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Research Article

Incidence, characteristics, and associated factors of pressure injuries acquired in intensive care units over a 12-month period: A secondary analysis of a quality improvement project

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ABSTRACT

Objectives: To determine the 12-month cumulative incidence, characteristics, and associated factors of pressure injuries acquired in Intensive Care Units.
Setting: Four intensive care units in a Norwegian University Hospital.
Research methodology: A prospective observational cohort study using data from daily skin inspections during a quality improvement project. We used descriptive statistics and logistic regression. Variables associated with the development of intensive care unit-acquired pressure injuries are presented with odds ratios (OR), and 95% confidence intervals.
Results: The 12-month cumulative incidence of patients (N = 594) developing intensive care unit-acquired pressure injuries was 29 % (172/594) for all categories and 16 % (95/594) when excluding category I pressure injuries (no skin loss). Cumulative incidence for patients acquiring medical device-related pressure injuries was 15 % (91/594) and 11 % (64/594) for category II or worse. Compression stockings (n = 51) and nasogastric tubes (n = 22) were the most frequent documented medical devices related to pressure injuries. Development of pressure injuries category II or worse was significantly associated with vasoactive drug infusions (OR 11.84, 95 % CI [1.59; 88.13]) and longer intensive care unit length of stay (OR 1.06, 95 % CI [1.04; 1.08]).
Conclusion: The 12-month cumulative incidence of intensive care unit-acquired pressure injuries was relatively high when category I pressure injuries were included, but comparable to other studies when category I was excluded. Some medical device-related pressure injuries were surprisingly frequent, and these may be prevented. However, associated factors of developing pressure injuries were present and deemed non-modifiable.
Implications for clinical practice: Awareness about pressure injury prevention is needed in the intensive care unit considering high incidences. Nurses can detect category I pressure injuries early, which may be reversed. Our findings show several factors that clinicians can control to reduce the risk of pressure injuries in the intensive care unit.

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Introduction

A pressure injury (PI) is defined as an injury to the skin, nearby and/or underlying tissue, which occurs due to pressure, sometimes in combination with shear, and usually over bony prominences (European Pressure Ulcer Advisory Panel et al., 2019). Medical devices may cause a 'medical device-related pressure injury' (MDRPI), which usually develops in different locations than traditional PIs (European Pressure Ulcer Advisory Panel et al., 2019). PIs are categorised into four categories, I: non-blanchable erythema; II: partial thickness skin loss; III: full thickness skin loss; IV: full thickness tissue loss. PIs can also be categorised as unstageable (depth unknown) or suspected deep tissue injury (depth unknown). MDRPIs may develop in the mucosal membrane, which cannot be categorised. Category I PIs do not have skin loss present, and in most cases, they are reversible when correct interventions are provided (Halfens et al., 2001; Stansby et al., 2014; UK National Clinical Guideline Centre, 2014). Several studies exclude category I when reporting PI incidence, prevalence and associated factors of PIs (Chaboyer et al., 2018).

PIs are defined as adverse events and significant healthcare issues (European Pressure Ulcer Advisory Panel et al., 2019; Coyer et al., 2017). These injuries are associated with pain prolonged treatment with longer hospital stays, longer rehabilitation, increased morbidity and mortality, and lead to significant financial costs for healthcare systems and society (European Pressure Ulcer Advisory Panel et al., 2019; Labeau et al., 2021; McEvoy et al., 2021; Padula & Delarmente, 2019).

Patients in the ICU are at increased risk of developing PI because of multiple pathophysiologic mechanisms. ICU patients are often sedated, immobilised and exposed to a large number of medical devices and equipment needed to provide life-saving treatment, thereby being at risk of PI development (de Almeida Medeiros et al., 2018; Jackson et al., 2019; Labeau et al., 2021; Sala et al., 2021). The incidence of PI is significantly higher in the ICU compared to other contexts (Coyer et al., 2017; Tschannen & Anderson, 2020), varying between 16 and 26 % (Chaboyer et al., 2018). Prevalence of PIs ranges between 16 and 17 % (Labeau et al., 2021; Rubulotta et al., 2022; Lin et al., 2022). Preventing PIs in ICU patients may be difficult due to many intrinsic and unmodifiable risk factors (Labeau et al., 2021), such as reason for admission to the ICU and local factors in the ICU (Deschepper et al., 2021; Deschepper et al., 2022). Existing PI risk assessment tools are not necessarily helpful in identifying ICU patients at more risk than others (Cox et al., 2020; Sala et al., 2021; Zhang et al., 2021). This may affect preventive work carried out in ICUs. Studies are required to better understand the extent and characteristics of PIs, and factors associated with the development of PIs in ICU patients, to achieve targeted risk assessment, implement prevention measures, and improve patient care (Chaboyer et al., 2018; de Almeida Medeiros et al., 2018).

To our knowledge, no studies on PIs have captured PI data, including both MDRPIs and traditional PIs, over a 12-month period. Thus, the main objective of the present study was to determine the incidence of PIs and to describe the characteristics of PIs occurring in ICU patients. In addition, we aimed to determine associated factors of acquiring PIs in four ICUs in Norway over a 12-month period.

Methods

Design

A secondary analysis of data from a quality improvement project with multiple interventions in four ICUs in Norway was performed. The quality improvement project was designed as a prospective and observational cohort study. The methods of encouraging compliance with a selection of guidelines and evidence-based practice included educational sessions, engagement of local opinion leaders and audit and feedback of quality indicators via established, closed Facebook groups, where most of the ICU nurses were members (Petosic et al., 2019), and emails. The majority had seen the Facebook posts 24 h after posting (Petosic et al., 2021). In addition to PIs, the intervention focused on pain, agitation/sedation and delirium (Petosic et al., 2021), early mobilisation (Hauff et al., 2022), multi-professional ward rounds and early enteral nutrition. The current analysis and report focus exclusively on PIs.

