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Original article

Predictors of pressure ulcer risk in adult intensive care patients: A retrospective case-control study

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ABSTRACT

Objectives: To evaluate the predictive power of risk factors for pressure ulcers in adult intensive care patients.
Method: A retrospective case-control study was performed utilising a heterogeneous sample group allocated into a case group with pressure ulcers ($n = 90$) and a control group without pressure ulcers ($n = 90$). The analysis explored the predictive power of risk factors for pressure ulcers using a hierarchical logistic regression model.
Results: The risk factors that predicted pressure ulcers were friction (OR = 5.97), previous history of pressure ulcers (OR = 5.43), prolonged intensive care unit stay (OR = 3.92), dehydration (OR = 3.18), elevated skin temperature by 1–2 °C (OR = 3.12) and treatment of other comorbidities (OR = 2.79).
Conclusion: Adult intensive care patients have an increased risk of developing a pressure ulcer. These risk factors are regarded as strong predictors for pressure ulceration. This study advances nursing knowledge in that it investigates additional risk factors for the development of pressure ulcers and it identifies a set of factors that best predict their occurrence, which may contribute to the nurses' diagnostic reasoning in the intensive care unit.

Implications for clinical practice

- The identification of risk factors for pressure ulcers in critically ill patients may offer strategies to promote safe care and reduce the risk of morbidity and mortality in these patients.
- The set of factors that increase pressure ulcer risk in adult intensive care patients identified in this study may contribute to better diagnostic reasoning by nurses.
- Knowledge about risk factors for the development of pressure ulcers may lead to good nursing practice and promote excellent prevention in adult intensive care patients.

Introduction

Patient safety is part of the central axis of care and quality management in health services. It involves environmental safety and risk management, including infection control, safe use of medicines, equipment safety, safe clinical practice and a safe environment of care (WHO, 2002).

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In the 1990s, the report "To err is human: building a safer health system" was published by the Institute of Medicine in the United States of America. The high incidence of adverse events in hospital institutions, usually caused by human error, presented by the report, stimulated public debate about patient safety worldwide (WHO, 2002).

The World Health Organisation (WHO) estimates that one in 10 patients are victims of adverse events in health care and approximately 43 million patient safety incidences occur every year.

The intensive care unit (ICU) is the sector that has the greatest chance of occurrence of adverse events due to the clinical instability of patients and the high number of interventions. Pressure ulcers (PUs) are common adverse events with high prevalence and incidence in the ICU (Boyle et al., 2006).

PUs cause great physical and emotional suffering to the patient, compromise the rehabilitation process, prolong hospitalisation, increase the risk of other diseases, decrease quality of life and increase financial costs for healthcare organisations (Carson et al., 2012). Worldwide, costs for the treatment of pressure ulcers and their complications are estimated at $11 billion annually (AHRQ, 2014).

In the United States, 2.5 million hospitalised patients develop pressure ulcers each year, with a prevalence of 22%, and approximately 60,000 patients died from injury-related complications (AHRQ, 2014; Van gilder et al., 2009; Still et al., 2013). The presence of PUs was significantly associated with mortality at 21 days in patients with severe traumatic brain injury (Dhandapani et al., 2014).

Pressure ulcer prevention is a strategy directly related to patient safety and should be a priority of health professionals, especially nurses (Santos et al., 2016). The recognition of risk factors for PUs and the use of prevention measures are recommended practices that can reduce the incidence of cases and improve nursing care for patients admitted to the ICU (Duncan, 2007; Stechmiller et al., 2008).

The literature identifies evidence concerning evaluation and identification of PU risk factors, especially in ICU, such as age, comorbidity, treatment, extremes of weight, prolonged ICU stay, inadequate nutrition, decreased mobility, incontinence, anaemia, lymphopenia, medicines, hypoalbuminemia, friction, skin moisture, oedema, elevated skin temperature, sedation and limitations of sensory perception (Alderden et al., 2011, 2017; Nijs et al., 2008; Frankel et al., 2007; Kaitani et al., 2010). However, other factors may be included, such as: previous history of pressure ulcer, smoking, insufficient caregiver knowledge of pressure ulcer prevention, dry skin, tissue hypoperfusion, dehydration, thin skin, pressure, shearing forces and scaly skin. In this context, it is necessary to identify a set of risk factors that best predict the risk for developing a pressure ulcer in ICU.

