

Research Article

Critical care nurses' knowledge and attitudes toward pressure injury prevention: A pre and post intervention study

Bassam Alshahrani^{a,b,1,*}, Rebekkah Middleton^{a,2}, Kaye Rolls^{a,3}, Jenny Sim^{a,c,d,4}

^a School of Nursing, Faculty of Science, Medicine & Health, University of Wollongong, Australia

^b College of Nursing, Taibah University, Saudi Arabia

^c WHO Collaborating Centre for Nursing, Midwifery & Health Development, Faculty of Health, University of Technology Sydney, Australia

^d School of Nursing & Midwifery, University of Newcastle, Central Coast Clinical School, Australia



ARTICLE INFO

Keywords:

Attitudes
Critical care
Intensive care
Knowledge
Nurses
Pressure injury
Pressure ulcer
Prevention

ABSTRACT

Objective: To explore nurses' knowledge and attitudes towards pressure injury prevention before and after implementing an educational intervention.

Design/Method: A pre-and post-intervention study. Pre-intervention data collection involved administering an instrument, including demographic information, the Pressure Ulcer Knowledge Assessment Tool version 2, and the Attitudes towards Pressure Ulcer Prevention instruments. Following the analysis of pre-intervention data, an educational intervention was implemented. Post-intervention data were collected using the same instrument.

Setting: Intensive care units at three Saudi Arabian hospitals.

Main outcome measures: Nurses' knowledge and attitudes towards pressure injury prevention.

Results: The pre-intervention phase included 190 participants, and the post-intervention phase included 195 participants. Participants completed a paper-based survey at two different time points between June 2021 and March 2022. The mean pre-intervention scores for nurses' knowledge and attitudes towards pressure injury prevention were 43.22% and 74.77%, respectively. Following the educational intervention, the knowledge and attitude scores increased significantly to 51.22% and 79.02%, respectively. Higher knowledge of pressure injury prevention was positively associated with positive attitudes towards prevention practices. Age, clinical nursing experience, and experience in intensive care units were identified as factors correlated with knowledge of pressure injury prevention. A Bachelor's qualification or higher predicted better knowledge and attitudes towards pressure injury prevention.

Conclusions: Nurses' knowledge and attitudes towards pressure injury prevention greatly improved following tailored, evidence-based education. The educational intervention featured multiple on-site bedside discussions, case studies, small-group presentations, and the provision of printed resources.

Implications for Clinical Practice: Nurses' knowledge and attitudes towards pressure injury prevention should be examined, and education provided to ensure evidence-based prevention practices are implemented. Tailored small-group education sessions delivered conveniently could be an effective approach. Efforts should focus on attracting and retaining experienced, highly qualified nurses to ensure the adoption of evidence-based prevention practices.

* Corresponding author.

E-mail addresses: bdsa936@uowmail.edu.au (B. Alshahrani), rmiddle@uow.edu.au (R. Middleton), Krolls@uow.edu.au (K. Rolls), Jenny.Sim@uts.edu.au (J. Sim).

[@Abu_maysam](https://twitter.com/Abu_maysam) (B. Alshahrani), [@bekkmiddle](https://twitter.com/bekkmiddle) (R. Middleton), [@kaye_rolls](https://twitter.com/kaye_rolls) (K. Rolls), [@jennysim_1](https://twitter.com/jennysim_1) (J. Sim)

¹ Orcid Id: 0000-0002-0428-0412

² Orcid Id: 0000-0002-8440-7451

³ Orcid Id: 0000-0003-1807-6620

⁴ Orcid Id: 0000-0001-6863-0541

<https://doi.org/10.1016/j.iccn.2023.103528>

Received 6 March 2023; Received in revised form 27 July 2023; Accepted 7 August 2023

Available online 19 August 2023

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Introduction

A pressure injury (PI) occurs following localised damage to the skin caused by pressure on the skin or underlying tissue due to bony prominences, shear or friction (EPUAP, NPIAP, & PPIA, 2019). Pressure injuries can also develop around medical devices. Pressure injuries can be classified as stage 1, stage 2, stage 3, stage 4, unstageable, and deep tissue PIs (EPUAP, NPIAP, & PPIA, 2019). Healthcare experts have agreed that PIs are mostly preventable and should not occur in healthcare settings, leading some jurisdictions to classify them as 'never events' (AHRQ, 2019). The occurrence of severe PIs is indicative of major harm to patients and is linked to increased mortality (Pachá et al., 2018).