Setting and study procedures

Four ICUs providing advanced critical care at Oslo University Hospital participated in the present study. The ICUs had 6–10 staffed ICU beds each. Two ICUs had mainly trauma- and surgical patients, of which one specialised in neuro intensive care, and two ICUs had mixed medical and general surgical patients. During the data collection period, all regular nursing staff were trained in skin assessment in one-hour interactive lectures, scheduled in their work plan (September 2017) as part of the multifaceted intervention campaign. Two to three lectures were organised per ICU to reach all. The lecture focused on the definition of PI, classification of categories, including differential diagnoses, moisture-associated skin damage (MASD) and incontinence-associated dermatitis (IAD) (to avoid confusion and miscounts of PIs) (Johansen et al., 2020) and ultimately, PI-prevention strategies. In addition, emphasis was placed on all ICU patients being at risk of developing PIs. Following the educational sessions, Facebook posts were used for a six-month period to maintain awareness and vigilance on the subject.

Participants

ICU-patients, consecutively admitted to one of the four ICUs during the study period (June 12, 2017, to May 31, 2018) and met the inclusion criteria, were prospectively enrolled in the study. Inclusion criteria were all adult (18 years or older) patients with a minimum ICU length of stay (ICU-LOS) of 48 h. Readmitted ICU patients with previous inclusion and patients with missing data on PI were excluded from the analyses.

Data collection

Demographic data were retrieved from the Norwegian Intensive Care Registry (NIR). Data on PIs were documented by the bedside nurse on each shift on a specific PI study-sheet or in the electronic patient charting system (MetaVision™, iMDsoft, Israel). The PI reporting study-sheet had the possibility of signing for daily skin inspections, documenting PIs on admission, new PIs, medical devices related to MDRPI, location of the PIs and PI categorisation based on the categorisation system by the European Pressure Ulcer Advisory Panel et al. (2019). Each study-sheet included a guide to PI categorisation with an explanation of the categories and images with examples, including the differential diagnoses of MASD and IAD, to prevent these from being counted as PIs. PIs registered in MetaVision™ were compared with those retrieved from the reporting sheets. If a form was missing, the PIs from MetaVision™ were included in the dataset and vice versa.

Variables

Outcome variables related to PIs were PI present on admission (yes/no), number of new PIs, MDRPI (yes/no), number of new MDRPIs, PI-category, PI-location (at each PI), and medical device documented related to MDRPIs (at each MDRPI).

To describe the sample, the following demographic, clinical variables were derived from NIR: age, sex, Simplified Acute Physiology Score (SAPS II), primary cause of ICU admission (defined NIR categories), number of ICU admissions, intensive care treatment (e.g. invasive mechanical ventilation and vasoactive infusion), Nursing Activities Score (NAS), duration of mechanical ventilation, ICU-LOS, and mortality. The patient's body weight was the last documented weight during the ICU stay.

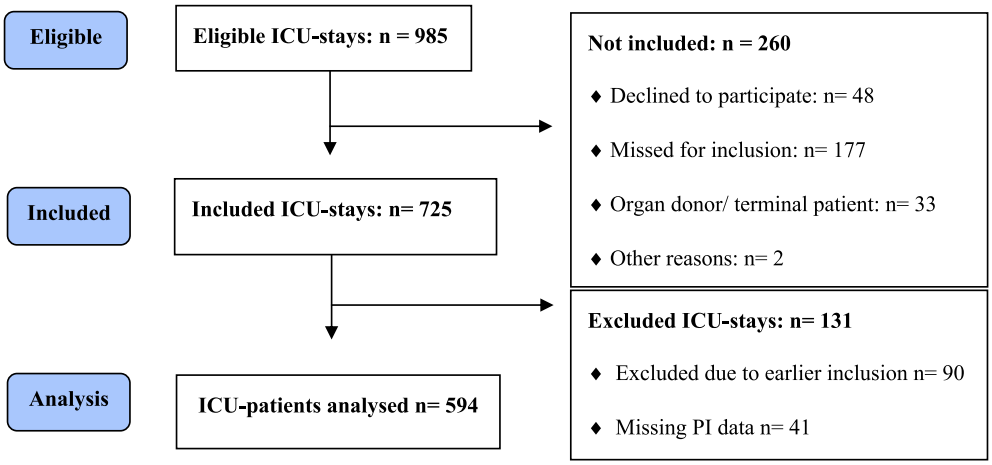

Fig. 1. Flow diagram, inclusion, exclusion of ICU-stays and analysis of ICU-patients, ICU acquired PIs. Abbreviations: (ICU) Intensive Care Unit, (PI) Pressure Injuries.

Data analyses

Continuous variables were described with mean (standard deviation (SD)) or median (interquartile range (IQR)) as appropriate, and categorical variables were described as numbers and percentages. Data were analysed with the IBM Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp., Armonk NY), and Microsoft Excel (2016) was used to summarise and display numbers and counts.

The 12-month cumulative incidence of ICU-acquired PIs was calculated as the proportion of patients who developed at least one PI (new event) during the ICU stay, for PIs in general and for MDRPIs separately. Cumulative incidences are reported, both including and excluding category I. The incidence density rate was defined as the number of patients who developed an ICU-acquired PI, category II or worse, per 1000 ICU days.

In assessing the characteristics of ICU-acquired PIs, categories and locations were presented in the two subgroups: PIs (traditional) and MDRPIs.

