supplementary online appendix 2.

Working conditions: unit turnover and registered nursing hours per patient day

The unit-turnover rate was defined as the total number of registered nurse full-time equivalents (FTEs) who voluntarily left one unit for another in 1 year, divided by the number of registered nurse FTEs assigned to the unit in that year. Measuring FTEs includes and controls for the proportionate contributions of part-time and full-time employees. Termination (discontinuation of employment either voluntarily or involuntarily) was not included in this study because the hospital's director of nursing felt that termination more strongly represents a nurse's overall experience with the hospital rather than with the nurse's particular unit. The turnover rate was rescaled (multiplied by a factor of 10) and interpreted as a 10% change in the rate to make result interpretation more applicable to hospitals' actual goal setting. The Department of Human Resources provided 2005 data on nurse turnover for the numerator of the unit-turnover metric, and total FTE nurses for each nursing unit in 2005, establishing the denominator.

Registered nursing hours per patient day (RNHPPD), as defined by the American Nurses Association (ANA)/National Quality Forum (NQF), is the annual sum of agency and hospital registered nurse (RN) productive hours (direct patient care activities as opposed to administrative or other tasks) divided by the

total number of patient days in the calendar year, as follows:

$$\text{RNHPPD} = \frac{\text{productive agency RN hours} + \text{productive hospital RN hours}}{\text{total number of patient days/year}}$$

Nursing hours and total patient days for 2005 were acquired from the hospital's Department of Nursing. Average RNHPPD values were calculated for each nursing unit.

Outcome measures

Patient injuries

The nursing-sensitive patient injuries examined were patient falls, decubitus ulcers ('pressure ulcers'), and pulmonary embolism/deep vein thrombosis (PE/DVT). These outcomes were chosen because of the availability of the data and because the ANA considers the first two injuries to be 'nursing-sensitive indicators', meaning they reflect the structure, process and outcomes of nursing care,[24] and because all three injuries are considered preventable and may have severe repercussions. The Centers for Medicare and Medicaid Services no longer reimburses hospitals for costs associated with medical errors termed 'never events', occurring while in a healthcare facility, including patient death associated with a fall, stage 3 or 4 pressure ulcers acquired after admission, and patient death or serious disability associated with intravascular air embolism.[25]

The Agency for Healthcare Research and Quality's publicly available Windows QI software, the Patient Safety Indicators (PSIs) (http://www.qualityindicators.ahrq.gov/psi_download.htm), was applied to the hospital's administrative discharge data to identify decubitus ulcers and PE/DVT. PSIs were used because the PSI algorithm accounts for patient diagnoses by adjusting the denominator to focus on patients for whom the relevant injury is most likely preventable.[26] Patient falls were measured using data from Patient Safety Net (PSN) V.3.0, a voluntary, electronic reporting system for the occurrence of errors and near misses developed by the University HealthSystems Consortium (https://www.uhc.edu/11851.htm). All patient falls were selected regardless of whether injury resulted. PSN was chosen as the data source for falls because it provides the most comprehensive record of patient falls, as PSIs capture only those falls resulting in postoperative hip fracture. The hospital's Department of Risk Management provided patient-level outcomes from 2005. The categories for PSN and PSI are presented in supplementary online appendix 3.

Nurse injuries

Nurse injury was defined as the occurrence of a reported needle-stick, splash, slip, trip or fall. Occupational exposures to blood-borne pathogens through needlesticks and splashes are of concern because of the risk and severe consequences of hepatitis B and C, and HIV and AIDS infection.[27–29] Slips, trips and falls (STFs) are also important because their incidence rate in hospitals is much higher than that found in all other private industries. For example, Bell *et al* identified this magnitude to be 75% greater in a study in which the hospital incidence rate of STFs was 35.2 per 10 000 employees.[30] Back injuries were excluded because the hospital felt that work relatedness was difficult to determine. Individual-level nurse injury data from 2005 were acquired from the Hospital's Division of Occupational Medicine. Nurse injuries were routinely recorded by the hospital in written injury reports which were then entered in a database.

