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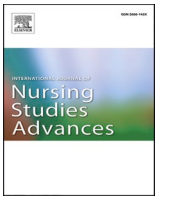

Safety culture, quality of care, missed care, nurse staffing and their impact on pressure injuries: A cross-sectional multi-source study

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ABSTRACT

Background: Safety culture is known to influence patient outcomes, but the relationship between nursing units' safety cultures and the development of pressure injuries in acute care hospitals is unclear. Pressure injuries are a nursing-sensitive patient outcome and are widely considered preventable.
Objective: To examine the impact of unit safety culture, nursing unit characteristics, and missed care on pressure injury rates in Saudi Arabian hospitals.
Design: A multi-center cross-sectional study was conducted between August and November 2021 and compared to secondary data on the incidence of pressure injuries.
Settings/Participants: A total of 653 nurses from 35 units in five Ministry of Health hospitals in Saudi Arabia participated in this study.
Methods: The survey included validated scales of safety culture, nurse staffing, and nurses' perceptions of quality of care, missed care, and the frequency of pressure injury. Secondary data on pressure injuries were collected from the Ministry of Health administrative database between 2018 and 2021. Descriptive analysis and Generalized Linear Models were performed.
Results: Higher safety culture scores were associated with fewer pressure injuries (β = -2.000, 95% Confidence Interval [CI] -3.107, -0.893) and lower nurses' perceptions of the frequency of pressure injuries in their unit (β = -1.224, 95% CI -2.255, -0.192). High scores on the sub-scales of hospital management (β = -2.105, 95% CI -2.835, -1.375) and safety climate (β = -1.402, 95% CI -2.383, -0.421) were the most statistically significant predictor for pressure injury prevention. Higher frequency of missed nursing care was positively associated with higher rates of pressure injuries (β = 1.606, 95% CI 0.187, 3.024) and higher nurses' perceptions of the frequency of pressure injuries (β = 1.243, 95% CI 0.211, 2.363). There was a positive relationship between higher nurses' perceptions of the frequency of pressure injury and higher incidence rate of pressure injury as reported in the incident management system (β = 1.183, 95% CI 0.065, 2.301).
Conclusion: Nursing units with stronger safety climate and safety behavior scores, higher ratings of hospital and unit quality of care, and lower levels of missed nursing care were associated with lower incidence of pressure injury and nurses' perceptions of the frequency of pressure injury in their units. Nurses' perceptions of the frequency of pressure injuries are concordant with the incidence of pressure injuries and can be a valid measure to capture patient outcomes within a specific time.

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Tweetable abstract: High safety culture and lower missed care are linked to fewer pressure injuries in Saudi Arabian hospitals. Nurses' perceptions of pressure injury frequency aligned with reported incidence rates, indicating a valid measure of patient outcomes.

1. Introduction

Pressure injuries, also known as pressure ulcers, are among the top five adverse events reported in hospitalized patients (Artico et al., 2020; Nghiem et al., 2022), with patients in the United States experiencing 2.5 million hospital-acquired pressure injuries each year (Ferguson et al., 2020). Most pressure injuries are preventable; however, the prevalence of pressure injuries ranges from 11.8% to 13.9% (Li et al., 2020; Rodgers et al., 2021). Negative patient outcomes such as infections, mortality, increased length of stay, and high costs are associated with the occurrence of pressure injuries (Nghiem et al., 2022). Pressure injuries are considered a nursing-sensitive patient outcome and are commonly used as an indicator of the quality of nursing care (Artico et al., 2020; Sim et al., 2019)

Nurses are pivotal to improving patient safety and preventing hospitalization-related adverse events (Alanazi et al., 2022). They are present in acute care settings 24 hours per day, 7 days per week. Nurses also provide first-line monitoring and education, plan for patient care processes, deliver clinical expertise in prevention and treatment, detect errors, and evaluate care outcomes. The role of nurses in the care process is crucial for patient safety; however, nurses' negative attitudes towards safety and the omission of required care have the potential to contribute to poor outcomes in acute care settings (Tonkikh et al., 2021).

Alanazi et al. (2022) conducted a systematic review to examine the relationship between nurses' safety attitudes and nursing-sensitive patient outcomes. The authors found limited evidence on the association between nursing unit safety culture and pressure injuries (Alanazi et al., 2022). A single hospital study found nursing units with strong safety climate and teamwork sub-scale scores had lower numbers of reported pressure injuries (Taylor et al., 2012), while two studies found no statistically significant associations between safety culture and pressure injuries in nursing units (Ausserhofer et al., 2013; Brown and Wolosin, 2013). In addition, four studies reported inconsistent associations between individual nurses' attitudes towards safety sub-scales and nurses' perceptions of the frequency of pressure injury occurrence (Han et al., 2020; Kakemam et al., 2021; Wang et al., 2014; Yesilyaprak and Demir Korkmaz, 2021).