To describe associated factors with ICU-acquired PIs, category II or worse, three multiple logistic regressions were conducted. Regression model 1 used the variable occurrence of ICU-acquired PI (traditional), regression model 2 used the variable occurrence of ICU-acquired MDRPI, and regression model 3 used the variable occurrence of ICU-acquired PI (any kind) as the response variable. For all three models, explanatory variables used were ICU number (the ICU admitted to), ICU-LOS, SAPS II, patient sex, weight, PI present on admission, vasoactive infusions and previous admission to ICU. For model 1, the occurrence of MDRPI was added as an explanatory variable, and similarly, for model 2 the occurrence of PI (traditional) was added. Looking for associated variables rather than predictive variables, the explanatory variables listed were included in all models before the model was fitted to data on the basis that they were interesting candidate variables for this problem. The multicollinearity of the explanatory variables in each model was checked by calculating Variance Inflation Factors. No multicollinearity was discovered in any of the models. The results were presented as Odds Ratio (OR) with 95 % confidence interval (CI) and p-values for each variable for both models. The missing values in the variable weight (n = 96) were replaced by the mean weight. Regression analysis was done in RStudio under R version 4.2.1 (R Core Team, 2023).

Ethical approval

This study was approved by the Norwegian Regional Ethics Committee (REK) (2016/2281/REK sør-øst A), the local data protection officer, and ICU management. All patients were prospectively included

Table 1
Characteristics of included ICU* patients (n = 594).

Characteristics	Total n = 594
Age, years, Median (IQR)	59.2 (43.1, 68.8)
Sex, Male, n (%)	402 (68.2)
Body weight (kg)[a]**,** Mean (SD)	81.6 (19.48)
SAPS II**, Points, Median (IQR)	35 (26.0, 50.0)
Reason for ICU admission	
Respiratory failure, n (%)	65 (10.9)
Circulatory/cardiovascular failure, n (%)	47 (7.9)
Gastroenterological failure, n (%)	121 (20.4)
Neurological failure, n (%)	87 (14.6)
Sepsis, n (%)	20 (3.4)
Injury/Trauma, n (%)	173 (29.1)
Other***, n (%)	81 (13.6)
Admitted to ICU number	
ICU 1, n (%)	220 (37.0)
ICU 2, n (%)	93 (15.7)
ICU 3, n (%)	181 (30.5)
ICU 4, n (%)	100 (16.8)
ICU Treatment	
Invasive mechanical ventilation, n (%)	502 (84.5)
Tracheostomy, n (%)	160 (26.9)
Non-invasive ventilation, n (%)	63 (10.6)
Intracranial pressure monitoring, n (%)	86 (14.5)
Vasoactive infusion >6 h, n (%)	502 (84.5)
Extended haemodynamic monitoring [b], n (%)	73 (12.3)
Targeted temperature management, n (%)	23 (3.9)
Haemodynamic support [c], n (%)	15 (2.5)
Renal replacement therapy, n (%)	107 (18.0)
Repositioning (time to firs), Hours, Median (IQR)	4.5 (2.5, 8.4)
Mobilised in the ICU, n (%)	469 (79)
Mobilised within 72 h, n (%)	240 (40)
NAS** **per ICU-day** (Points), Median (IQR)	144.4 (129.8, 160.0)
Time on mechanical ventilation, Days [b], Median (IQR)	4.6 (1.6, 10.0)
ICU-LOS***, Days, Median (IQR)	6.7 (3.7, 11.8)
ICU mortality, n (%)	47 (7.9)

Abbreviations: (IQR) Interquartile range presented with 25 and 75 percentiles, (SD) standard deviation
*Intensive Care Unit.
**Simplified Acute Physiology Score II.
***Other = intoxication, haematological failure, kidney failure, postoperative care.
****Nursing Activities Score.
*****Length Of Stay in ICU.
[a] Due to missing data for Bodyweight; n = 498.
[b] Extended hemodynamic monitoring includes pulmonary artery pressure monitoring (SwanGanz) or pulse contour cardiac output (PiCCO).
[c] Haemodynamic support includes extracorporeal membrane oxygenation (ECMO), intra-aortic balloon pump (IABP), or ventricular assist device (Impella).

Table 2
Number of pressure injuries (PIs) in category (I-IV), unstageable, suspected deep tissue injury and mucosal membrane; PIs (traditional) and medical device related pressure injuries (MDRPIs).

PI Categorisation	PIs (traditional) (n = 174)	MDRPIs (n = 144)
Category I, n (%)	102 (58.6)	63 (43.8)
Category II, n (%)	49 (28.2)	56 (38.9)
Category III, n (%)	2 (1.1)	8 (5.6)
Category IV, n (%)	2 (1.1)	0 (0.0)
Unstageable PIs, n (%)	1 (0.6)	3 (2.1)
Suspected deep tissue PI, n (%)	18 (10.3)	11 (7.6)
Mucosal membrane PI, n (%)	0 (0.0)	3 (2.1)

when written, informed consent was signed by the patient or their caregivers.

Results

Patient characteristics

Of 725 included ICU stays, 594 patients were analysed after exclusions (Fig. 1). The median ICU-LOS was 6.7 days (IQR 3.7, 11.8) and the mortality rate was 8 % (47/594). Two-thirds of patients were men (68 %), and the median age was 59.2 (IQR 43.1, 68.8) years. The most common reasons for admission were injury/ trauma (29 %, 173/594) and gastroenterological failure (20 %, 121/594), and the median SAPS II score was 35.0 (IQR 26.0, 50.0). The majority of the patients received mechanical ventilation (85 %, 502/594), 27 % (160/594) received a tracheostomy, and 85 % (502/594) received vasoactive medications during their ICU stay. The median NAS score per ICU day was 144.4 (IQR 129.8, 160.0) (Table 1).

PI incidence and PI characteristics

The 12-month cumulative incidence of patients who developed an ICU-acquired PI was 29 % (172/594) for all categories and 16 % (95/594) (category II or worse). The cumulative incidence for patients acquiring a MDRPI was 15 % (91/594) and 11 % (64/594) (category II or worse). The incidence density rate of ICU acquired PIs (category II or worse) was 15.8 per 1000 ICU days (a total of 95 patients during 5994 ICU days).