Pressure injuries frequently occur in intensive care units (ICUs) despite the adoption of evidence-based methods to prevent them. Patients in ICUs are highly susceptible to PIs due to their immobility and the severity of their health condition (Jacq et al., 2021). Pressure injury development in ICUs is considered a multifactorial process and can be challenging to prevent (Labeau et al., 2021). Neurological impairment, essential life-saving medical treatment, fluid replacement, and the administration of vasoactive medications, as well as pathophysiological conditions that restrict repositioning, are common in ICUs and increase the risk of PI development (Gefen et al., 2021). This has resulted in more PIs in ICUs than in other healthcare settings, putting a considerable physical, psychological, and financial burden on a population regarded as the sickest in the healthcare system (Chaboyer et al., 2018).

Critical care nurses have a key role in implementing PI prevention practices in critical care settings as prevention practices are a core nursing responsibility (Gocmen Baykara et al., 2021; Lovegrove et al., 2021). Pressure injuries are considered an indicator of quality nursing care and classified as a nursing-sensitive patient outcome (Rodgers et al., 2021; Sim et al., 2019). However, many factors make prevention challenging in ICUs. Alshahrani et al. (2021) identified that having access to highly skilled nurses with knowledge of PIs in ICUs is associated with an increase in the adoption of preventative measures and helps develop best practice.

The latest update of the clinical practice guideline for the prevention and management of PIs includes evidence-based recommendations and summaries that have been tailored specifically for critical care settings (EPUAP, NPIAP, & PPIA, 2019). The guidelines recommend that healthcare workers' knowledge and attitudes towards PI prevention should be assessed regularly to support clinical recommendations and identify challenges. Despite this, PI prevention practices are often not evidence-based (Beeckman et al., 2011). Negative attitudes and low levels of knowledge about PI prevention are known barriers to implementing guidelines in clinical practice (Alanazi et al., 2022; Lovegrove et al., 2021). Hence, it is crucial to investigate nurses' knowledge and attitudes about PI prevention to inform the design of intervention initiatives that can improve patient outcomes.

Aims

To explore nurses' knowledge and attitudes towards PI prevention before and after implementing an educational intervention in ICUs in the Kingdom of Saudi Arabia (KSA).

Methods

Study design

A pre and post intervention study was used. The pre-intervention data were collected between May and June 2021 to capture the initial participants' knowledge and attitudes regarding PI prevention. Following the baseline assessment, an educational intervention was implemented to enhance nurses' knowledge and promote positive attitudes towards PI prevention. The post-intervention assessment was conducted between March and April 2022 to measure any changes from

the baseline data. Therefore, the study was a pre and post intervention study, with the educational program serving as the intervention between the two assessment points. This study forms part of a larger study conducted as part of a doctoral project and used the Knowledge-to-Action framework to guide study design (Graham et al., 2006).

Setting

The study included ICUs from three hospitals in different regions of the KSA that are overseen by the Ministry of Health. The selection was purposive and included one university hospital and two tertiary hospitals that provided specialised services, such as cardiology, neurology, renal care, burn care, trauma care, and 24-hour emergency departments. All ICUs within each hospital were included in the study, resulting in a total of 3 medical ICUs, 3 surgical ICUs, 2 intermediate ICUs, 1 neuro ICU, and 1 cardiology ICU. The average number of ICU beds across each hospital was 80. Patient admissions to the ICUs were elective, direct, or emergency, and the average duration of ICU stay ranged from 17 to 19 days.

Sample

Registered Nurses working in ICUs were invited to participate in the study. Individual nurses were eligible to participate if they worked in one of the ICUs at the time of data collection, held KSA nursing registration, and consented to complete the survey. Approximately 300 nurses were eligible to participate. The nurses in the participating units held various degrees in nursing and were licensed by the Saudi Commission for Health Specialties. Historically, nurses in the Saudi health system mainly possessed diplomas, resulting from limited availability of bachelor's degree programs and the presence of long-term foreign nurses. However, there has been a recent trend of an increasing number of nurses with bachelor's degrees or higher qualifications being registered with Saudi Commission for Health Specialties (Saudi Health Council, 2019).

Data collection

Data were collected at two time points (pre- and post-intervention). Completing the survey constituted tacit consent. The surveys were promoted through posters placed in nurses' lounges, hospital communication systems, and staff emails to encourage participation. Nursing educators provided support and encouragement for participation during their unit visits. A contact person was chosen from each research site to serve as a liaison between the research team and study participants, as strict access restrictions due to COVID-19 were in place. The selection of these individuals was based on their availability and easy access to participating units. Their responsibilities included distributing paper-based surveys to all nurses working in ICUs, collecting them upon completion, and securely placing them in a designated box.

Surveys were developed using Papersurvey.io™ which uses optical character recognition to recognise participant responses and eliminate the need for manual data entry. Surveys were collected from participating units and scanned and submitted to the research team for manual and electronic verification prior to analysis. Verification was completed using a 3-step process: 1) manual inspection of surveys to ensure all pages were scanned accurately; 2) verification of individual responses to accurately record data related to messy writing or where participants entered data outside of the allocated response field; and 3) manual review of all data fields for accuracy in character recognition.