Poor safety culture and work environments link to higher levels of missed care. Despite the accumulating evidence on the impact of missed care (Jones et al., 2015), the association between missed nursing care and pressure injury development is rarely studied. Patients who develop pressure injuries have experienced missed nursing care as the required prevention activities have either not occurred or have been inadequate (Kalisch et al., 2014; Kim et al., 2022). A literature review by Recio-Saucedo et al. (2018) on the association between missed care and patient outcomes found mixed evidence related to pressure injuries. Missed care was a statistically significant predictor of pressure injury in one study, while no significant association was found in two studies (Ausserhofer et al., 2013; Recio-Saucedo et al., 2018). Higher levels of missed care can result from inadequate staffing levels and workplace culture; both are known to impact patient safety.

Nurse staffing and its relationship to patient outcomes have been widely studied (Dall'Ora et al., 2022; Musy et al., 2021; Tonkikh et al., 2021). However, there is limited research on the link between nurse staffing and pressure injuries. A synthesis of the literature conducted by Griffiths et al. (2016) reported that three studies identified associations between higher staffing levels and lower rates of pressure injuries, whereas two studies found the opposite. A systematic review by Tuinman et al. (2021) on nursing staffing in long-term healthcare settings found five studies reported a negative association between higher numbers of registered nurses and lower prevalence of pressure injuries, but six studies found no association between nursing staffing, including certified nursing assistants and licensed practical nurses, and pressure injuries. A systematic review was conducted to examine nursing staffing methodologies and their impact on patient outcomes, including pressure injury, and also found inconclusive results (Twigg et al., 2021). Twigg et al. (2021) recommended using different approaches to measure patient outcomes. This study, therefore, examined nurse staffing, missed care, and safety culture and collected pressure injury data from two sources: an administrative dataset and nurses' perceptions of the frequency of pressure injuries in their units.

Donabedian's (1988) structure-process-outcome framework was used to guide the development of this study. Donabedian's model enabled us to conceptualize how structural elements, including staffing levels and the quality of care, and process elements, including safety culture and missed care, are related to the outcome of pressure injuries. The outcomes included the incidence rate of pressure injuries and nurses' perceptions of how frequently pressure injuries occurred. Therefore, the aim of this study was to examine the relationships between unit safety culture and nursing unit characteristics, such as nurses' perceptions of quality of care, missed care, and nurse staffing, and pressure injury rates in Ministry of Health hospitals in Saudi Arabia. The primary outcome measure in this study was pressure injuries.

2. Methods

2.1. Study design

A cross-sectional study was conducted between August and November 2021 in five Ministry of Health hospitals in Saudi Arabia. In addition, data on pressure injuries was sourced from a 2018–2021 administrative dataset developed by the Ministry of Health, which included data from the same five hospitals. This study is part of a larger doctoral project examining the impact of nurses' safety

attitudes on nursing-sensitive patient outcomes.

2.2. Participants

Nurses from 35 inpatient nursing units in five Ministry of Health hospitals were invited to participate in the study. Inpatient units included critical care, medical, surgical, and mixed medical-surgical wards. Emergency departments, operating theaters, and outpatient departments were excluded, as these units do not report pressure injury data to the Ministry of Health database. Individual nurses were eligible to participate if they had worked at the hospital for 3 months and worked in one of the included units.

De-identified data from the Ministry of Health dataset was requested for patients who developed a pressure injury during the years 2018, 2019, 2020, and 2021. The Ministry of Health dataset was sourced from incident management reports for pressure injuries and was available for 33 of the 35 units over this period.

2.3. Data collection

Nurses in participating units were invited to complete a web-based survey. The survey was promoted using a flyer with a QR code that was displayed on staff notice boards in the units. Nurses were also sent an email with a link to the study's participant information sheet. One generic flyer was used across all sites, but the landing page required participants to identify the hospital where they worked. This detail then enabled an individualized hospital-level participant information sheet to be shared with prospective participants. The survey included demographic items, the Safety Attitudes Questionnaire, and questions on missed care, nurse staffing, nurses' perceptions of quality of care, and the frequency of pressure injuries. In addition, we sought 4 years of pressure injury data for participating hospitals between 2018 and 2021 from the Ministry of Health.

2.4. Measures

2.4.1. Demographics

The survey included 14 demographic questions. Nurses were asked to identify their age, gender, nationality, years of experience, qualifications, shift duration, job status, and type of employment contract. Nurses also selected their unit and indicated the case mix of the unit where they worked. Individual nurse responses were aggregated at the unit level by means or proportions for analysis (Lee et al., 2018).