It is well established that increases in the number of patient comorbidities corresponds to increased length of stay, cost of care, and risk of dying in the hospital.[31 32] These factors, in turn, can influence the patient outcomes of interest in this study. Accordingly, a patient complexity metric was included to control for the effect of each patient's comorbidities.

Statistical analysis

For each nursing unit in the study, unit turnover, RNHPPD, and the six domains of the SAQ constituted the main explanatory variables. For the patient outcome models, patient complexity was included as a control to address the potential confounding effect of the patient's condition. The All Patient Refined Diagnosis Related Group Patient complexity level was extracted from the hospital's discharge database. It is calculated using International Classification of Diseases, ninth revision (ICD9) diagnoses, ICD9 procedures, and patient age by the 3M APRDRG grouping software, V.12 (http://solutions.3m.com/wps/portal/3M/en_US/3M_Health_Information_Systems/HIS/Products/APRDRG_Software/). For the analysis, patient complexity was dichotomised into high (complexity level 3 or 4) or low (complexity level 1 or 2) categories to separate high and low severity of illness/mortality risk.

STATA was used to perform all analyses (Stata 8, StataCorp LP, College Station, Texas, USA). Descriptive statistics were used to compare characteristics between nursing units with and without nurse injuries. Correlations among variables were explored using Pearson's product moment, and simple logistic regressions were conducted for each outcome to determine variable selection for the final model. To justify aggregation of SAQ domains at the nursing unit level, $R_{WG(J)}$ was

calculated according to the method described by James *et al*.[33] Coefficients of reliability (Cronbach's α) for each domain of the SAQ were calculated using the α command in Stata.

The multilevel model preserves the structure of the data as it was collected by analysing outcomes at the individual level (patient and nurse injuries), while allowing explanatory covariates to be analysed at both individual levels (patient complexity) and group levels (unit working conditions, average unit SAQ scores). Intraclass correlation coefficients (ICCs) for each model were estimated according to Hox (2002):[34]

$$\text{ICC}: \rho = \sigma^2\left(\sigma^2 + \pi^2/3\right)$$

where σ^2 is the between-unit variance and $\pi^2/3$ is the within-unit variance expressed as a constant.

For each regression, the unit of analysis was the patient (nested within the nursing unit) or the nurse (nested within the nursing unit). Individual outcomes on the same unit were presumed to be dependent. Multilevel logistic regression models with a random intercept were used to account for this clustering.

The dependent variable in the nurse injury model was the log odds of the probability of individual-level nurse injury versus the probability of no injury. Seventy-eight nurses out of 723 experienced an injury. Unit turnover, RNHPPD, and the SAQ domains were included as unit-level explanatory covariates.

The dependent variable in each patient injury model was the log odds of the probability of individual-level patient injury versus the probability of no injury. From the 28 260 discharges in the PSI dataset, 105 decubitus ulcers and 167 PE/DVT were identified. From the 28 876 discharges in the PSN dataset, 290 patient falls were identified. Unit turnover, RNHPPD and the SAQ domains were included as unit-level explanatory covariates. Patient complexity was included as a patient-level covariate.

p Value statistics have been shown to be inappropriate for observational studies.[35 36] ORs with 95% CIs are presented instead of p values to focus on the direction, magnitude and precision of the associations rather than hypothesis testing. While the results are highlighted for which the lower and upper bound of the CI are either above or below one, the results that slightly cross the null but whose magnitude and precision suggest that they are worthy of further consideration are also reported.

RESULTS

Table 1 compares units with and without reported injuries, presenting unit-level summary statistics including total patient safety events and total nurse injuries. Units with patient falls had lower average SAQ scores than units without falls, and this trend was also evident for PE/DVT though less robust. No important differences were observed between the study variable means for the 29 units included and the 17 units excluded (data not shown).