Data collection instruments

Pre-intervention survey

The pre-intervention survey included 46 items and was divided into

three sections: demographic questions, the English version of the Pressure Ulcer Knowledge Assessment Tool (PUKAT 2.0) (Manderlier et al., 2017), and the English version of the Attitude towards Pressure Ulcer Prevention (APuP) (Beekman et al., 2010). The items from the PUKAT 2.0 and APuP instruments were included with the original authors' permission. Non-identifying data, employment characteristics, and experiences were captured through demographic questions.

The PUKAT 2.0 is a validated instrument that evaluates nurses' understanding of current evidence-based information about PIs (Manderlier et al., 2017). PUKAT 2.0 contains 25 multiple-choice questions about nurses' knowledge in six dimensions: aetiology, classification and observation, risk assessment, nutrition, prevention, and specific patient groups. The scores range from 0 to 25, with higher scores indicating greater knowledge. All questions have 5 multiple-choice response options including "I do not know the answer". The PUKAT 2.0 has been reported to have valid and reliable psychometric properties with an intraclass correlation coefficient of 0.69 and an average item difficulty of 0.56 (Manderlier et al., 2017).

The APuP is a validated instrument that investigates nurses' overall attitudes towards PI prevention. The APuP consists of thirteen statements with four-point Likert-scale responses. The APuP assesses a participant's level of agreement and attitudes towards preventing PIs from five perspectives: Personal competency to prevent pressure ulcers, Priority of pressure ulcer prevention, Impact of pressure ulcers, Responsibility in pressure ulcer prevention, and Confidence in the effectiveness of prevention (Beekman et al., 2010). The APuP underwent validation in a prospective psychometric instrument validation study. The internal consistency, measured by Cronbach's alpha, was 0.79 and the overall intraclass correlation coefficient was 0.88 (Beekman et al., 2010).

Pre-intervention surveys were distributed in May 2022, providing time for baseline data analysis. This allowed for the preparation of a comprehensive report to be shared with the nursing leadership teams in each hospital, in line with the KTA framework's emphasis on stakeholder engagement and identification of potential barriers prior to the intervention.

Post-intervention survey

The post-intervention survey included 51 items. One new item was added to the demographics section to identify if participants had completed the pre-intervention survey. The PUKAT 2.0 and APuP sections were unchanged. A fourth section was added and included four items to gain additional data on participants' perceptions of the educational intervention as a whole and what they thought were the most notable barriers to implementing PI prevention measures. All other processes were identical to the pre-intervention survey. The post-intervention instruments were distributed three weeks after the four-month intervention was completed. This timing ensured sufficient time for participants to absorb and apply the knowledge provided in their routine care, thereby assessing the impact of the intervention on their knowledge and practices.

The intervention

After collecting baseline data, an educational intervention was developed. The intervention was implemented in each unit between December 2021 and March 2022. The intervention was formulated by incorporating the pre-intervention findings and utilising evidence-based recommendations from the Prevention and Treatment of Pressure Ulcers/injuries: Clinical Practice Guideline (EPUAP, NPIAP, PPIA, 2019) and the SSKINCARE bundle (NHS, 2015). The educational intervention included unit-based presentations, bedside and case study discussions, practical demonstrations and the distribution of printed educational resources at each site. The intervention was facilitated by the first author and delivered following a unit-by-unit approach. A total of 294 nurses

participated in the educational intervention at multiple time points in the three hospitals. Fig. 1 illustrates the approach and provides information about the intervention.

Data analysis

Items from the PUKAT 2.0 instrument were recoded to indicate if the response was correct or incorrect. Items marked as 'I don't know the answer', where multiple answers were selected, or where the item was skipped were considered incorrect. As a result, participant responses were computed to generate a total score and sub-scale scores. The PUKAT 2.0 instrument does not have a recommended cut-off score to indicate satisfactory knowledge levels (Manderlier et al., 2017).

The responses for the APuP section were recoded based on guidance by the instrument developers (Beekman et al., 2010). Every statement is scored on a four-point Likert scale, where 1 indicates strong agreement, 2 indicates agreement, 3 indicates disagreement, and 4 indicates strong disagreement. Negatively phrased items (3, 4, 5, 7, 8, 10, and 13) were reverse-scored (Beekman et al., 2010). Multiple answers or no responses were treated as invalid responses and not included. Total score and sub-scale scores were computed, which were subsequently converted into percentages for outcome classification. Attitude scores were categorised as positive or negative based on agreement levels with a cut-off value of 75 %, where mean scores of 75 % or above were considered satisfactory (Beekman et al., 2010).