Risks associated with pressure ulcers are often unrecognised. A prevalence study of pressure ulcers performed in Norway showed poor knowledge among the nursing team regarding the classification of pressure ulcers and risk assessment of PUs (Bjøro and Ribu, 2009).

In this context, knowledge of nurses in the assessment of the predictive accuracy of PU risk factors is considered relevant and could promote a positive impact on patient safety with excellence in the care of the critically ill patient.

This study advances nursing knowledge in that it investigates additional risk factors for the development of pressure ulcers (Alderden et al., 2011, 2017; Nijs et al., 2008; Frankel et al., 2007; Kaitani et al., 2010) and it identifies a set of factors that best predict the occurrence of pressure ulcers in intensive care unit patients.

This study aimed to answer the following question: What are the risk factors that increase the chances of development of pressure ulcers in intensive care unit patients? To answer this question, we aimed to evaluate the predictive power of risk factors for pressure ulcers in adult intensive care patients.

Method

Design and setting

This was a retrospective case-control study, conducted in the first semester of 2016 in a general ICU of a large university hospital in northeast Brazil. This is a reference unit for quality in the care of critically ill patients.

Sample

The study population included patients admitted to the ICU of the hospital. The following parameters were used in the sample calculations: 95% confidence level ($Z1\text{-}\alpha/2 = 1.96$), 80% power ($Z1\text{-}\beta = 0.84$), odds ratio of developing ulcers due to a pressure of greater than 2.5 ($OR = 2.5$), and ratio between the number of controls and cases equal to 1 ($r = 1$). Assuming equal numbers of cases and controls, the sample size was 90 in each group (90 cases and 90 controls), for a total of 180 patients. No losses occurred during the data collection process.

Cases included patients with pressure ulcers at the time of data collection, the control group included patients without pressure ulcers. This classification was performed by the researcher through evaluation of the patient at the time of a bath and/or by checking the nursing records in the information system of the hospital.

The eligibility criterion for the case and control groups was age equal to or greater than 18 years. For the case group, the presence of at least one pressure ulcer from "stage I" was required. Sampling was done consecutively.

Instrument

A data collection form was specifically designed by the researchers for this study. The instrument included items regarding social and clinical data and pressure ulcer risk factors. It was validated by seven teacher nurses with experience in nursing diagnoses and pressure ulcers. Modifications to the organisation of the questions were suggested to clarify the measurement. The suggestions made by the experts were applied to the final version of the form.

Procedure

The data were obtained by a primary source through direct interaction with the patient and through a physical examination. Secondary source included the clinical records. To perform the data collection, the researcher classified the patient as case or control group and delegated the data collection function to another researcher.

Data analysis

The data were organised by means of a spreadsheet built in Microsoft Excel and were analysed using the statistical package R, version 3.0.2 (R Core Team, 2015).

Continuous data (age, length of hospital stay, length of ICU stay) were presented by means of measures of central tendency and dispersion. The Kolmogorov-Smirnov test was applied to check the normality of the data ($p < 0.05$). Categorical data were dichotomized and presented as percentages and frequencies (gender, comorbidities). Patient characteristics were compared between cases and controls using the Mann–Whitney *U* test.

Table 1
Characteristics of case and control groups.

Variables	Case (n = 90)	Control (n = 90)	Statistic
Gender			p = 0.765
Female	43 (48%)	41 (46%)	OR = 1.093
Male	47 (52%)	49 (54%)	IC95% = [0.609-1.964]
Comorbidities			p = **0.001**
Yes	75 (83%)	56 (62%)	OR = **3.036**
No	15 (17%)	34 (38%)	IC95% = [1.509–6.108]

Variables	Group	Mean (±)	Medium	p Value
Age (years)	Case	58.6 (±15.5)	61.0	**0.026**
	Control	61.4 (±14.2)	63.0	
Length of hospital stay	Case	22.3 (±33.3)	12.0	**<0.001**
	Control	31.4 (±13.1)	17.0	
Length of ICU stay	Case	6.7 (±11.1)	3.0	**0.002**
	Control	10.3 (±4.6)	5.0	

Note. OR – Odds Ratio; CI – Confidence interval; *p – value* of Mann–Whitney *U* test.

The risk factors for the development pressure ulcers were dichotomised as present or absent. They were divided into previous clinical factors (block 1), actual clinical factors (block 2) and skin factors (block 3).