A Pearson correlation matrix for falls was run to elucidate correlations among variables for the final models. A representative table for falls is included as supplementary online appendix 4. The Pearson correlation matrix showed that scores for individual SAQ domains were highly correlated with one another (r=0.65−0.91), therefore each domain was examined in a separate model using the same panel of explanatory covariates. The SAQ Stress Recognition results were excluded due to concerns about this domain's construct validity, which requires additional examination beyond the scope of this study. The authors are preparing a separate analysis of this domain.

Justification for aggregating individual responses to the SAQ by nursing unit is given in table 2. Sufficient within-unit homogeneity existed to warrant aggregation at the unit level ($R_{WG(J)}$ 0.643−0.831). Table 2 also presents Cronbach's α for each SAQ domain, which showed acceptable subscale reliability.

The ICC measures the degree of dependence in the outcome after accounting for the covariates. The larger the intraclass correlation, the more likely it is that nurse outcomes are correlated within their unit even after adjusting for the covariates. The ICCs for the random intercept logistic regressions were in the 'medium' to 'large' range.[37] The effective sample size was calculated[38] and it was found that the ICC did not significantly alter the effective sample size, thus preserving power (data not shown). Regardless of the ICC's size, the structure of the data and the study design still indicated the use of multilevel models as appropriate.

Figure 1 displays a summary of the magnitude, precision, and direction of the effect estimates for the main explanatory covariates by each injury outcome. Table 3 shows the results of the multilevel models adjusted by patient complexity. In general, the domains of the SAQ showed negative associations with injury outcomes, though the degree of precision varied. The Safety and Teamwork models were the most convincing, with ORs under 1.0 and more precise CIs for nurse injury and decubitus ulcer. For each 10-point increase in the average SAQ Safety domain score, a 48% reduction was observed in the odds of decubitus ulcer (OR=0.52, 95% CI 0.29 to 0.92), as well as a 45% reduction in the odds of nurse injury (OR=0.55, 95% CI 0.32 to 0.97). The Teamwork domain behaved similarly: for each 10-point increase in the average Teamwork domain score, a 44% reduction in the odds of decubitus ulcer

Table 1 Characteristics of nursing units

	Patient falls		Decubitus ulcer		PE/DVT		Nursing injuries	
	Units without	Units with	Units without	Units with	Units without	Units with	Units without	Units with
Nursing unit characteristics								
Number of nursing units (%)	3 (10)	26 (90)	11 (38)	18 (62)	10 (34)	19 (66)	8 (28)	21(72)
Count of injuries	0	290	0	105	0	167	0	78
Total patients discharged (%)	2268 (8)	26608 (92)	7947 (28)	20313 (72)	7475 (26)	20785 (74)	–	–
Total nurses employed (%)	–	–	–	–	–	–	158 (22)	565 (78)
Patient characteristics								
Complexity (scale: 1=low, 4=high), %								
0 (levels 1 and 2)	69.97	60.45	67.33	60.28	65.43	61.12	N/A	
1 (levels 3 and 4)	30.03	39.55	32.67	39.72	34.57	38.88		
	Mean (SE)							
Mean nursing hours per patient day	11.12 (0.09)	8.33 (0.02)	10.04 (0.04)	7.85 (0.02)	9.77 (0.04)	7.99 (0.02)	8.86 (0.21)	14.61 (0.31)
Turnover (%)	7.70 (0.12)	10.61 (0.18)	24.85 (0.56)	4.87 (0.03)	3.41 (0.06)	13.04 (0.22)	3.79 (0.50)	4.83 (0.48)
Unit-level mean SAQ domain score*								
Teamwork	88.34 (0.03)	75.49 (0.05)	82.73 (0.10)	75.19 (0.06)	82.55 (0.14)	75.42 (0.05)	79.65 (0.50)	78.25 (0.36)
Safety	84.55 (0.04)	76.69 (0.04)	79.60 (0.08)	77.33 (0.05)	80.36 (0.09)	77.11 (0.04)	78.3 (0.43)	76.88 (0.26)
Morale	80.61 (0.04)	70.69 (0.07)	73.61 (0.14)	71.75 (0.08)	75.40 (0.15)	71.14 (0.08)	73.64 (0.66)	74.81 (0.43)
Perceptions of management	74.69 (0.09)	61.49 (0.07)	62.68 (0.17)	63.01 (0.08)	64.76 (0.16)	62.25 (0.08)	60.97 (0.84)	65.1 (0.41)
Working conditions	78.07 (0.03)	69.48 (0.05)	72.39 (0.10)	70.10 (0.05)	71.69 (0.11)	70.40 (0.05)	67.91 (0.63)	71.83 (0.28)