Means, standard deviations (SD), standard errors, and percentages of scores were presented using descriptive statistics. Data were checked for distribution using boxplots and Q-Q Plots; and for homogeneity using the Levene's test. The chi-square test, the independent *t*-test, and the Welch's *t*-test (where appropriate) were used to analyse differences between groups. An analysis comparing the knowledge and attitude scores across different sites was performed (see supplementary file). Pearson's correlation was used to examine the relationships between continuous variables. A linear regression model using the enter method was used to determine if participants characteristics affected the knowledge and attitudes variables. A multiple regression analysis was run to determine which independent variables remained significant. Statistical analysis was performed using IBM SPSS Statistics for Windows (SPSS V.25, Inc. Chicago, IL, USA) with significance set at $p < 0.05$. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist during reporting (Von Elm et al., 2007).

Ethical considerations

The study obtained human research ethics approval from the Human Research Ethics Committee of the University of Wollongong (#2021/160) and the ethics committees at the three research sites (#REC-02-07-2021, #IRB 131-20211, #2156).

Results

A total of 190 nurses participated in the pre-intervention survey (response rate = 63.33 %), and 195 nurses participated in the post-intervention survey (response rate = 65.00%). The majority of participants in both phases were full-time registered nurses with Bachelor degrees. Most participants were female. The mean age of participants in the pre-intervention was 32.84 years (SD = 6.59), while in the post-intervention, it was 34.09 years (SD = 6.26). Among the 195 post-intervention participants, 87 (44.62 %) nurses indicated that they had completed the pre-intervention survey, 72 (36.92 %) did not complete it and 36 (18.82%) were unsure if they had completed it. Detailed demographic characteristics of the participants can be found in Table 1.

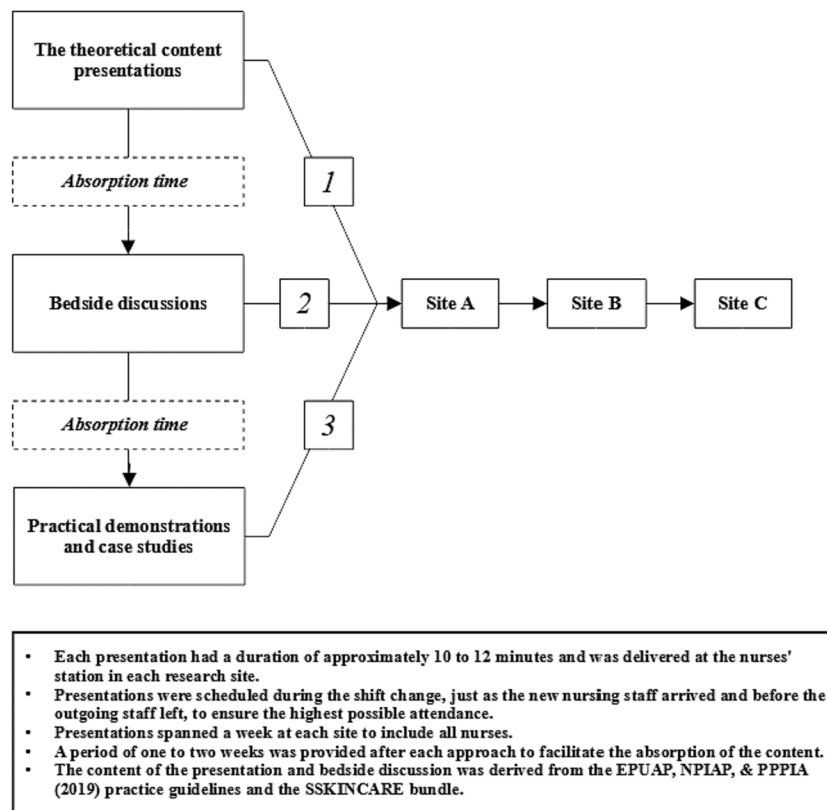


Fig. 1. The content and approach of delivering the educational intervention.

Pressure injury prevention knowledge

The pre-intervention PUKAT 2.0 total score was 43.22 % (0 to 72 %). The post-intervention PUKAT 2.0 total score was 51.22 % (4 to 72 %). The mean post-intervention scores were higher (M = 11.85, SE = 0.25)

Table 1
Demographic characteristics.