Block 1 was composed of variables related to previous risk factors: diabetes mellitus, comorbidities, treatment of comorbidities, previous history of UP, extreme weight, smoking and insufficient caregiver knowledge of pressure ulcer prevention. Block 2 represented variables related to actual risk factors: prolonged ICU stay, inadequate nutrition, decreased mobility, incontinence, anaemia, lymphopenia, medicines and changes in level of consciousness. Block 3 was formed by risk factors related to skin integrity: hypoalbuminemia, friction, skin moisture, dry skin, tissue hypoperfusion, dehydration, oedema, thin skin, elevated skin temperature by 1–2 °C, limitations of sensory perception, pressure, shearing forces and scaly skin.

A hierarchical logistic regression model with input of backward stepwise variables for the risk factors of developing pressure ulcers was used. The objective was to identify the set of risk factors that presented a strong indication for increased risk of developing pressure ulcers.

To verify the fit of the model, the Omnibus test was applied. The adequacy of each variable included in the model was analysed by the Wald Chi-square test. The Hosmer and Lemeshow test was applied to verify the goodness of the fit, comparing the expected and observed frequencies. Nagelkerke R2 was calculated to verify the predictive capacity of the model.

Ethical considerations

The study was approved by the Research Ethics Committee of the research institution (No. 848.997), and informed consent was obtained for each patient.

Results

This study had a sample of 180 participants, 90 in the control group and 90 in the case group. Table 1 represents the social and clinical characteristics of the groups. No differences were found between the gender of the groups; however, there were more elderly patients in the control group.

The comorbidities were more common in the case group, increasing the risk for the development of pressure ulcers (OR 3.036, IC 1.509-6.108). The control group had the longest length of hospital (p < 0.001) and ICU stay (p = 0.002).

Table 2
Risk factors of ND risk of pressure ulcer.

Risk factors	Cases (n = 90)	Control (n = 90)	Statistic
Previous			
Diabetes Mellitus			p = **0.013*** OR = 2.200
	40	24	IC95% = [1.177-4.112]
Comorbidities	75	56	p = **0.001*** OR = **3.036**
			IC95% = [1.509- 6.108]
Treatment of Comorbidities	73	55	p = **0,003*** OR = **2733**
			IC95% = [1389–5377]
Previous history of pressure ulcer			p = **0.001*** OR = 8.800
	15	2	IC95% = [1.949–39.724]
Extremes of weight			p = 0.282* OR = 1.474
	23	17	IC95% = [0.725–2.996]
Smoking			p = 0.873* OR = 1.053
	29	28	IC95% = [0.562–1.973]
Insufficient caregiver knowledge of pressure ulcer prevention			p = 0.445* OR = 0.675
	7	10	IC95% = [0.245–1.859]
Actual			
Prolonged ICU stay	35	7	p = **0.001*** OR = 7.545
			IC95% = [3.129–18.194]
Inadequate nutrition			p = **0.001*** OR = 3.414
	79	61	IC95% = [1.580–7.376]
Decreased mobility			p < **0.001*** OR = 4.908
	73	42	IC95% = [2.509–9.599]
Incontinence			**p = 0.004*** OR = 2.379
	50	31	IC95% = [1.304–4.342]
Anaemia			p = **0.005*** OR = 3.316
	82	68	IC95% = [1.388–7.921]
Lymphopenia			p = 0.551* OR = 1.195
	45	41	IC95% = [0.665–2.146]
Medicines			p = 0.639* OR = 0.864
	30	33	IC95% = [0.468–1.594]
Change in level of consciousness			p = 0.563* OR = 1.250
	18	15	IC95% = [0.586–2.667]
Skin integrity			
Hypoalbuminemia			p = **0.001*** OR = 3.415
	31	12	IC95% = [1.618–7.210]
Friction			p < **0.001*** OR = 16.000
	87	58	IC95% = [4.680–54.696]
Skin moisture			p = **0.002*** OR = 2.792
	37	18	IC95% = [2.792–5.433]
Dry skin			p = 0.065* OR = 1.771
	40	28	IC95% = [0.963–3.260]
Tissue hypoperfusion			p = **0.001*** OR = 2.929
	41	20	IC95% = [1.533–5.595]
Dehydration			p < **0.001*** OR = 6.155
	56	19	IC95% = [3.176–11.929]
Oedema			p = **0.003*** OR = 2.471
	56	36	IC95% = [1.357–4.500]
Thin skin			p = **0.007*** OR = 2.254
	52	34	IC95% = [1.241–4.095]
Elevated skin temperature by 1–2 °C	23	8	p = **0.003*** OR = 3.519
			IC95% = [1.479–8.372]
	39	29	IC95% = [0.876–2.953]
Limitations of sensory perception			p = 0.127* OR = 1.688
	28	19	IC95% = [0.859–3.314]
Pressure			p = Indeterminate
			OR = Indeterminate
			IC95% = Indeterminate
	0	0	
Shearing forces			*p = 0.278** OR = 3.143
	88	84	IC95% = [0.617–16.009]
Scaly skin			p = 0.382* OR = 1.359
	24	19	IC95% = [0.682–2.706]

OR = Odds Ratio; CI –Confidence interval; **p value* of the Chi-square test; ***p value* of Fisher's exact test.