Among the ICU-acquired PIs, category I was most common for both PIs (traditional) (59 %, 102/174) and MDRPIs (44 %, 63/144), followed by category II 28 % (49/174) and 39 % (56/144), respectively (Table 2).

The most common locations for PIs (traditional) were the sacrum and surrounding area (43 %, 75/174) and the heels (20 %, 34/174), and for MDRPIs were the face (30 %, 43/144) and toes (21 %, 31/144) (Fig. 2).

Compression stockings were the most common device identified with MDRPIs, accounting for 35 % (51/145). Other common devices were nasogastric (15 %, 22/145) and endotracheal tubes (12 %, 18/145) (Fig. 3).

Associated factors

Results of the logistic regression analysis of the three models are presented in Table 3. ICU-LOS was significantly associated with the occurrence of PIs (traditional), MDRPIs and PIs of any kind. The probability of developing an ICU-acquired PI, increased by 4 % (OR 1.04, 95 % CI [1.02; 1.06], p-value < 0.001), 3 % (OR 1.03, 95 % CI [1.01; 1.05], p-value = 0.010) and 6 % (OR 1.06, 95 % CI [1.03; 1.08], p-value < 0.001) per day increase in ICU-LOS for the three models, respectively (Table 3). For patients who received vasoactive infusion, the odds of developing an ICU-acquired PI (any kind) (model 3) increased by a

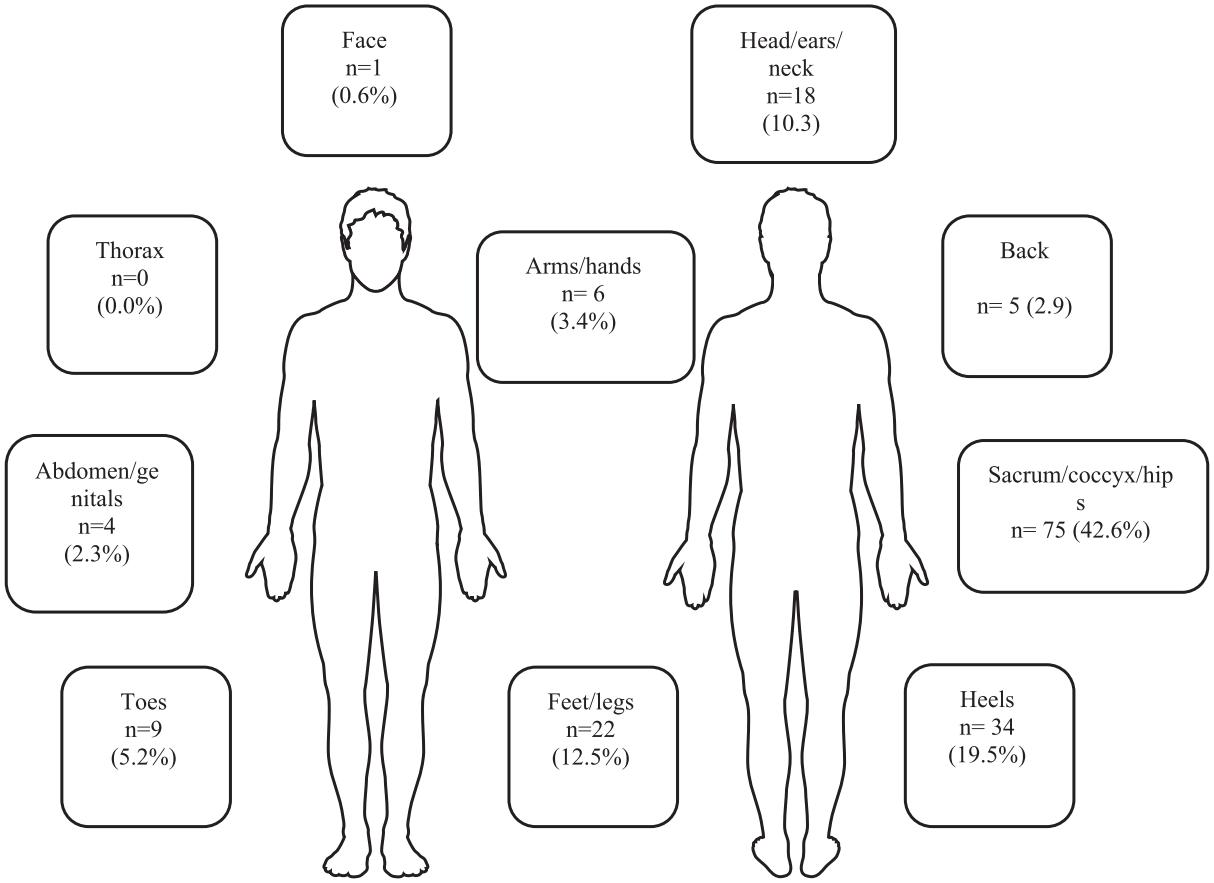

Fig. 2a. a): location of pressure injuries (traditional) category (I–IV), unstageable and suspected deep tissue injury (n = 174).