	Pre-intervention (n = 190)	Post-intervention (n = 195)
Age, Mean (SD)	32.84 (6.59)	34.09 (6.26)
Gender, n (%)		
Male	25 (13.16%)	37 (18.97%)
Female	154 (81.05%)	141 (72.31%)
Prefer not to say	11 (5.79%)	1 (0.51%)
Missing		16 (8.21%)
Nursing Experience, Mean (SD)	7.96 (6.15)	9.34 (6.07)
ICU Experience, Mean (SD)	4.44 (4.19)	5.31 (4.43)
Position, n (%)		
Registered nurse	162 (85.26%)	159 (81.51%)
Senior nursing specialist	1 (0.53%)	15 (7.69%)
Nurse practitioner	19 (10.00%)	3 (1.54%)
Nurse supervisor	2 (1.05%)	3 (1.54%)
Nurse consultant	1 (0.53%)	0 (0.00%)
Missing	5 (2.63%)	15 (7.69%)
Employment Status, n (%)		
Full-time	172 (90.53%)	173 (88.72%)
Temporary full-time	6 (3.16%)	7 (3.59%)
Part-time	0 (0.00%)	0 (0.00%)
Temporary part-time	3 (1.58%)	0 (0.00%)
Missing	9 (4.74%)	13 (7.67%)
Nursing Qualification, n (%)		
Diploma	12 (6.31%)	24 (12.31%)
Bachelor degree	164 (86.32%)	141 (72.31%)
Post-graduate certificate	4 (2.11%)	3 (1.54%)
Master degree	8 (4.21%)	15 (7.69%)
Missing	2 (1.05%)	11 (5.64%)

than the mean pre-intervention scores (M = 09.61, SE = 0.18) and were statistically significant [M = 2.24, 95 % CI [1.63, 2.86], t (355.74) = 7.16, p < 0.001]. An independent t-test was used to compare the overall knowledge scores between groups, and the post intervention scores were significantly higher than the pre intervention scores. Welch's t-test was used to assess the difference in mean knowledge sub-scale scores pre- and post-intervention. Results showed that after the intervention, participants scored higher than before on five subscales: aetiology, classification and observation, nutrition, pressure ulcer prevention, and specific patient groups. There were no statistically significant changes in the subscale "Risk assessment", despite scores improving. Table 2 shows the differences between the pre- and post-intervention phases, including item-level differences for the PUKAT 2.0.

Pressure injury prevention attitudes

The APuP score before the intervention was 74.77 % (38.88 / 52; range = 30 to 51). The APuP score after the intervention was 79.02 % (41.09 / 52; range = 31 to 52). The post-intervention score was higher than the pre-intervention score [M = 2.21, 95 % CI [-0.325, 0.117], t (309.56) = 4.19, p < 0.001]. A chi-square test was conducted to analyse the observed frequencies in the categorical variable. The results showed that 109 nurses exhibited positive attitudes towards PI prevention compared to 75 nurses in the pre-intervention phase [χ^2 (1) = 10.40, p < 0.001]. Results revealed that after the intervention, participants scored higher than before on three APuP subscales: 'Priority of pressure ulcer prevention', 'Impact of pressure ulcers', and 'Responsibility in pressure ulcer prevention'. The mean score on the 'Personal competency to prevent pressure ulcers' and the 'Confidence in the effectiveness of prevention' subscales increased but was not statistically significant. Table 3 presents the before and after intervention comparisons, along with APuP item differences.

Table 2
Results of the knowledge analysis (PUKAT 2.0).