2.4.2. Safety culture

Nursing unit safety culture was measured using the 41-item Safety Attitudes Questionnaire, developed by Sexton et al. (2006). This instrument was selected because it is widely used, valid and reliable, and easy to administer and has a short completion time, making it a convenient choice for evaluating the safety attitudes of healthcare professionals (Churruca et al., 2021; Culbreth et al., 2021; Elsous et al., 2017). The instrument originally contained factors that explored teamwork climate, safety climate, job satisfaction, stress recognition, perceptions of management at unit and hospital level, and working conditions. Recent studies have also reported a new factor called "safety behavior" (Dickens et al., 2021; Elsous et al., 2017), which is included in this study. The stress recognition sub-scale was not included in the overall safety culture score, as the subscale negatively correlated with other sub-scales and does not fit into the overall safety attitudes construct measured by the Safety Attitudes Questionnaire (Taylor and Pandian, 2013). Therefore, eight sub-scales and an overall total safety culture score were calculated. Responses were recorded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The average score of each sub-scale was calculated and presented as a percentage for each nursing unit. A score of 75% or greater indicates a positive safety culture (Kong et al., 2019).

2.4.3. Quality of care

Nursing unit quality of care was examined using a set of items asking nurses to rate the overall quality of care provided in their unit and hospital (Sermeus et al., 2011). These questions provide a valid and reliable indication of the quality of nursing care (Aiken et al., 2017; Bagnasco et al., 2020; Smith et al., 2020). For example, nurses were asked, "Overall, how would you rate the quality of care provided on your ward"? Nurses responded to the questions using a 4-point Likert scale (1 = *poor*, 2 = *fair*, 3 = *good,* and 4 = *excellent*). Responses were categorized into unfavorable (0 = *poor and fair*) and favorable (1 = *good and excellent*), and the proportion of favorable quality of care was calculated in each unit for analysis.

2.4.4. Missed care

Missed care was measured by asking participants to respond to the question, "On your most recent shift, which of the following activities were necessary but left undone because you lacked the time to complete them"? The measured activities included 13 nursing activities that were validated in the Basel Extent of Rationing of Nursing scale (Schubert et al., 2008) and adapted for use by Ball et al. (2018) and used in recent studies (Nantsupawat et al., 2022; Smith et al., 2020). This list of activities included: patient surveillance; skin care; frequent changing of patient's position; documentation of nursing care; administering medications on time; comfort/talk with patients; developing or updating nursing care plans/care pathways; educating patients or family; oral hygiene; pain management; planning care; preparing patients and families for discharge; and undertaking treatments/procedures. Missed care in each nursing unit was summarized as the proportion of nurses who missed at least one nursing activity.

2.4.5. Staffing

The patient-to-nurse ratio in each unit was determined by asking nurses to report the total number of patients and nurses on their most recent shift using two questions that have been used in previous studies (Nantsupawat et al., 2022; Sermeus et al., 2011). Patient load was calculated for each nurse and summarized at the unit level for analysis.

2.4.6. Outcome variables

The primary outcome of interest was the incidence rate of pressure injuries, which was assessed as the total number of hospital-acquired pressure injuries stage 2 or greater. Data on pressure injury incidents for the 4-year period from January 2018 to December 2021 were routinely provided to the Ministry of Health dataset by each hospital using a monthly reporting template. The research team requested a copy of all pressure injury incidents from the Ministry of Health dataset, and this was then validated by each hospital. This process ensured that pressure injuries that occurred within the nominated units were included in the final dataset and enhanced rigor. After hospital validation, a final dataset was received with 1512 pressure injury incidents across 686,954 inpatient days from 33 nursing units. The incidence rate of pressure injury for each unit was calculated by dividing the total number of pressure injuries by the total number of inpatient days multiplied by 1000 patient days (Kim et al., 2022).

The secondary outcome was nurses' perceptions of pressure injury frequency. Nurse-reported adverse events are considered a reliable and valid approach in nursing research for estimating adverse events (Ball et al., 2014; Lee et al., 2018). Nurses were asked to report the frequency of pressure injuries occurring in their ward using a 7-point Likert scale ranging from '1 = never' to '7 = daily' as part of the cross-sectional survey. The responses were categorized into a binominal variable for analysis: 0 = 'never happened' (*never and several times per year*) and 1 = 'had happened' (*at least once per month; several times per month; at least once per week; several times per week and daily*), using the approach of Van Bogaert et al. (2014) and Zhu et al. (2012) and based on the distribution of the data in this study. The proportion of nurses who indicated that pressure injury 'had happened' in each nursing unit was calculated for analysis.

2.5. Statistical analysis

Data analysis was performed using SPSS (version 28.0). Missing value analysis was conducted in the cross-sectional survey to identify the percentage of missing data. Missing data ranged from 0.2% to 5.0% and was not missing completely at random; therefore, multiple imputation methods using demographic characteristics were used to replace 2.1% of safety attitudes items (Boussat et al.,

Table 1
Nursing unit characteristics (n = 653).