Table 3
Logistic regression model for risk factors for the development of pressure ulcers in the ICU.

Stage 1	**Variables**	**B**	**OR**	**χ^2**	**gl**	**p value***	**IC95%**
	Previous history of pressure ulcer	2.01	7.44	6.12	1	0.013	1.52–36.46
	Comorbidities treatment	0.87	2.39	5.41	1	0.020	1.15 – 4.97
	Prolonged UCI stay	1.88	6.53	16.39	1	<0.001	2.63 – 16.18
	Constant	-1.14	0.32	11.93	1	0.001	
	Omnibus Tests of Model Coefficients						**R^2 Nagelkerke**
	Stage			40.16	3	<0.001	0.267
	Block			40.16	3	<0.001	
	Model			40.16	3	<0.001	
	Hosmer-Lemeshow test			3.41	3	0.333	
Stage 2	**Variables**	**B**	**OR**	**χ^2**	**gl**	**p value***	**IC95%**
	Previous history of pressure ulcer	1.693	5.43	3.83	1	0.050	1.00 – 29.64
	Treatment of Comorbidities	1.025	2.79	6.03	1	0.014	1.23 – 6.31
	Prolonged ICU stay	1.366	3.92	7.58	1	0.006	1.48 – 10.36
	Friction	1.786	5.97	6.74	1	0.009	1.55 – 22.99
	Dehydration	1.158	3.18	8.61	1	0.003	1.47 – 6.89
	Elevated skin temperature by 1–2 °C	1.139	3.12	4.88	1	0.027	1.14 – 8.59
	Constant	−3.318	0.04	20.97	1	<0.001	
	Omnibus Tests of Model Coefficients						**R^2 Nagelkerke**
	Stage			−2.27	1	0.132	0.455
	Block			34.92	3	<0.001	
	Model			75.08	6	<0.001	
	Hosmer-Lemeshow test			1.57	8	0.992	

OR = Odds Ratio; CI –Confidence interval; **p value* of the Wald Chi-square test.

The risk factors for developing PU were measured in the case and control groups. Table 2 presents the risk factors, divided into previous risk factors, actual risk factors and skin factors.

A backward stepwise hierarchical logistic regression model was adjusted to identify hierarchical causal relationships between the presumed risk factors for pressure ulcer development.

The variables that had a level of significance lower than 0.1 in the bivariate analysis were then analysed again.

After insertion and adjustment of the model with the three blocks, the variables that made up the second block had a p value greater than 0.05 and were thus excluded. Finally, a hierarchical model with two groups of variables was obtained. Table 3 presents the final model of logistic regression for risk factors for developing pressure ulcers.

The final logistic model presented a set of variables divided into two blocks. The first block included three variables related to previous risk factors. Previous history of PU increases the risk of developing PU around approximately five times (OR = 5.43). Patients who had received treatment for comorbidities experienced a nearly threefold increased risk of developing PU (OR = 2.79). Patients with a prolonged ICU stay had approximately four times the risk of developing PU (OR = 3.92).

In the second block, three variables directly related to skin integrity increased the risk of PU: friction (OR = 5.97), dehydration (3.18) and elevated skin temperature by 1–2 °C (3.12).

This set of six factors are strong indicators for increased risk of PU. Therefore, the applied logistic model showed statistical significance according to the Omnibus Test ($p < 0.001$). In addition, the coefficients of each factor included in the model were significant based on the Wald Chi-square test ($p < 0.05$). The coefficient of the model (R2 of Nagelkerke) had a value of 0.455, indicating that the risk factors included in the regression model explain 45.5% of the occurrence of PU in ICU patients. Finally, the observed and expected frequencies in the final model did not have significant differences according to the Hosmer-Lemeshow test ($p = 0.992$), providing evidence of the goodness of the fit.