PUKAT 2.0		Pre-intervention		Post-intervention		t	df	p value
Subscale	Items description	Mean (%)	SD	Mean (%)	SD			
Aetiology	Item 1: Causal factors in PI development	48.42	5.01	80.51	3.97	6.95	359.83	<0.001 ^b
	Item 2: Impact of elevated head-of-bed positioning (60°) on patient's skin	37.89	4.86	17.43	3.80	4.59	357.64	<0.001 ^b
	Item 3: Average percentage of patients with PIs	28.95	4.55	24.10	4.29	1.08	380.28	0.283 ^b
	Item 4: Association between excessively moist skin and increased body temperature with PI development	77.37	4.20	63.08	4.84	3.10	377.93	0.002 ^b
	Item 5: Case: Highest risk for PI development in an immobile patient	31.05	4.64	69.23	4.63	8.08	383	<0.001 ^a
	Item 6: Identifying correct statement: Risk assessment	11.58	3.21	04.61	2.10	2.51	324.96	0.070 ^b
	Aetiology subscale	39.21	19.68	43.16	18.81	2.02	383	0.045^a
Classification and observation	Item 7: Case: Observing a new blister on the patient's heel	16.32	3.70	15.38	1.23	5.22	229.45	<0.001 ^b
	Item 8: Case: Detecting PI stage I	40.00	4.91	71.79	4.51	6.62	378.36	<0.001 ^b
	Item 9: Identifying PI stage with the presence of necrotic tissue	55.79	4.98	71.79	4.51	3.30	377.17	<0.001 ^b
	Item 10: Case: Observing a bony structure in a wound	63.68	4.82	80.00	4.01	3.60	367.14	<0.001 ^b
	Classification and observation subscale	43.95	25.12	56.28	23.99	4.93	383	<0.001^a
Risk assessment	Item 11: Case: Risk assessment for patient is at risk	28.95	4.55	27.69	4.49	0.27	382.40	0.013 ^a
	Item 12: The frequency of skin assessment on pressure points	85.26	3.55	90.26	2.97	1.49	367.95	0.050 ^b
	Risk assessment subscale	57.11	27.50	58.97	27.51	0.67	383	0.505^a
Nutrition	Item 13: Case: The need for nutritional supplementation	29.47	4.57	46.67	5.00	3.52	381.45	<0.001 ^b
	Item 14: The most essential nutritional elements to prevent PI	51.58	5.01	54.36	4.99	0.54	383	0.586 ^a
	Item 15: Type of patients at risk to develop PI	74.73	4.36	83.59	3.71	2.14	370.43	0.032 ^b
	Nutrition subscale	51.93	29.38	61.54	30.97	3.12	383	0.002^a
Prevention	Item 16: Percentage of at-risk patients receiving adequate PI prevention	21.05	4.09	25.64	4.38	1.06	324.31	0.289 ^b
	Item 17: Identifying the semi Fowler position	10.53	3.08	54.87	4.99	10.53	370.37	<0.001 ^b
	Item 18: Determining the most effective repositioning protocol	57.37	4.96	76.92	4.22	4.16	342.11	<0.001 ^b
	Item 19: Assessing the suitability of using a ring cushion for PI prevention	13.16	3.39	46.15	4.99	7.60	328.34	<0.001 ^b
	Item 20: Bed linen utilisation for PI prevention	4.74	2.13	02.05	1.42	1.45	343.78	0.145 ^b
	Item 21: The optimal technique for positioning a seated patient	12.63	3.33	06.15	2.41	2.18	381.14	0.029 ^b
	Item 22: Case: PI prevention measures for a patient lying on a pressure redistributing foam mattress	52.10	5.01	64.62	4.79	2.50	327.95	0.013 ^b
	Item 23: PI prevention through repositioning	18.42	3.89	07.18	2.59	3.33	350.37	<0.001 ^b
	Prevention subscale	23.75	13.64	35.45	17.09	7.43	386	0.002^b
Specific patient groups	Item 24: PI development in operating rooms	14.21	03.50	41.03	4.93	6.16	383	<0.001 ^b
	Item 25: Highest-risk anatomical location for PI development in babies	70.53	04.57	61.54	4.88	1.87	383	0.036 ^b
	Specific patient groups subscale	42.37	29.68	51.28	38.48	2.54	363	0.011^b
Total PUKAT 2.0 score		43.22	12.82	51.22	15.87	6.73	306	<0.001^a

SD = Standard Deviation; t = T value; df = Degrees of freedom; a Using independent t-test; b Using Welch's t-test, Total PUKAT 2.0 score is out of 25.

Relationships between knowledge and attitude

Pearson's correlation identified that a higher knowledge score was correlated with a moderately positive attitude ($r = 0.34$, $p < 0.001$). A weak positive correlation was also identified between increased age and increased knowledge about PI prevention ($r = 0.12$, $p = 0.02$). There was a weak positive correlation between years of ICU experience and knowledge: the more years of experience, the greater the level of knowledge about PI prevention ($r = 0.12$, $p = 0.02$). Finally, there was a weak positive correlation between nurses' increased knowledge level and increased clinical experience in nursing ($r = 0.17$, $p < 0.001$). The results of the correlation analysis are shown in Table 4.

Regression analysis for knowledge and attitude

Multiple linear regression analysis revealed that nurses who had a bachelor's qualification had higher knowledge scores ($\beta = 1.48$, $p = 0.03$, CI (95 %) = [0.13, 2.82]). Nurses with a Bachelor's degree or higher had a 1.48 times higher chance of having sufficient knowledge about PI prevention. Similarly, the variable of bachelor qualification also predicted attitude ($\beta = 2.61$, $p = 0.03$, CI (95 %) = [0.31, 4.91]). Having a Bachelor's degree in Nursing or a higher qualification was associated with a 2.61 times higher positive attitude towards preventing PIs. The remaining demographic characteristics did not statistically significantly predict knowledge or attitudes. Table 5 presents the results of the multiple regression analysis.

Discussion

This study examined nurses' knowledge and attitudes regarding PI prevention in intensive care settings before and after receiving an educational intervention at three hospitals across three regions of the KSA. The findings of this study indicate that a large proportion of nurses had a knowledge deficit regarding PI prevention before implementation of the intervention. These findings are consistent with those of other studies conducted in similar critical care settings (Hu et al., 2021; Zhang et al., 2021). This may suggest that nurses are not adequately prepared to implement PI prevention programs in critical care settings within their pre-registration nursing programmes (Li et al., 2022).