Variables	All units 35 units (n = 653) Mean (SD)	Critical Care 8 units (n = 314) Mean (SD)	Medical 10 units (n = 111) Mean (SD)	Surgical 8 units (n = 87) Mean (SD)	Mixed Medical-Surgical 9 units (n = 141) Mean (SD)
Age					
(years)	33.62 (5.75)	33.19 (1.32)	33.63 (2.52)	33.76 (1.57)	34.40 (1.77)
Missing	8	4	3	1	
Experience					
(years)	9.14 (4.90)	9.02 (1.59)	7.68 (1.82)	8.65 (1.33)	9.82 (1.29)
Missing	28	15	4	4	5
	Frequency (%)	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**
Gender					
Male	87 (13.3)	43 (13.7)	8 (7.2)	8 (9.3)	28 (19.7)
Female	548 (83.9)	264 (84.1)	100 (90.1)	75 (87.2)	109 (76.8)
Missing	18	7	3	3	5
Background					
Arabic	159 (24.3)	73 (23.2)	29 (26.1)	35 (40.7)	22 (15.5)
Non-Arabic	492 (75.3)	239 (76.1)	82 (73.9)	51 (59.3)	120 (84.5)
Missing	2	2			
Highest Qualification					
Diploma	77 (11.8)	30 (9.6)	20 (18.0)	21 (24.4)	6 (4.2)
Bachelor or higher	576 (88.2)	284 (90.4)	91 (82.0)	65 (75.6)	142 (95.8)
Missing	0				
Shift duration					
8 h	224 (34.3)	70 (22.3)	72 (64.9)	49 (57.0)	33 (23.2)
12 h	415 (63.6)	242 (77.1)	34 (30.6)	34 (39.5)	105 (73.9)
Missing	14	2	5	3	4
Job category					
In-charge\Head nurse	509 (77.9)	62 (19.7)	27 (24.3)	19 (22.1)	35 (24.6)
Staff nurse	143 (21.9)	252 (80.3)	84 (75.7)	67 (77.9)	106 (74.6)
Missing	1				1
Job status					
Temporary	585 (89.6)	28 (8.9)	10 (9.0)	13 (15.1)	10 (7.0)
Permanent	61 (9.3)	284 (90.4)	99 (89.2)	73 (84.9)	129 (90.8)
Missing	7	2	2		3

Note: SD = standard deviation.

2021). Missing data for nurse staffing items were managed using the approach described by Al-ghraiybah et al. (2022). The negatively worded items were reverse scored, and Safety Attitudes Questionnaire scores were transformed from a 5- to 100-point scale for analysis.

Descriptive statistics, including means and standard deviation (SD) for continuous variables, and frequencies and percentages for categorical variables, were used to summarize the data. Median and interquartile ranges (IQR) were reported for skewed variables. The associations between the study variables were conducted in two steps. In the first step, bivariate correlations were used to explore the strength and direction of the associations between variables. Gamma regression with log link models was fitted using Generalized Linear Models (GLM) to identify the strength and direction of the association between the variables. Gamma regression was appropriate based on the normality and homoscedasticity of the data. Nursing unit types, hospital size, and qualifications of nurses were used to control for factors known to affect nursing-sensitive patient outcomes (Audet et al., 2018). The associations were considered statistically significant at $p < .05$, and 95% confidence intervals were reported.

2.6. Ethical approval

The study was approved by the University of Wollongong, Human Research Ethics Committee (HREC), on June 29, 2021 (Approval No. 2021/214). In addition, ethical approvals from Saudi Arabia were granted by the Ministry of Health (Approval No. 1443-206207), King Saud Medical City (Approval No. H1RI-18-Jul21-01), and King Fahad Medical City (Approval No. 21-296E).

3. Results

3.1. Demographics

A total of 653 nurses completed the web-based survey from 35 nursing units in the five hospitals. Of the 35 units, almost half of the respondents worked in critical care, and the majority were female. Table 1 provides further details on the characteristics of nurses in this study.

3.2. Nursing unit safety culture

The overall safety culture score has been summarized by unit type and is presented in Table 2. None of the unit types recorded a positive safety culture score of 75 or higher in any sub-scale or the overall safety culture score. Across the unit categories, the highest average overall safety culture score was in medical units, and the lowest score was in surgical units. Medical units recorded the highest safety culture scores in most sub-scales, with the highest mean scores in job satisfaction and safety behavior. The lowest safety culture scores were in surgical units, with the lowest sub-scale score in working climate.

3.3. Quality of care, missed care, and staffing

Table 3 presents data on nurses' perceptions of quality and missed care and nurse staffing levels for each unit category. The highest ratings for hospital and unit quality of care were in medical units and the lowest were in surgical units. For missed care, a large proportion of nurses reported missed care activities in each nursing unit, with an average percentage of missed care of 74.28%. The highest percentage of missed care was recorded in surgical units. For nurse staffing levels, the average patient-to-nurse ratio over the last 24 h (morning, afternoon, and night shifts) was five patients. The highest ratio was in surgical units and the lowest was in critical care units.