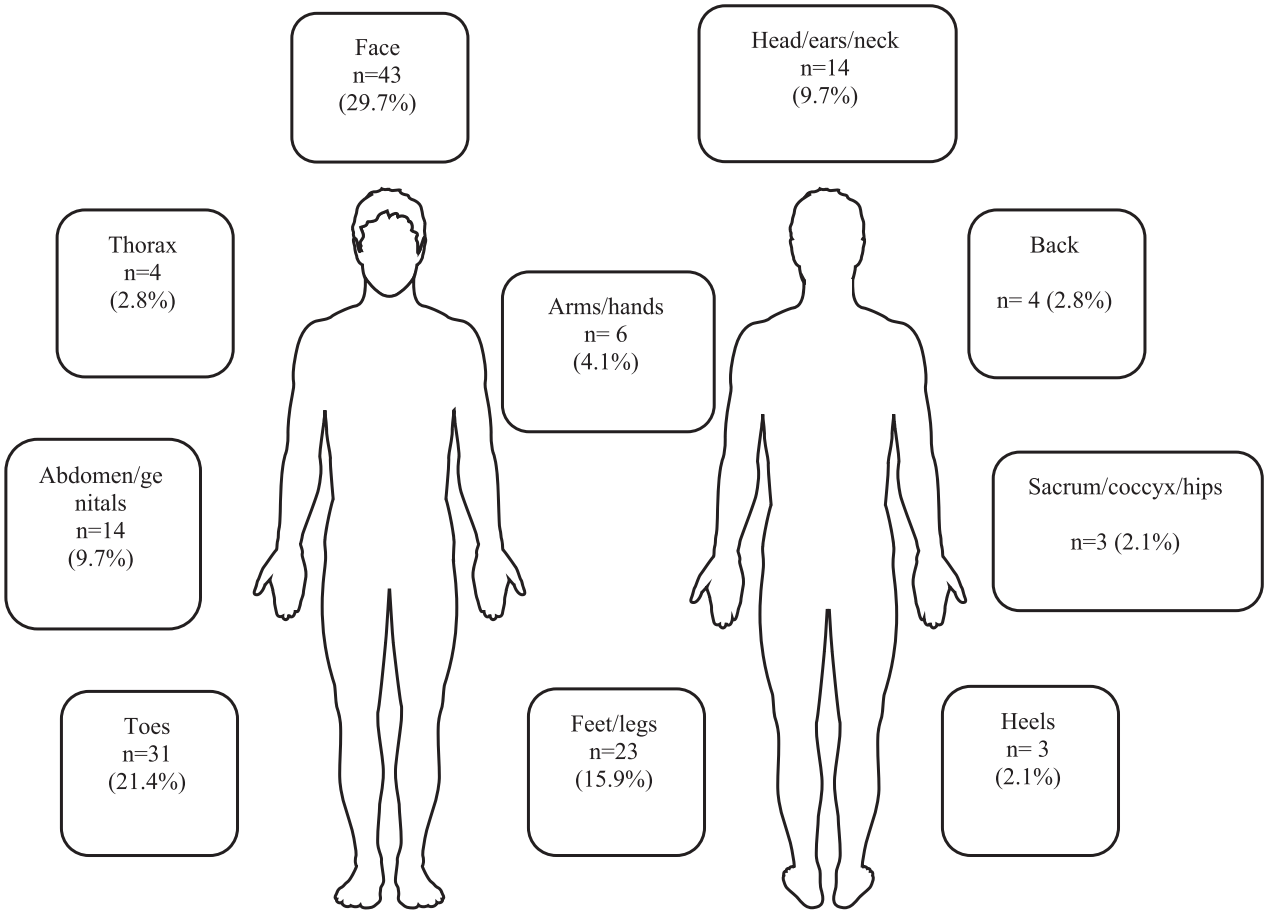

Fig. 2b. Location of medical device related pressure injuries category (I-IV), unstageable, suspected deep tissue injury and mucosal membrane pressure injuries (n = 144).

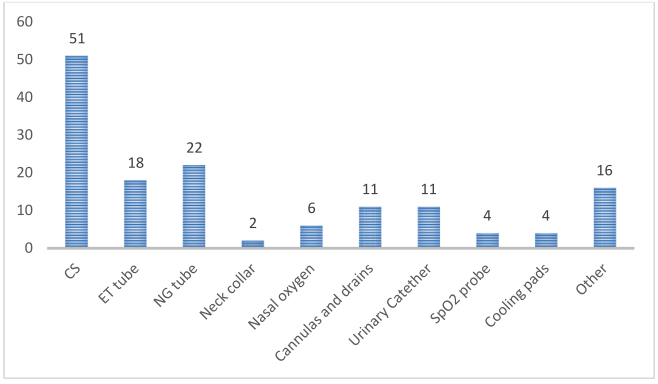

Fig. 3. Number of devices identified in context with medical device related pressure injuries (n = 145). Abbreviations: CS: Compression Stockings; ET: Endotracheal; NG: Nasogastric; SpO2: peripheral Oxygen Saturation.

factor of 11.84 (OR 11.84, 95 % CI [1.59; 88.13], p-value = 0.016) compared with patients who did not receive vasoactive infusion. There was a significant association between developing PIs (traditional) and MDRPIs (model 1) (OR 3.33, 95 % CI [1.53: 7.24], p-value = 0.002), and between MDRPIs and PIs (traditional) (model 2) (OR 3.30, 95 % CI [1.53; 7.12], p-value = 0.002).

Discussion

The main findings from the present study were a cumulative incidence of patients developing ICU-acquired PIs of 29 %, including category I PIs and 16 % for category II PIs or worse. For MDRPIs, the cumulative incidence was 15 % and 11 %. Category I was the most common category for all PIs. Sacrum was the most common location for PIs (traditional) and the face was most common for MDRPI. The most frequent devices documented with MDRPIs were compression stockings, followed by nasogastric tubes. Development of ICU-acquired PIs was associated with ICU-LOS, vasoactive infusion and another kind of ICU-acquired PI.