Nurses' knowledge scores improved after receiving a tailored, evidence-based educational intervention. This finding aligns with the research conducted by Gocmen Baykara et al. (2021), which demonstrated the effectiveness of tailored PI prevention education programs in enhancing nurses' knowledge. The improvement may be attributed to intensive training, including small groups and bedside discussions, designed using the KTA framework (Graham et al., 2006). Interactive learning experiences and personalised feedback may also have contributed. The majority of participants in our study held a bachelor's degree, which aligns with research showing that nurses with a bachelorette education have enhanced ability to efficiently translate knowledge into practice (Parisod et al., 2022). The use of diverse delivery approaches underscores the significance of regular knowledge updates for the effective implementation of evidence-based practices (Deakin

Table 3
Results of the attitudes analysis (APuP).

APuP	Subscale	Items' concept	Pre-intervention		Post-intervention		t	df	p value
			Mean	SD	Mean	SD			
Personal competency to prevent pressure ulcers (/12)		Item 1: Confidence in preventing PI	3.22	0.50	3.37	0.56	2.63	344.50	0.009 ^b
		Item 2: Well-trained in PI prevention	3.10	0.58	3.25	0.55	2.47	347	0.014 ^a
		Item 3: Perceived difficulty in PI prevention and comparing oneself to others	2.87	0.71	2.85	0.88	0.28	335.34	0.777 ^b
		Total subscale	9.20	1.11	9.46	1.45	1.88	322	0.061^b
Priority of pressure ulcer prevention (/12)		Item 4: Perception of excessive focus on PI prevention	1.99	0.68	2.80	0.87	9.70	329.69	<0.001 ^b
		Item 5: Understand the importance of PI prevention	3.24	0.88	3.19	0.87	0.53	350	0.596 ^a
		Item 6: Making PI prevention a priority	3.33	0.69	3.22	0.69	1.56	349	0.118 ^a
		Total subscale	8.57	1.49	9.20	1.68	3.73	344	<0.001^a
Impact of pressure ulcers (/12)		Item 7: Discomfort associated with PI	3.19	0.85	3.29	0.83	1.10	350	0.270 ^a
		Item 8: The overemphasising the financial impact caused by PI	2.64	0.78	2.95	0.80	3.68	346	<0.001 ^a
		Item 9: The financial impact caused by PI on society	2.81	0.74	2.87	0.80	0.73	345	0.463 ^a
		Total subscale	8.64	1.62	9.15	1.67	2.86	344	0.004^a
Responsibility in pressure ulcer prevention (/8)		Item 10: Responsibility for PI development in patients	3.03	0.82	3.20	0.92	1.83	340.26	0.068 ^b
		Item 11: Significance of the role in PI prevention	3.28	0.65	3.57	0.55	4.53	349	<0.001 ^a
		Total subscale	6.32	1.17	6.78	1.23	3.60	344	<0.001^b
		Item 12: PIs are preventable in high-risk patients	3.05	0.62	3.02	0.72	0.31	347	0.757 ^a
Confidence in the effectiveness of prevention (/8)		Items 13: PIs are rarely preventable	3.03	0.75	3.13	0.75	1.21	341	0.228 ^a
		Total subscale	6.08	0.92	6.19	1.12	1.01	320	0.317^b
		Total APuP Score (/52)	38.88	4.31	41.09	5.13	4.19	309.56	<0.001^b
Percentage of participants with a positive attitude			74.77%	(n = 75)	79.02%	(n = 109)	1	<0.001^c	

t = T value; df = Degrees of freedom;

Total APuP score is out of 52.

^a Using independent t-test; ^b Using Welch's t-test; ^c Using Chi-square test.

Table 4
Correlation between demographic variables and knowledge and attitudes.

		1	2	3	4	5
Age	Pearson	1				
	p value					
Nursing experience	Pearson	0.66*	1			
	p value	<0.001				
Experience in ICU	Pearson	0.45	0.39	1		
	p value	<0.001*	0.646			
Knowledge	Pearson	0.12*	0.17*	0.12*	1	
	p value	0.026	0.001	0.019		
Attitudes	Pearson	0.05	0.10	0.05	0.34*	1
	p value	0.440	0.072	0.380	<0.001	

*Significant correlation values.

et al., 2023).

Nurses' attitudes towards PI prevention were less than satisfactory prior to the intervention, with an average of 74.77 %. This result was discordant with other studies conducted in the same and other contexts (Barakat-Johnson et al., 2018; Grešš Halász et al., 2021; Hu et al., 2021), but similar to one other study conducted in ICUs in Iran (Khojastehfar et al., 2020). It is possible that nurses in our study were unaware of the severity of the problem, had insufficient knowledge, viewed PI prevention as a low-priority task, or did not fully appreciate its importance

Table 5
Results of multiple linear regression to investigate demographics effect on nurses' knowledge and attitude.

