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Research Article

Cohort study to determine the risk of pressure ulcers and developing a care bundle within a paediatric intensive care unit setting

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ABSTRACT

Objective: Determine the incidence and risk factors for pressure ulcers in a paediatric intensive care unit. Use the information gathered to develop preventive pressure ulcer care bundles.
Research methodology: Prospective cohort study using Braden Q Scale for Predicting Pressure Sore Risk and European Pressure Ulcer Advisory Panel Pressure Ulcer Staging tool.
Setting: General paediatric intensive care unit in a tertiary level hospital between May and October 2017.
Results: Seventy-seven children were recruited. Most children were male (n = 42, 54.5%) and all nine children (11.7%) that developed a pressure ulcer were male. The main risk factor for developing a pressure ulcer was lack of physical activity. None of the children assessed as high or severe risk developed a pressure ulcer. Eight (89%) pressure ulcers were assessed as grade one. Seven pressure ulcers (77.8%) were on the facial and scalp area and all seven children were receiving airway support at the time the pressure ulcers developed.
Conclusion: Incidence of pressure ulcers was 11.7%, with the facial and scalp area the most common anatomical areas affected. Medical devices appeared to be the prime causative factor. Based on our data we have modified and launched the SSKIN care bundle for the paediatric intensive care unit setting.

Implications for clinical practice

- Children are a separate population to adults. The identification of risk factors for pressure ulcers in paediatric settings is needed to develop and implement effective care bundles for this cohort of patients.
- For critically unwell children pressure ulcers are most likely to appear on the facial and scalp area while airway support is being provided, these are commonly termed medical device related injuries.
- Knowledge about risk factors for the development of pressure ulcers in paediatric intensive care units will contribute to optimising patient care provided by members of the health care team.

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Introduction

A pressure ulcer (PU) is a defined as "*localised injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear*" (Baharestani and Ratliff, 2007). A person's risk of developing a PU depends on their tissue integrity and how well they respond to external pressure and shear forces (Becker et al., 2017, de Almeida Medeiros et al., 2018; Visscher et al., 2013). Given the often poor medical condition of children admitted to intensive care units, these individuals are at risk of develop a PU (Razmus, 2018; Razmus and Bergquist-Beringer, 2017). Indeed, the National Pressure Ulcer Advisory Panel reports that children who are admitted and cared for in a paediatric intensive care unit (PICU) are at greater risk of developing PUs to their peers who are not admitted to PICU (Baharestani and Ratliff, 2007).

The implications associated with the development of PUs include morbidity, increased length of stay, infection and a negative impact on a patient's quality of life. A review published in 2017 estimated that the cost of PUs to the healthcare systems in United States and the United Kingdom was in excess of $15 and £2 billion (Dealey et al., 2012; Ocampo et al., 2017), respectively.

Given the consequences of PUs for both patients and the health service the first joint improvement collaboration project to take place in Ireland aimed to reduce the incidence of hospital-acquired PUs to zero (Health Service Executive, 2016). This joint collaboration, between the Quality Improvement Division in the Health Service Executive (which is responsible for the provision of public health care) and the Royal College of Physicians Ireland, was launched in February 2014 and involved 21 healthcare settings, but did not include a paediatric centre or hospital (Flynn, 2014). Since the launch of the 'Pressure Ulcers to Zero' initiative the Health Service Executive (HSE) has published additional reviews and guidelines on PU care. However, the most recent review on PUs, published in 2018, is for adult patients and does not include the paediatric population in detail (Health Service Executive, 2018a). The HSE's 'Wound Management Guidelines 2018' (Health Service Executive, 2018b) only contains three evidence statements with recommendations on caring for a child with, or at risk of developing, a PU. This is the first national guideline in Ireland to mention the paediatric population in terms of PU care. However, the current rate of PUs in the Irish paediatric healthcare settings is unknown.