Discussion

In the case and control groups, the confounding variables of gender and age were observed homogeneously between the groups. Male gender had a higher prevalence in both groups, corroborating with a previous study with a similar sample of patients admitted to ICUs (Borghardt et al., 2015). Elderly patients were more frequent in this study. The literature shows a relationship between advanced age and pressure ulcers (Maida et al., 2014; Alderden et al., 2011, 2017; Frankel et al., 2007).

The set of risk factors in blocks in this study was supported by literature. Systematic review shows the complex interplay of PU risk factors and links epidemiological, physiological and biomechanical evidence to facilitate the understanding of the development of PU (Coleman et al., 2014).

Previous history of pressure ulcers increases the chance of developing new PUs five times. The healing process is a long process and the healed lesion does not have the same tensile strength and may lose its integrity more easily. With regard to this, the literature corroborates this finding pointing to previous ulcers as being highly predictive of the development of recurrent ulcers (Pound et al., 2005). The recurrence of pressure ulcers is related to increased health costs and hospitalisation time (Ljung et al., 2017).

Patients who received treatment for comorbidities had a three times greater risk of developing PU. A retrospective observational cohort showed a univariate analysis comparing patients with and without pressure ulcers and comorbidity. The results indicated that 10.7% of critically ill patients developed PU and the more common comorbidities were renal and cardiovascular disease (O'Brien et al., 2014). Furthermore, diabetic patients presented an increase of the risk to develop pressure ulcer (Frankel et al., 2007).

The presence of the risk factor, prolonged ICU stay, increased the chance of developing a pressure ulcer by threefold. A comparative study between the development of PU in ICU and hospitalisation units found that ICU hospitalisation may lead to a higher risk of developing PU, especially when this treatment occurs for a prolonged period (Cremasco et al., 2012; Lahmann et al., 2012). According to binary logistic regression, age, longer ICU stay and infrequent repositioning are significant predictors of all stages of pressure ulcers (Tayyib et al., 2016). Therefore, length of ICU stay is directly related to the gravity of the patients' illness and their needs for healthcare.

The friction risk factor is responsible for a fivefold increase in the chances of an ICU patient developing PU. A previous study showed that friction is 10 times more prevalent in ICU patients (Lahmann et al., 2012). Modifying or removing forces that cause pressure or friction is a key to the prevention of these injuries

(Phillips and Seiverling, 2015). Another study investigated the possibility of using low friction sheets made with synthetic fibres for the prevention of pressure ulcers. These bed sheets had coefficients of friction up to 50% less than conventional sheets (Rotaru et al., 2013).

The findings indicate a three-fold increased chance of developing pressure ulcers for ICU patients with dehydration. Dehydration reduces the supply of oxygen to the tissues and the turgor of the skin, which contributes to increased chances of developing PUs (Barrientos et al., 2005). Another study of nursing diagnosis validated that dehydration is an important risk factor for the development of pressure ulcers (Santos et al., 2016).

The presence of a higher skin temperature by 1–2 °C is a risk factor that increases the chance of developing PU by three times. Increases in temperature and pressure are warning signs, intensifying the sensitivity of the tissues to the development of PU (National Pressure Ulcer Advisory Panel – NPUAP et al., 2014). A previous study evaluated the temperature differences between erythaematous areas and surrounding healthy tissue. The results showed that 63% of the erythaematous sites were warmer than healthy tissue (Sprigle et al., 2001).

The literature counterposes this result, the skin temperature 38.5° was identidyed as a protective effect to pressure ulcer development in ICU patients. This efect is not clear, but may be associated with the improved oxygenation of the tissue (NIJS et al., 2008).

Limitations

This study had limitations related to the sample size and the findings should be interpreted with caution. The unmatched case and control groups and the convenience sampling method may have affected the identification of risk factors for the development of PU. However, the odds ratio was greater than two in this study, confirming the relevance of the risk factors identified.

Conclusion

ICU patients have an increased risk of developing PUs. A set of six risk factors including friction, previous history of pressure ulcers, prolonged intensive care unit stay, dehydration, elevated skin temperature by 1–2 °C and treatment of comorbidities, must be regarded as having strong predictive power for the development of PUs.

The results of this study may enhance the knowledge of nurses in clinical practice. They may also contribute to safer care and to nursing practice in the prevention of PUs in critically ill patients. The dissemination of these findings in an international context provides a foundation for evidence-based practice, favouring nursing diagnostic reasoning. This may support the best outcomes for ICU patients.

Conflict of interest

The authors declare that there is no conflict of interest.

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