Our study found a relatively high cumulative incidence compared to a meta-analysis reporting cumulative incidence in the ICU ranging from 12 % to 28 % (Chaboyer et al., 2018). The same meta-analysis (2018) also reported the cumulative incidence, excluding category I, ranging from 0 % to 24 %, similar to our findings. Regarding MDRPIs, our findings were similar to other studies with a pooled incidence of 12 % and prevalence of 10 % (Jackson et al., 2019), but much lower than the 48 % reported incidence in a recent study (Dallı et al., 2022). Heterogeneity in PI study design, including different measurement methods, is common in studies reporting PIs and MDRPIs incidence and prevalence in the ICU, making comparison of numbers challenging (Chaboyer et al., 2018; Jackson et al., 2019). Daily skin inspection for 12 months is rare in studies reporting PI incidence (Chaboyer et al., 2018) but may possibly contribute to trustworthy data on PIs in ICU patients. Half of the ICU-acquired PIs identified in this study were category I. Noteworthy, category I does not include skin loss and may thus be underreported. Cox et al. (2020) found category II to be the most commonly reported category in retrospectively collected data from a database. Whether daily skin inspections by bedside nurses in this study are comparable to traditional skin inspections by PI experts or other data collection

Table 3
Odds Ratio for a patient developing pressure injuries (traditional) (category II or worse), medical device related pressure injuries (category II or worse), and all pressure injuries (category II or worse). Results from the logistic regression (n = 594).

	Model 1: PI (traditional)			Model 2: MDRPI			Model 3: All PI		
Factors	OR	95 % CI	p-value	OR	95 % CI	p-value	OR	95 % CI	p-value
(Intercept) ICU* no 1	**0.004**	**[0.0003;0.05]**	**<0.001**	$8.83 \cdot 10^{-9}$	[0.00; inf]	0.978	**0.007**	**[0.0007;0.07]**	**<0.001**
ICU no 2	1.77	[0.71;4.45]	0.224	0.33	[0.10;1.04]	0.059	0.71	[0.32;1.56]	0.391
ICU no 3	1.23	[0.57;2.67]	0.60	1.08	[0.49;2.14]	0.962	1.14	[0.63;2.06]	0.672
ICU no 4	0.97	[0.0.36;2.63]	0.954	0.91	[0.38;2.16]	0.835	0.99	[0.48;2.07]	0.980
ICU-LOS**	**1.04**	**[1.02;1.06]**	**<0.001**	**1.03**	**[1.01;1.05]**	**0.010**	**1.06**	**[1.04;1.08]**	**<0.001**
SAPS II***	1.01	[0.99;1.03]	0.267	1.00	[0.98;1.02]	0.935	1.01	[0.99;1.02]	0.379
Sex (Reference: Women)	**0.51**	**[0.26;0.99]**	**0.049**	**3.18**	**[1.42;7.12]**	**0.005**	1.21	[0.69;2.11]	0.501
Weight	1.01	[0.99;1.02]	0.402	0.99	[0.97;1.01]	0.242	1.00	[0.98;1.01]	0.697
PI on admission (Reference: No)	2.08	[0.90;4.83]	0.088	1.28	[0.53;3.09]	0.580	1.72	[0.85;3.47]	0.129
Vasoactive infusion (Reference: No)	5.86	[0.76;44.93]	0.089	$8.22 \cdot 10^{-6}$	[0.00; inf]	0.981	**11.84**	**[1.59;88.13]**	**0.016**
Previously admitted to ICU (Reference: No)	0.81	[0.37;1.78]	0.593	1.65	[0.81;3.37]	0.166	1.23	[0.68;2.24]	0.494
Device related PIs (Reference: No)	**3.33**	**[1.53;7.24]**	**0.002**	–	–	–	–	–	–
PIs not related to device (Reference: No)	–	–	–	**3.30**	**[1.53;7.12]**	**0.002**	–	–	–

Abbreviations: PI; Pressure Injury; MDRPI; Medical Device Related Pressure Injury, OR; Odds ratio, CI; Confidence interval,
*Intensive Care Unit.
**ICU-Length Of Stay.
***Simplified Acute Physiology Score II.

methods is debatable. Interrater reliability of PI categorisation among nurses has previously been shown to be low (Beeckman et al., 2007; Strand & Lindgren, 2010). Education sessions may improve PI prevention (Alshahrani et al., 2023). However, the ongoing quality improvement campaign during the data collection period could have contributed to identifying and documenting more PIs than other studies, especially for category I PIs. On the other hand, the campaign could also have decreased the development of ICU-acquired PIs into a worse category or the patients obtaining new PIs. Category I PIs are considered reversible with correct interventions (UK National Clinical Guideline CentreHalfens et al., 2001; Stansby et al., 2014; UK National Clinical Guideline Centre, 2014). However, category I PIs have been shown to be associated with increased mortality (Labeau et al., 2021). This shows the importance of the healthcare providers' role in detection of PIs, correct categorisation, and, not least, preventing category I PIs from developing further.

Differences in clinical settings and patient characteristics may also contribute to heterogeneity among PI studies, but not all studies report these factors (Chaboyer et al., 2018; Jackson et al., 2019). The present study included patients who spent a minimum of 48 h in the ICU of a large university hospital, and thus included the most complex and seriously ill ICU patients. The ICU patients had a median SAPS II score of 35 and 85 % received invasive mechanical ventilation and infusion of vasoactive drugs. In other studies, fewer patients received vasoactive drugs (Cox et al., 2020), were on mechanical ventilation (Labeau et al., 2021) and had lower SAPS II scores (Cox et al., 2020; Labeau et al., 2021). Low blood pressure and administration of vasoactive drugs have been shown to be a predictor of PI development, and MDRPIs are often associated with devices used for mechanical ventilation (Cox & Roche, 2015; Jackson et al., 2019; Sala et al., 2021).