Table 2
Average scores of safety culture sub-scales by nursing unit type.

Safety culture sub-scale	All units 35 units ($n = 653$) Mean (SD)	Critical care unit 8 units ($n = 314$) Mean (SD)	Medical unit 10 units ($n = 111$) Mean (SD)	Surgical unit 8 units ($n = 87$) Mean (SD)	Mixed Medical-Surgical unit 9 units ($n = 141$) Mean (SD)
Teamwork climate	63.28 (7.24)	65.25 (16.05)	64.35 (16.33)	61.14 (16.28)	64.28 (16.40)
Safety climate	64.68 (5.36)	64.76 (14.95)	67.56 (15.17)	61.33 (15.47)	66.73 (15.82)
Job satisfaction	65.53 (8.10)	66.01 (20.86)	69.82 (21.21)	62.85 (16.35)	64.00 (20.49)
Perceptions of unit management	60.49 (5.13)	59.79 (16.72)	63.35 (18.04)	57.32 (16.86)	60.65 (16.93)
Perception of hospital management	55.13 (6.72)	54.08 (19.25)	55.89 (20.51)	53.47 (19.52)	54.21 (19.05)
Stress recognition	54.99 (8.56)	56.99 (23.79)	51.43 (23.97)	55.20 (19.61)	61.85 (22.44)
Working climate	52.25 (6.92)	51.88 (21.68)	53.70 (22.45)	50.67 (21.57)	52.48 (20.01)
Safety behavior	65.38 (8.52)	66.13 (18.37)	68.23 (21.57)	62.69 (17.93)	67.12 (16.98)
Overall score	60.20 (4.62)	60.48 (12.76)	61.92 (13.53)	58.02 (12.50)	61.10 (13.05)

Note: SD = standard deviation.

Table 3
Nursing unit average scores of quality of care, missed care and staffing.

Nursing unit ($n = 35$)	All units Mean (SD)	Critical care units Mean (SD)	Medical units Mean (SD)	Surgical units Mean (SD)	Mixed Medical-Surgical units Mean (SD)
Hospital quality of care (% of favorable)	58.68 (20.80)	65.03 (13.05)	68.22 (23.17)	48.43 (22.18)	51.56 (18.40)
Unit quality of care (% of favorable)	67.94 (21.95)	71.05 (12.18)	76.06 (26.00)	53.58 (25.40)	68.93 (17.16)
Unit quality of care - last shift (% of favorable)	74.19 (16.71)	74.04 (8.97)	81.69 (11.28)	62.59 (22.27)	76.31 (18.16)
Missed care (% missed care)	74.28 (18.05)	73.11 (12.86)	75.44 (24.20)	77.37 (18.36)	71.27 (16.26)
Staffing level (patient-to-nurse ratio)	4.67 (1.99)	1.95 (0.40)	5.71 (1.97)	5.87 (0.88)	4.89 (1.18)

Note: SD = standard deviation.

3.4. Pressure injuries

Pressure injury incidence data and nurse estimates of pressure injury frequency are presented in Table 4. For the primary outcome, 1512 stage 2 or above pressure injuries were recorded in 33 nursing units between 2018 and 2021. The number of reported pressure injury incidents per nursing unit varied considerably, ranging from an average of 14 to a maximum of 161 per calendar year. The incidence rate of pressure injuries over the four years ranged from 0.0 to 9.98 incidents per 1000 inpatient days. Intensive care units recorded the highest incidence of pressure injury per 1000 inpatient days, whereas surgical units recorded the lowest rate.

For the secondary outcomes, nurses' perceptions of pressure injury frequency were calculated in all 35 included nursing units ($N = 620$ nurses). Across nursing units, pressure injuries were reported to occur frequently by 38.89% of nurses, as indicated by their response of at least once per month; several times per month; at least once per week; several times per week; or daily. The highest occurrence of pressure injury, as estimated by nurses, was in intensive care units, while the lowest occurrence was reported in mixed medical-surgical units. Medical and surgical units reported similar proportions of pressure injury frequencies (See Table 4).

3.5. Association between safety culture, quality of care, staffing, missed care, and pressure injuries

Table 5 summarizes the associations between the primary and secondary outcomes and the variables of interest. Generalized linear models were created to explore the predictors that are associated with the incidence of pressure injury and nurses' perceptions of pressure injury frequency. After controlling for nursing unit type, hospital size, and nurses' qualification, ten predictors that influenced the incidence of pressure injury were identified. Eleven predictors that influenced nurses' perceptions of pressure injury frequency in each unit were identified.

The overall safety culture score and seven of the eight safety attitudes sub-scales were found to be negatively associated with the incidence of pressure injury (see Table 5). The overall safety culture score and perception of hospital management were the most significant predictors. Higher overall safety culture scores were associated with a reduction in the incidence of pressure injury. Nursing units with a positive perception of hospital management were also associated with lower rates of pressure injury. In addition, higher perceptions of hospital and unit quality of care were associated with lower incidence rates of pressure injury. Higher frequencies of missed care reported by nurses on their last shift were also positively associated with a higher incidence of pressure injury.