*Stress Recognition domain omitted due to authors' concerns with construct validity.
PE/DVT, pulmonary embolism/deep vein thrombosis; SAQ, Safety Attitudes Questionnaire.

(OR=0.56, 95% CI 0.38 to 0.82) and a 40% reduction in the odds of nurse injury was found (OR=0.60, 95% CI 0.41 to 0.89). The Morale domain also showed a negative association with these outcomes, but slightly crossed the null.

In many of the models, working conditions were associated with both patient and nurse injury. As expected, RNHPPD showed a negative association with falls and decubitus ulcers, with falls having the more precise estimates. Controlling for all other covariates, in the Safety model each additional hour of RNHPPD was associated with a 9% decrease in the odds of patient falls (OR=0.91, 95% CI 0.83 to 1.00). RNHPPD slightly exacerbated the risk of PE/DVT, an effect of reasonable precision, and showed no effect on nurse injury. Unit turnover increased the risk of nurse injury and PE/DVT: in the Teamwork model, unit turnover was positively associated with nurse injury (OR=1.68, 95% CI 1.00 to 2.84) and with PE/DVT (OR=1.15, 95% CI 0.97 to 1.37). These estimates appear to be meaningful given the consistent direction of the intervals away from the null, and the narrow CIs. In the Teamwork model, higher unit turnover reduced the odds for falls (OR=0.84, 95% CI 0.69 to 1.02).

The estimates for RNHRPPD and unit turnover were virtually the same in all models, and the results from the Teamwork model are discussed as exemplars. Either Teamwork or Safety could have been chosen because they produced the most precise results among the

Table 2 Data aggregation results

SAQ domain†	$r_{WG(J).uniform}$* mean (SE)	Cronbach's α‡
Teamwork	0.831 (0.021)§	0.7769
Safety	0.771 (0.087)	0.7543
Morale	0.764 (0.048)	0.8798
Perception of Management	0.643 (0.044)	0.7493
Working Conditions	0.782 (0.019)	0.6924

*$r_{WG(J)}$.uniform = within-unit homogeneity.
†Five-point scale.
‡Coefficient of reliability.
§One unit excluded due to outlier effect.
SAQ, Safety Attitudes Questionnaire.