Location of PIs (traditional) and MDRPIs differed as expected. Our findings of PIs located on sacral (and surrounding area) and heels were comparable to previous findings (Chaboyer et al., 2018; Jacq et al., 2021). Although compression stockings were the most common device, the face was the most common location of ICU-acquired MDRPIs due to several devices causing facial PIs. In this study, facial PIs were related to endotracheal and nasogastric tubes and not masks used in non-invasive ventilation, which have previously been associated with MDRPIs, especially with prolonged mask-ventilation (Lin & Chang, 2023). The number of MDRPIs in association with compression stockings (36 %) was surprisingly high. However, a previous study by Hobson et al., (2017) reported as many as 74 % of all MDRPI being related to compression stocking. This may indicate that use of compression stockings in combination with risk factors such as poor peripheral circulation and vasoactive infusions should be considered with care, although more research is needed on this matter.

We found higher odds of developing ICU-acquired PIs with vasoactive infusion and longer ICU-LOS, corresponding well with other findings on predictors of ICU-acquired PIs (Cox et al., 2020; de Almeida Medeiros et al., 2018). High SAPS II scores and ICU-LOS over three days were shown to be a predictor of PIs in the DecubICUs study (Labeau et al., 2021). However, we did not find any association between ICU-acquired PIs and SAPS II. Obtaining an ICU-acquired PI increased the odds of developing a MDRPI and vice versa. This suggests that the presence of any PI increases the risk of new PIs, which is somewhat expected. Some risk factors for developing PIs are not modifiable. These include ICU-LOS, cause of admission, diagnosis, weight and having a PI. This should be taken into consideration when developing PI prevention measures (Edsberg et al., 2014; Tschannen & Anderson, 2020). Modifiable efforts such as mobilisation, use of heel offloading boot and repositioning of medical devices may prevent PI development, especially in high-risk patients (Barakat-Johnson et al., 2022).

Strengths and limitations

The study's strength was the relatively large patient sample and bedside nurses documenting PIs on each shift over a 12-month period, after being provided with tools and training for skin assessment. However, there are limitations regarding the present data collection method. Uncertainties regarding correct PI categorisation may be present, especially for MDRPIs. We consider the process of interpreting the handwritten forms as a possible source of inaccuracy and error in this study. There was little missing data on patient characteristics, but some variables were unsuitable for regression analysis due to missing data, such as Non-Invasive Ventilation treatment and support surfaces (bed and chair). In addition, we did not collect data on risk assessment scores, underlying conditions or modifiable risk factors, such as mobilisation and repositioning of patients and devices. Finally, the study data are from 2017 to 2018, which should be considered by readers.

Conclusion

Nearly one-third of patients admitted to the ICU without PIs developed PIs during their ICU stay. PI category I accounted for most PIs (traditional) and MDRPIs. ICU-acquired PIs (traditional) occurred mainly in the sacral area and heels, whereas MDRPI occurred mainly in the face and toes. Nearly half of the ICU-acquired PIs were related to devices, with compression stockings being the most common device. Vasoactive infusions and ICU-LOS were associated with development of ICU-acquired PIs (any kind). These findings may give important information on which factors increase patients' risk of developing PIs in the ICU.

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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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References

Alshahrani, B., Middleton, R., Rolls, K., Sim, J., 2023. Critical care nurses' knowledge and attitudes toward pressure injury prevention: A pre and post intervention study. Intensive Crit. Care Nurs. 79, 103528.

Barakat-Johnson, M., Lai, M., Stephenson, J., Buhr, H., Campbell, J., Dolton, A., Jones, S., Leong, T., Reddy, N., Coyer, F., 2022. Efficacy of a heel offloading boot in reducing heel pressure injuries in patients in Australian intensive care units: A single-blinded randomised controlled trial. Intensive Crit. Care Nurs. 70, 103205.

Beeckman, D., Schoonhoven, L., Fletcher, J., Furtado, K., Gunningberg, L., Heyman, H., Lindholm, C., Paquay, L., Verdu, J., Defloor, T., 2007. EPUAP classification system for pressure ulcers: European reliability study. J. Adv. Nurs. 60 (6), 682–691.

Chaboyer, W.P., Thalib, L., Harbeck, E.L., Coyer, F.M., Blot, S., Bull, C.F., Nogueira, P.C., Lin, F.F., 2018. Incidence and prevalence of pressure injuries in adult intensive care patients: a systematic review and meta-analysis. Crit. Care Med. 46 (11), e1074–e1081.

Cox, J., Roche, S., 2015. Vasopressors and development of pressure ulcers in adult critical care patients. Am. J. Crit. Care 24 (6), 501–510.

Cox, J., Schallom, M., Jung, C., 2020. Identifying risk factors for pressure injury in adult critical care patients. Am. J. Crit. Care 29 (3), 204–213.

Coyer, F., Miles, S., Gosley, S., Fulbrook, P., Sketcher-Baker, K., Cook, J.-L., Whitmore, J., 2017. Pressure injury prevalence in intensive care versus non-intensive care patients: a state-wide comparison. Aust. Crit. Care 30 (5), 244–250.

Dallı, Ö.E., Ceylan, İ., Girgin, N.K., 2022. Incidence, characteristics and risk factors of medical device-related pressure injuries: An observational cohort study. Intensive Crit. Care Nurs. 69, 103180.

de Almeida Medeiros, A. B., Fernandes, M.I.d.C.D., de Sá Tinôco, J.D., Cossi, M.S., de Oliveira Lopes, M.V., de Carvalho Lira, A.L.B., 2018. Predictors of pressure ulcer risk in adult intensive care patients: A retrospective case-control study. Intens. Crit. Care Nurs. 45, 6–10.

Deschepper, M., Labeau, S.O., Waegeman, W., Blot, S.I., DecubICUs study Team, & European Society of Intensive Care Medicine, 2021. Pressure injury prediction models for critically-ill patients should consider both the case-mix and local factors. Intensive Crit. Care Nurs. 65, 103033.

Deschepper, M., Labeau, S.O., Waegeman, W., Blot, S.I., Team, D.S., 2022. Heterogeneity hampers the identification of general pressure injury risk factors in intensive care populations: a predictive modelling analysis. Intensive Crit. Care Nurs. 68, 103117.