The overall safety culture score and two of the eight safety attitudes sub-scales were negatively associated with nurses' perceptions of pressure injury frequency. Higher scores of overall safety culture and safety climate were associated with lower nurses' perceptions of pressure injuries in their unit. Higher ratings for quality of care at the hospital, unit, and on the most recent shift were associated with lower rates of pressure injuries being reported by nurses. In addition, higher patient load per nurse and the presence of missed care on the previous shift were positively associated with higher reported rates of pressure injury frequency. Specifically, missed care related to adequate patient surveillance, changing of patient's position, and skin care all led to higher proportions of pressure injuries being reported by nurses in their unit.

3.6. Association between incidence of pressure injury and nurses' estimated pressure injury frequency

There was a moderate positive relationship between the incidence of pressure injury from administrative data sources and nurses'

Table 4
Incidence and frequency of pressure injury.

	All units Median (IQR)	Critical care unit Median (IQR)	Medical unit Median (IQR)	Surgical unit Median (IQR)	Mixed Medical-Surgical unit Median (IQR)
Pressure injury incidence rate (per 1000 IPDs)	33 units 0.88 (0.49–1.58)	6 units 2.82 0.95–9.25)	10 units 0.85 (0.20–1.75)	8 units 0.52 (0.45–0.75)	9 units 1.18 (0.76–1.58)
Pressure injury reported by nurses (% of frequency)	35 units ($n = 620$) 38.89% (18.18–50.00)	8 units ($n = 314$) 49.12% (41.25–79.74)	10 units ($n = 111$) 37.22% (15.63–57.50)	8 units ($n = 87$) 37.50% (12.50–57.50)	9 units ($n = 141$) 26.67% (13.66–34.31)

Note: IPDs = inpatient days; IQR = interquartile ranges.

Table 5
Results of the association between safety culture, quality of care, missed care, staffing and pressure injury – GLM models.

Variables	Incident data (Primary outcome) Incidence rate of pressure injury ($n = 33$ units)				Nurse Reported (Secondary outcome) Frequency of pressure injury ($n = 33$ units)			
	β	95% CI		p	β	95% CI		p
		Lower	Upper			Lower	Upper	
Overall safety culture score	-2.000	-3.107	-0.893	<.001	-1.224	-2.255	-0.192	.036
Teamwork climate	-0.808	-1.630	0.015	.054	-0.724	-1.463	0.016	.140
Safety climate	-1.316	-2.400	-0.232	.017	-1.402	-2.383	-0.421	.018
Job satisfaction	-0.911	-1.574	-0.248	.007	-0.256	-1.369	-0.017	.184
Perceptions of unit management	-1.703	-2.767	-0.638	.002	-0.749	-1.972	0.475	.230
Perception of hospital management	-2.105	-2.835	-1.375	<.001	-0.186	-1.018	0.647	.662
Stress recognition	-0.076	-0.786	0.634	.834	-0.603	-1.216	0.011	.078
Working climate	-1.732	-2.773	-0.691	.001	-0.713	-1.082	0.392	.082
Safety behavior	-0.909	-1.603	-0.215	.010	-0.663	-1.166	-0.062	.022
Hospital quality of care	-1.842	-3.104	-0.579	.004	-1.544	-2.575	-0.513	.005
Unit quality of care	-1.108	-2.177	-0.040	.042	-1.720	-2.534	-0.905	<.001
Unit quality of care - last shift	-1.396	-2.842	0.050	.059	-1.345	-2.844	-0.371	.026
Overall missed care	1.606	0.187	3.024	.026	1.243	0.211	2.363	.023
Missed adequate patient surveillance	0.520	-0.671	1.710	.392	1.533	0.612	2.454	<.001
Missed frequent changing of patient's position	0.462	-0.865	1.788	.495	1.956	0.884	3.029	<.001
Missed skin care	0.565	-0.688	1.817	.377	1.546	0.618	2.474	.001
Staffing level	-0.028	-0.238	0.183	.797	0.185	0.023	0.357	.049
Nurses' reported pressure injury frequency	1.183	0.065	2.301	.038	–	–	–	–

Note: β = beta; CI = confidence interval.
Adjusted for nursing unit type, hospital size, and qualification.

perceptions of the frequency of pressure injury in 33 nursing units ($r = 0.459$, $p < 0.05$). The result of the regression identified a relationship between nurses' perceptions of the frequency of pressure injuries in their unit and the actual incidence rate of pressure injury (See Table 5). In addition, the overall safety culture score, safety climate, safety behavior, and quality of care at the hospital and unit level were negatively associated with both sources of pressure injury data.