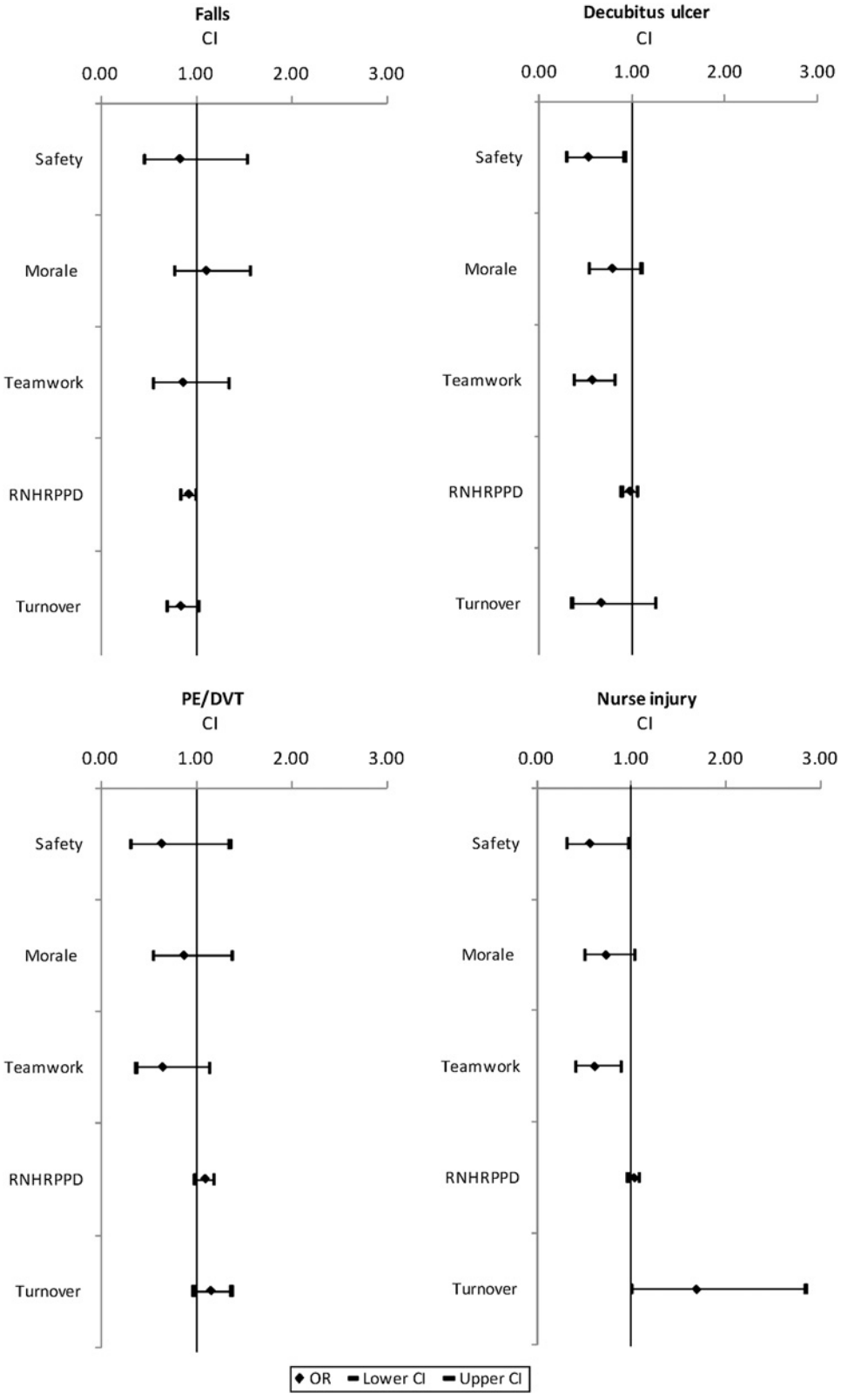

Figure 1 Comparison of 95% CIs by injury outcome and major explanatory covariates. Results for Safety, Morale, and Teamwork are from their respective models (see table 3). Registered nursing hours per patient day (RNHPPD) and Turnover results are from the Teamwork model.

models. Among the SAQ domains, Teamwork and Safety are the best understood (Sexton, personal communication, 2007) because interventions targeting both the Teamwork and Safety domains have already been developed and tested, with impressive results.[39 40]

DISCUSSION

This study explored associations of safety climate and nurse working conditions with injury outcomes for both nurses and patients. Meaningful relationships were

Table 3 Results of multilevel logistic regression with random intercept: injury type by SAQ domain