Edsberg, L.E., Langemo, D., Baharestani, M.M., Posthauer, M.E., Goldberg, M., 2014. Unavoidable pressure injury: state of the science and consensus outcomes. J. Wound Ostomy Cont. Nurs. 41 (4), 313–334.

European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel & Pan Pacific Pressure Injury Alliance, 2019. Prevention and Treatment of Pressure Ulcers/injuries: Clinical Practice Guideline: the International Guideline. EPUAP/NPIAP/PPIA, Cambridge Media.

Halfens, R.J., Bours, G.J., Van Ast, W., 2001. Relevance of the diagnosis 'stage 1 pressure ulcer': an empirical study of the clinical course of stage 1 ulcers in acute care and long-term care hospital populations. J. Clin. Nurs. 10 (6), 748–757.

Hauff, T., Petosic, A., Småstuen, M.C., Wøien, H., Sunde, K., Stafseth, S.K., 2022. Patient mobilisation in the intensive care unit and evaluation of a multifaceted intervention including Facebook groups: A quasi-experimental study. Intensive and Critical Care Nursing 103315.

Hobson, D.B., Chang, T.Y., Aboagye, J.K., Lau, B.D., Shihab, H.M., Fisher, B., Young, S., Sujeta, N., Shaffer, D.L., Popoola, V.O., 2017. Prevalence of graduated compression stocking–associated pressure injuries in surgical intensive care units. J. Crit. Care 40, 1–6.

Jackson, D., Sarki, A.M., Betteridge, R., Brooke, J., 2019. Medical device-related pressure ulcers: A systematic review and meta-analysis. Int. J. Nurs. Stud. 92, 109–120.

Jacq, G., Valera, S., Muller, G., Decormeille, G., Youssoufa, A., Poiroux, L., Allaert, F., Barrois, B., Rigaudier, F., Ferreira, P., 2021. Prevalence of pressure injuries among critically ill patients and factors associated with their occurrence in the intensive care unit: The PRESSURE study. Aust. Crit. Care 34 (5), 411–418.

Johansen, E., Lind, R., Sjøbø, B., Petosic, A., 2020. Moisture associated skin damage (MASD) in intensive care patients: A Norwegian point-prevalence study. Intensive Crit. Care Nurs. 60, 102889.

Labeau, S.O., Afonso, E., Benbenishty, J., Blackwood, B., Boulanger, C., Brett, S.J., 2021. Prevalence, associated factors and outcomes of pressure injuries in adult intensive care unit patients: the DecubICUs study. Intensive Care Med. 47 (2), 160–169.

Lin, Y.-H., Chang, W.-P., 2023. Characteristics and risk factors of facial pressure injuries in acute inpatients using noninvasive positive pressure ventilation: A retrospective case control study. Intensive Crit. Care Nurs. 78, 103453.

Lin, F.F., Liu, Y., Wu, Z., Li, J., Ding, Y., Li, C., Jiang, Z., Yang, J., Wang, K., Gao, J., 2022. Pressure injury prevalence and risk factors in Chinese adult intensive care units: A multi-centre prospective point prevalence study. Int. Wound J. 19 (3), 493–506.

McEvoy, N., Avsar, P., Patton, D., Curley, G., Kearney, C.J., Moore, Z., 2021. The economic impact of pressure ulcers among patients in intensive care units. A systematic review. J. Tissue Viability 30 (2), 168–177.

Padula, W.V., Delarmente, B.A., 2019. The national cost of hospital-acquired pressure injuries in the United States. Int. Wound J. 16 (3), 634–640.

Petosic, A., Småstuen, M.C., Beeckman, D., Flaatten, H., Sunde, K., Wøien, H., 2021. Multifaceted intervention including Facebook-groups to improve guideline-adherence in ICU: A quasi-experimental interrupted time series study. Acta Anaesthesiologica Scandinavica 65 (10), 1466–1474.

Petosic, A., Sunde, K., Beeckman, D., Flaatten, H.K., Wøien, H., 2019. Use of social media for communicating about critical care topics: A Norwegian cross-sectional survey. Acta Anaesthesiologica Scandinavica 63 (10), 1398–1405.

R Core Team, 2023. _R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Rubulotta, F., Brett, S., Boulanger, C., Blackwood, B., Deschepper, M., Labeau, S.O., Blot, S., 2022. Prevalence of skin pressure injury in critical care patients in the UK: results of a single-day point prevalence evaluation in adult critically ill patients. BMJ Open 12 (11).

Sala, J.J., Mayampurath, A., Solmos, S., Vonderheid, S.C., Banas, M., D'Souza, A., LaFond, C., 2021. Predictors of pressure injury development in critically ill adults: a retrospective cohort study. Intensive Crit. Care Nurs. 62, 102924.

Stansby, G., Avital, L., Jones, K., Marsden, G., 2014. Prevention and management of pressure ulcers in primary and secondary care: summary of NICE guidance. BMJ 348.

Strand, T., Lindgren, M., 2010. Knowledge, attitudes and barriers towards prevention of pressure ulcers in intensive care units: a descriptive cross-sectional study. Intensive Crit. Care Nurs. 26 (6), 335–342.

Tschannen, D., Anderson, C., 2020. The pressure injury predictive model: a framework for hospital-acquired pressure injuries. J. Clin. Nurs. 29 (7–8), 1398–1421.

UK National Clinical Guideline Centre, 2014. The prevention and management of pressure ulcers in primary and secondary care.

Zhang, Y., Zhuang, Y., Shen, J., Chen, X., Wen, Q., Jiang, Q., Lao, Y., 2021. Value of pressure injury assessment scales for patients in the intensive care unit: systematic review and diagnostic test accuracy meta-analysis. Intensive Crit. Care Nurs. 64, 103009.