4. Discussion

This study examined the association between pressure injuries and nursing unit characteristics, safety culture, quality of care, missed care, and nurse staffing levels using multiple data sources. The study found nursing units with strong safety climate and safety behavior sub-scale scores and higher ratings of hospital and unit quality of care reported a lower incidence of pressure injuries and fewer pressure injuries as reported by nurses. In addition, nursing units with lower levels of missed care had a lower incidence of pressure injuries and less frequent pressure injuries, as reported by nurses. There was a statistically significant positive association between a higher incidence rate of pressure injury and higher nurses' perceptions of the frequency of pressure injury.

Pressure injuries, stage 2 or greater, occurred at a rate of 0.88 per 1000 patients days in this study, which is considerably higher than reported in previous research that includes all pressure injury stages (AlMutairi et al., 2020; Kim et al., 2022; Li et al., 2020). Nurses' perceptions of the frequency of pressure injuries were also higher in the current study than the incidence rates would suggest. In our study, the frequency of pressure injuries is higher than the frequency reported in studies conducted in Switzerland (Ausserhofer et al., 2013), South Korea (Han et al., 2020), Iran (Kakemam et al., 2021), and China (Wang et al., 2014). The higher proportion of nurses who reported that pressure injuries frequently occurred in our study is consistent with a Saudi Arabian study, which reported a cumulative pressure injury incidence rate of 39.3% (33/84 patients) (Tayyib et al., 2016). A possible explanation of the variance in these results might relate to the impact of the COVID-19 pandemic on healthcare systems, as the data in our study were collected in 2021, which may have resulted in higher numbers of patients requiring advanced life support, higher lengths of stay, and staff shortages. The high percentage of missed care reported by nurses (74.3%) in this study may have contributed to higher pressure injury rates being identified. Patients in the intensive care unit had higher incidence rates than other patients in this study. This finding is not unique to Saudi Arabia and has been reported internationally (Coyer et al., 2017). Higher incidence in intensive care unit patients may relate to impaired mobility, which is a significant factor in pressure injury development (Alshahrani et al., 2021; Kim et al., 2022). Repositioning is important for preventing pressure injuries and is recommended every 2–3 hours (AlMutairi et al., 2020). In a study conducted by Tayyib et al. (2016) in two intensive care units in Saudi Arabia, the mean time for repositioning patients was 4.96 hours. Infrequent re-positioning may explain the high rate of pressure injuries in the intensive care units in our study and is likely to relate to missed nursing care and nurse staffing shortages.

A strong safety culture within nursing units was associated with a lower incidence rate of pressure injuries and lower levels of nurses' perceptions of how frequently pressure injuries occur. Nursing units with a strong safety climate, high perceptions of organizational commitment to safety, and effective safety behaviors, such as collaborations with nurses, physicians, and pharmacists, were all associated with lower rates of pressure injuries and less frequent pressure injuries being reported by nurses in their units in the last year. Strong safety climate and teamwork climate were also associated with a lower incidence of pressure injuries in one study (Taylor et al., 2012) but not related to the incidence of pressure injury (Brown and Wolosin, 2013) and nurses' perceptions of the frequency of

pressure injury (Ausserhofer et al., 2013) in other studies. Teamwork climate was not associated with the incidence of pressure injuries or nurses' perceptions of the frequency of pressure injuries in our study; however, the direction of the association was positive. There may be methodological reasons for these mixed results, as different studies have analyzed data at the individual participant level, and others are aggregated to ward or hospital level (Han et al., 2020; Kakemam et al., 2021; Wang et al., 2014; Yesilyaprak and Demir Korkmaz, 2021). Pressure injury prevention requires a team approach to care, as no one nurse is responsible for pressure injury prevention for individual patients over a 24-hour period (Ferguson et al., 2020). Therefore, aggregating results to the unit level is an appropriate strategy when exploring outcomes related to pressure injuries.

Nursing units with higher ratings of hospital quality of care and lower levels of missed care were associated with a lower incidence of pressure injury and lower perceptions of the frequency of pressure injury. Previous researchers have also reported a positive association between missed care and nurse-reported pressure injury (Schubert et al., 2009). Our study also examined specific nursing activities that relate to pressure injury prevention that had been missed. Missed care related to patient surveillance, repositioning of patients, or providing skin care was associated with higher reported rates of pressure injuries by nurses in our study. Kalisch et al. (2014) found that patients who develop skin breakdown or pressure injury reported a substantial increase in the overall amount of missed nursing care. Our study identified that 74.3% of nurses reported that they had missed care on their most recent shift, and this may explain the higher frequency of pressure injuries in our study. Exploring the reasons behind missed care and its link with pressure injuries in the context of Saudi Arabian hospitals requires further study. High levels of nurse staffing have been shown to reduce the amount of reported missed care (Nantsupawat et al., 2022); however, effective leadership and management can also contribute to the reduction of missed care levels (Dutra and Guirardello, 2021).