	Falls, n=290		Decubitus ulcer, n=105		PE/DVT, n=167		Nurse injury, n=78	
Model	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Safety (per 10 unit change)	0.83	0.46 to 1.53	0.52*	0.29 to 0.92	0.64	0.31 to 1.35	0.55*	0.32 to 0.97
Nursing hours per patient day (per 1 hour change)	0.91*	0.83 to 1.0	0.93	0.85 to 1.02	1.07	0.98 to 1.17	1.00	0.94 to 1.1
Turnover rate (per 10% change)	0.83	0.68 to 1.02	0.68	0.37 to 1.23	1.15	0.96 to 1.38	1.66	0.98 to 2.8
Complexity (high/low)	3.43	2.64 to 4.48	124.20	17.2 to 896.0	11.63	7.37 to 18.38		
σ^2		1.09		0.69		1.38		0.46
ICC		0.25		0.17		0.30		0.12
Morale/Job satisfaction (per 10 unit change)	1.10	0.77 to 1.57	0.78	0.54 to 1.1	0.87	0.55 to 1.38	0.72	0.51 to 1.03
Nursing hours per patient day (per 1 hour change)	0.91*	0.83 to 0.99	0.94	0.85 to 1.04	1.08	0.98 to 1.19	1.01	0.95 to 1.08
Turnover rate (per 10% change)	0.85	0.69 to 1.04	0.68	0.37 to 1.24	1.16	0.96 to 1.40	1.64	0.96 to 2.78
Complexity (high/low)	3.46	2.66 to 4.51	126.20	17.5 to 910.1	11.70	7.40 to 18.5		
σ^2		1.07		0.83		1.43		0.52
ICC		0.24		0.20		0.30		0.14
Teamwork (per 10 unit change)	0.86	0.55 to 1.34	0.56**	0.38 to 0.82	0.65	0.37 to 1.14	0.60*	0.41 to 0.89
Nursing hours per patient day (per 1 hour change)	0.92	0.84 to 1.00	0.97	0.89 to 1.06	1.09	0.99 to 1.19	1.02	0.96 to 1.08
Turnover rate (per 10% change)	0.84	0.69 to 1.02	0.66	0.35 to 1.25	1.15	0.97 to 1.37	1.68*	1.0 to 2.84
Complexity (high/low)	3.43	2.64 to 4.48	124.40	17.3 to 897.0	11.60	7.34 to 18.3		
σ^2		1.09		0.50		1.31		0.38
ICC		0.25		0.13		0.29		0.10
Working conditions (per 10 unit change)	0.98	0.55 to 1.75	0.66	0.37 to 1.17	0.79	0.39 to 1.59	0.90	0.50 to 1.63
Nursing hours per patient day (per 1 hour change)	0.91*	0.83 to 0.98	0.94	0.85 to 1.04	1.08	0.98 to 1.18	1.00	0.93 to 1.07
Turnover rate (per 10% change)	0.84	0.69 to 1.03	0.73	0.43 to 1.23	1.18	0.96 to 1.41	1.67	0.99 to 2.82
Complexity (high/low)	3.45	2.65 to 4.50	126.10	17.5 to 909.6	11.70	7.4 to 18.48		
σ^2		1.09		0.86		1.44		0.68
ICC		0.25		0.21		0.30		0.17
Perceptions of management (per 10 unit change)	0.98	0.66 to 1.47	0.83	0.54 to 1.27	0.78	0.49 to 1.25	0.89	0.59 to 1.32
Nursing hours per patient day (per 1 hour change)	0.91*	0.83 to 0.99	0.94	0.85 to 1.04	1.08	0.99 to 1.18	1.00	0.94 to 1.07
Turnover rate (per 10% change)	0.84	0.69 to 1.03	0.68	0.37 to 1.26	1.14	0.95 to 1.37	1.65	0.98 to 2.76
Complexity (high/low)	3.45	2.65 to 4.50	126.80	17.6 to 914.6	11.68	7.40 to 18.45		
σ^2		1.09		0.94		1.35		0.66
ICC		0.25		0.22		0.29		0.17

*$p<0.05$, **$p<0.01$.
σ^2, variance of random effect for nursing unit; ICC, intraclass correlation coefficient; PE/DVT, pulmonary embolism/deep-vein thrombosis; SAQ, Safety Attitudes Questionnaire.

found between the safety climate domains of Safety and Teamwork and decubitus ulcer and nurse injury, between nursing hours per patient day (RNHPPD) and patient falls, and between unit turnover and both patient and nurse injuries. These findings suggest that nurse and patient injuries share common underlying causes.