	PUKAT 2.0 scores				APuP scores			
	B	t	p	CI (95%)	B	t	p	CI (95%)
Age	0.06	1.69	0.093	-0.01, 0.14	-0.03	-0.47	0.640	-0.14, 0.09
Sex	-0.11	-0.29	0.771	-0.85, 0.63	-0.69	-1.15	0.252	-1.87, 0.49
Nursing experience	0.01	0.23	0.821	-0.08, 0.10	0.11	1.46	0.145	-0.04, 0.25
Experience in ICU	0.02	0.39	0.695	-0.08, 0.12	-0.01	-0.09	0.928	-0.18, 0.16
Position	-0.34	-1.59	0.113	-0.76, 0.08	-0.08	-0.24	0.813	-0.76, 0.60
Employment status	-0.55	-0.79	0.431	-1.92, 0.82	1.16	1.03	0.306	-1.07, 3.39
Qualification (Bachelor degree or higher)	1.48	2.16	0.031	0.13, 2.82	2.61	2.23	0.026	0.31, 4.91

B = Beta coefficient; t = T value; CI = Confidence Interval.

(Lee et al., 2022; Rostamvand et al., 2021).

Frequently repeated educational sessions with nurses may have contributed to noticeable changes in outcomes. This result aligns with those of other studies (Barakat-Johnson et al., 2018; Jiang et al., 2020; Khong et al., 2020), indicating that the educational intervention was tailored and delivered effectively, allowing for sustained learning and behavioural changes. It also implies that the intervention addressed a gap in implementing preventive measures recommended by the international guidelines (EPUAP, NPIAP, & PPPIA, 2019). The findings of this study support use of the KTA framework to ensure that PI prevention education is focused on individualising interventions to meet the needs and characteristics of the target audience and facilitate sustained behaviour change through continued support and reinforcement (Graham et al., 2006).

Relationships between nurses' demographic characteristics and their knowledge and attitudes towards PI prevention were identified. The mean knowledge scores for PI prevention were found to be higher among older nurses, contrary to the findings of previous studies that suggest that younger nurses exhibit higher scores (Kaddourah et al., 2016; Khojastehfar et al., 2020). However, recent evidence from a systematic review and meta-analysis conducted by Wu et al. (2022) supports our findings, showing that older nurses have higher knowledge scores for PI prevention. Older nurses may have had greater opportunities to acquire specialised knowledge and skills related to PI

prevention through work experience and observation (Mlambo et al., 2021).

A bachelor's degree or higher in nursing was found to be an independent factor that improved nurses' knowledge and attitudes toward PI prevention. Jiang et al. (2020) conducted a large-scale study and found that nurses with a bachelor's degree were more likely to have good PI knowledge than nurses with a diploma or less. Similarly, Zhang et al. (2021) found that nurses with a bachelor's degree had more positive attitudes toward preventing medical device-related PIs. However, it is important to note that experience and continuing education may also impact nurses' knowledge and attitudes regarding PI prevention (Jiang et al., 2020).

Strength and limitations

Strengths of this study include the utilisation of baseline data to inform the development of a tailored educational intervention, ensuring alignment with participants' needs and targeted outcomes. This approach facilitated knowledge translation and attitude change.

A limitation of the study is the absence of unique participant codes, preventing assessment of knowledge and attitude change for individual participants. This limited our ability to assess the relationship between the intervention and observed changes. Future studies should implement mechanisms to accurately track participants across evaluation phases. Additionally, the lack of a criterion for defining sufficient knowledge in the PUKAT2.0 instrument limited the depth of assessment.

Conclusions

This multi-centre study examined nurses' knowledge of, and attitudes towards, PI prevention in ICUs before and after an educational intervention. The intervention involved small-group sessions, bedside discussions, case studies, and presentations, resulting in an improvement in nurses' knowledge about PI prevention. Nurses' attitudes towards PI prevention practices also improved following the intervention. These findings provide insight into the importance of context-specific and tailored educational interventions to improve PI prevention practices for critically ill patients.

Funding statement

No funding was received to support conducting this study. The first author is a recipient of a PhD scholarship from the Government of Saudi Arabia, but the funding authority was not engaged in either the writing of this paper or the decision to publish it.

Ethical considerations

The study obtained human research ethics approval from the Human Research Ethics Committee of the University of Wollongong (#2021/160) and the ethics committees at the three research sites (#REC-02-O7-2021, #IRB 131-20211, #2156).

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.

Acknowledgments

The authors would like to express their gratitude to Dr Bradley Wakefield for his support and direction with statistical analysis. The authors would also like to thank all participants for their involvement in this study.

Author contributions

All authors: made significant contributions to the conceptualisation and design, data collection, data analysis, and data interpretation. BA: involved in data collection and analysis, and initial drafts writing. RM, KR and JS: involved in drafting the manuscript or revising it critically for important intellectual content. BA, RM, KR and JS: approved the final version to be submitted for publication. All authors: have agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the article are appropriately investigated and resolved.

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