In this study, there was no statistically significant relationship between patient-to-nurse ratios and the number of pressure injuries recorded in the administrative data; however, higher numbers of patients per nurse were associated with more frequent pressure injuries being reported by nurses. In acute care hospitals, higher nurse staffing levels were associated with a lower rate of pressure injuries in two studies, while the opposite was found in one study and no association in another (Assaye et al., 2021). Two systematic reviews found similar results in different healthcare settings with inconsistent associations between staffing levels and pressure injuries (Tuinman et al., 2021; Twigg et al., 2021). A possible explanation for the inconsistency between findings from the two data sources in our study may relate to the impact of the COVID-19 pandemic on pressure injury rates, given increases in hospitalizations and staff shortages (Al Muharraq, 2021). The mixed results in previous research could also be related to the source of nurse staffing data (Dall'Ora et al., 2022). Different methods are used to measure nurse staffing levels, including using administrative data to calculate patient-to-nurse ratios or nursing hours per patient day and the use of nurse-reported data on staffing and patient assignments (Assaye et al., 2021). The association between these variables may be affected by other structural and process factors, such as the nursing practice environment and collaborations among staff (Griffiths et al., 2016). Further investigations to determine the impact of nurse staffing levels on pressure injuries are required to improve patient safety within healthcare systems.

This study sought to evaluate if nurse-reported data was an accurate predictor of the number of pressure injuries reported via an administrative data source. There was a positive association between nurses' perceptions of pressure injury frequency and the incidence rate of pressure injuries. This result strengthens existing claims that nurse perceptions of pressure injury frequency are a reliable predictor of pressure injury rates. This result is consistent with a study on falls in 22 units by Cina-Tschumi et al. (2009), which identified that higher nurse-reported falls were associated positively with higher fall rates. The two sources of pressure injury data in this study showed the same association with safety culture and quality of care. Negative associations were found between the overall safety culture score and the sub-scales of safety climate and safety behavior, hospital and unit quality of care, and the two sources of pressure injury data. In addition, a positive association was found between missed care and the two sources of pressure injury data. This finding supports the use of nurses' perceptions of the frequency of pressure injuries as an accurate reflection of the actual pressure injury frequency in acute hospital settings.

5. Limitations

This study used a cross-sectional survey to gather data on safety culture, missed care, and other nurse characteristics; thus, a causal relationship among variables cannot be inferred. The data collected in the cross-sectional survey was self-reported, which may have led to social desirability bias, and data was collected during the COVID-19 pandemic, which may have affected response rates, nursing workloads, and nursing care practices. Nurse participants in the cross-sectional survey were employed at five different Ministry of Health hospitals. A QR code was used for participants to access the survey, and participants had to self-select their hospital and unit as part of data collection. No additional safeguards were in place to ensure only nurses who were eligible to participate in the research provided data.

The primary outcome of this study was collected from an administrative dataset that used incident reports of pressure injury occurrence (stage 2 or greater). It is not possible to assess whether all pressure injuries were reported in the incident management systems or the volume of missing data within the administrative dataset. There was no risk adjustment for patient characteristics conducted on the administrative dataset as personal identifying data from each incident was not available to the research team. Risk adjustment to account for differences in patient case mix that may have influenced pressure injury outcomes, therefore, was not possible. The study included five hospitals in Saudi Arabia, and therefore the results may not be generalizable to other settings. However, to the best of our knowledge, this is the first study that examines the associations between nursing units' safety culture and quality of care using well-established and validated instruments with two sources of pressure injury data.

6. Conclusion

This study sought to understand the associations between two sources of pressure injury data and safety culture, quality of care, missed care, and staffing levels. The study demonstrated that nursing units with strong safety climates and safety behaviors, higher ratings of hospital and unit quality of care, and lower levels of missed nursing care had a lower incidence of pressure injuries and nurses' perceptions of pressure injury frequency. Nurses' perceptions of the frequency of pressure injury at the unit level were positively associated with the incidence rate of pressure injuries recorded within the administrative dataset. Nurse-reported pressure injuries can be considered a valid measure to capture pressure injury incidence within a specific timeframe. Additional research exploring the prevalence and incidence rates of pressure injuries and investigating the reasons behind missed care in the Saudi Arabian context is required.

Data availability statement

The primary dataset collected and analyzed during the current study is available from the corresponding author on request. Secondary data is not available due to privacy/ethical restrictions imposed by the data custodian.

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CRediT authorship contribution statement

Faisal Khalaf Alanazi: Conceptualization, Methodology, Investigation, Resources, Data curation, Writing – original draft, Visualization, Writing – review & editing. **Samuel Lapkin:** Methodology, Supervision, Writing – review & editing, Visualization. **Luke Molloy:** Supervision, Writing – review & editing, Visualization. **Jenny Sim:** Conceptualization, Methodology, Supervision, Writing – review & editing, Visualization, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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