A negative association was found between two SAQ domains, Safety (perception of organisational commitment to safety) and Teamwork (perception of the quality of collaboration), with the odds of both decubitus ulcer and nurse injury. For each 10-point increase in the average Safety or Teamwork score, the odds of decubitus ulcer declined by 44–48% and the odds of nurse injury by 40–45%. These associations align with the findings of a recent meta-analysis of 203 independent samples in which social support, leadership, and safety climate were all key aspects of a supportive environment which explained the most variance in safety outcomes across industries.[9]

Given that decubitus ulcers are most common among relatively immobile patients, these findings raise interesting questions for care delivery. Nursing care for immobilised patients is generally more exhausting because regular lifting is required. The demands of caring for such patients could increase the importance of teamwork and have a special impact on safety. It thus seems reasonable that the Teamwork and Safety domains could reflect the potential for fatigue and other injury risk factors associated with caring for this patient population, as well as these patients' risk of decubitus ulcer.

The finding of a negative relationship between RNHPPD and patient falls corroborates previous findings of Krauss *et al*, who demonstrated that patient falls are sensitive to nurse-to-patient ratios, with patients seven times more likely to fall when the nurse was assigned seven or more patients than when the nurse had three patients or fewer.[41] The advantage of increased nursing time for patients at risk for falls seems intuitive: more patient contact creates additional capacity for direct observation, and thus more opportunities to prevent a fall. The slightly exacerbated risk of PE/DVT with increasing RNHPPD is counter intuitive and deserves more careful study using a longitudinal study design.

A positive association was found between the odds of PE/DVT and the unit-turnover rate, but a negative association between unit turnover and the rates of both patient falls and decubitus ulcers. Increased nurse turnover has been associated with longer patient length of stay and higher costs per discharge,[42] but knowledge is still emerging regarding the relationship between nurse turnover and patient outcomes.[43–46] A recent study by Bae *et al* used a unit-turnover metric identical to the one used in this study, and found that higher rates of unit turnover were associated with lower levels of patient falls, consistent with our finding.[47] Similarly and equally surprising, Mark *et al* found that units with more experienced nurses had both lower turnover and higher fall rates.[48]

Further, a 68% increase in the odds of nurse injury was found with each 10% increase in the unit-turnover rate. While evidence links organisational climate and nurse turnover,[5 49 50] little has been established about the direct effect of turnover on occupational safety outcomes, though such research has been recommended.[43 44 46] Higher unit-turnover rates may result in a greater proportion of nurses who are new to the unit, and therefore less experienced with the unit's specific procedures, techniques and equipment, putting nurses at greater risk of injury. A study of worker's compensation records found that significant changes in job tasks or title may essentially constitute a 'new job', and also found an inverse relationship between job tenure and claim rates, with workers in the first month of a job four times more likely to have a lost-time claim than those with over 1 year on the job.[51] In the nursing context specifically, it has been found that nurses with less than 5 years of experience are at greater risk of sharps injuries.[29] In a related finding among home healthcare workers, the risk of sharps injuries and blood/body fluid exposures increases across those holding full-time, part time and per-diem employment.[52]

Unit turnover, in sum, was positively associated with nurse injury and the odds of PE/DVT, but negatively associated with the odds of patient falls and decubitus ulcers. These relationships indicate that while unit turnover is a common predictor for both nurse and patient injuries, the causal connections are likely to be complex. Further study is warranted to explore the specific processes that might explain the differing associations between unit turnover and each of these safety outcomes.

The results show the importance of controlling for patient complexity when investigating patient injury outcomes. Patient complexity shows a strong positive association with each of the patient injury outcomes investigated. This finding is consistent with the literature on associations between patient complexity and adverse outcomes.[31]

The authors cannot determine whether a nurse injury preceded unit turnover or whether unit turnover was a causal factor for nurse injury due to the cross-sectional aspects of this study. However, the study design is strengthened by the fact that nurse safety perceptions were measured before the safety outcome data were collected. A meta-analysis by Beus *et al* demonstrates that injuries have a significant predictive effect on safety climate, especially when measured at the organisational level, necessitating a prospective measurement of safety

climate by researchers investigating safety climate's effect on injuries.[12] Under-reporting of nurse injury is also a concern because the data are based on voluntary injury reports, and it is well established that occupational injuries are under-reported by healthcare workers.[53 54] On balance, the authors believe that the associations identified are meaningful and worthy of further investigation using other methods, including classic longitudinal designs. Regarding the restriction of this study to the 29 units with at least a 60% response rate, it is conceivable that low response rate units were different from those that were included. The survey included secondary data available to the investigator only after administration by the hospital. To the investigators' knowledge, no effort was made to gather additional data about low response rate units. However, the low response rate units did not have significantly different means for the study variables under investigation (data not shown). While the single-hospital setting and the restriction to the higher-response units limit the generalisability of this study, the associations identified can now be further explored in a multi-hospital study.

In addition, unit type or skill mix was not investigated. Lake *et al* found variability in patient falls by unit type.[55] Moreover, Dunton *et al* have shown that in describing the negative association of RNHPPD with patient falls, the magnitude of the effect size varies by unit type.[56] The control of patient complexity in this study may address some of this variability, but does not do so entirely. A skill mix metric would help identify the proportion of licensed versus unlicensed nursing personnel, which in combination with higher RNHPPD is generally associated with decreased patient injuries.[57 58] Unruh suggests that there is a threshold skill mix level beyond which an increase in the proportion of licensed nurses has no additional influence.[58] Since RNHPPD was included in this study, it seems unlikely that adding skill mix to the model would have substantially changed the results.

The unit-turnover metric accounted for nurses who left one unit for another, but did not account for nurses who left the hospital entirely. The latter group is captured by commonly used termination metrics. In addition to the conceptual reasons for excluding this variable from the study (the global nature of termination vs the local nature of unit turnover), exploratory data analysis found that termination was not significant in the bivariate results for either nurse or patient injury (data not shown). The authors expect the inclusion of a combined metric for unit turnover and termination would not have changed the direction of the observed associations, but may have increased the magnitude of the overall effect. These two metrics offer insight into different aspects of nurses' experience and may fruitfully be used together in future research.

It is important to note that the science underlying the sensitivity of the SAQ is still in its infancy. The SAQ was used in this study because of the available surveys measuring hospital safety climate, only the SAQ had been used to explore the relationship between safety climate scores, patient outcomes and nurse turnover.[59] Sexton reported that increasingly positive perceptions on four of the six SAQ domains were associated with shorter intensive care unit stays, lower medication errors and decreased nurse turnover.[22 23 60] As further research explores the SAQ's sensitivity compared with actual changes in the healthcare environment, it will be possible to draw increasingly precise conclusions from studies involving this instrument.

CONCLUSION

This study demonstrates that nurses and patients share similar organisational risk factors for injury. The strength of evidence is most convincing from the Teamwork and Safety domains of the SAQ, each of which was negatively associated with decubitus ulcers and nurse injuries. This study also demonstrates that unit turnover should be analysed not merely as an organisational outcome, but should also be among the working conditions considered as a risk factor for nurse and patient injuries. These results suggest that patient and nurse safety may constitute linked outcomes rather than distinct silos. Traditionally, the fields of occupational and patient safety have been addressed separately, but regarding them as related components of an organisation's safety culture might be more apt. Future healthcare safety research and intervention efforts should consider a new paradigm integrating lessons learnt from both disciplines to more comprehensively and efficiently reduce preventable injuries to both workers and patients.

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Do nurse and patient injuries share common antecedents? An analysis of associations with safety climate and working conditions

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