Given the need for individualised care and the increased likelihood of a PU developing in a PICU setting it is important that risk factors associated with PU are identified. This will assist in the development and implementation of both preventative and treatment guidelines for pressure ulcers in the PICU, to assist all staff in optimising patient care specific to the paediatric population.

Objectives

The primary objective of this study was to determine PU incidence and risk factors associated with the development of PU in the General PICU. Secondary objective was to use the information gathered to inform care bundles for PU prevention within the PICU setting.

Methods

Setting

This prospective cohort study was undertaken in a general PICU in the largest tertiary-level paediatric hospital in Children's Health Ireland, Crumlin. The general PICU has 15 beds and accepts children from birth, independent of birthweight, or gestational age at delivery.

Ethics

Ethical approval was awarded by the Ethics (Medical Research) Committee Office for Children's Health Ireland, Crumlin (Reference: GEN/558/17). As all children were already assessed for pressure ulcers and the study was using a different tool to collect this information (alongside standard documentation) and no intervention was applied in the study, the Ethics (Medical Research) Committee Office granted a waiver for seeking parental consent and child assent.

Participants

We used convenience sampling to enrol children who were admitted between 11th May 2017 up to, and including, 11th September 2017. No exclusion criteria was applied. Enrolment in the study stopped on the 12th September 2017, but the follow-up period continued until 30th September 2017. This was to ensure that participants who were enrolled in the study were followed-up until they were discharged from the PICU, or developed a PU (whichever occurred first).

Data collection

For three weeks before the start of the study all nursing staff were required to attend a study training session. Study champions (nursing staff with an interest in skin care) were also available throughout the study period to assist their colleagues with data collection.

All children had their risk for developing a PUs assessed, during each shift by the bedside nurse and another PICU nurse (independent of each other), using the Braden Q Scale for Predicting Paediatric Pressure Ulcer Risk (Bergstrom and Braden, 2002; Noonan et al., 2011; Vocci et al., 2018). The Braden Q Scale is a widely used in paediatric settings and is a validated tool that screens a child's chances of developing a PU based on seven risk factors included in the tool. These seven risk factors are divided into intensity and duration of pressure and tolerance of the skin and supporting structures. The risk factors included in the Braden Q Scale are mobility, activity, sensory perception, moisture, friction-shear, nutrition and tissue perfusion and oxygen. Each risk factor is awarded a score of one to four and the total score ranges from 7 to 28, with a lower score indicating a higher risk of PU development. A total score of $\leq$9 indicates a severe risk of developing a PU, a score of 10–12 indicates high risk, a score of 13–15 indicates moderate risk and a score of 16–23 indicates mild risk. As the tool does not have a corresponding risk category for scores $\leq$24, we classified this as low risk of developing a PU.

Once a PU was identified it was graded by the bedside nurse and another PICU nurse (independent of each other), using the European Pressure Ulcer Advisory Panel (EPUAP) Pressure Ulcer Staging tool (European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel, 2009). As the primary objective of this study was to determine the incidence and risk factors associated with the development of PU in the General PICU the child was no longer involved in the study once a PU developed or they were discharged from the PICU (whichever occurred first).

If divergence occurred in the risk assessment of the Braden Q Scale it was first assessed if the contrasting risk assessment resulted in a different overall score and which risk group the child was assigned to. If the divergence did not change the child's risk group the assessment done by the bed-side nurse was used in

the analysis. If the divergence did change the child's risk group the assessment was considered a missing data point.

Since July 2012 all healthcare records in the PICU have been electronic based. We extracted the required data pertaining to the characteristics about the study population, nursing care and what interventions were provided, from the healthcare record. All data was entered, and pseudonymised, into Microsoft Excel 2013 and then transferred to IBM SPSS version 24 for coding and analysis.

Data analysis

Categorical variables are presented as numbers and percentages and were analysed using the Chi-Square Test. Continuous data are showed as medians with their interquartile (IQR). Mood's median test was used to test for differences in the medians between those that did and did not develop a PU. The Spearman's Correlation Co-Efficient measured the strength and direction of association between continuous variables. The statistical significance value was set at $p \leq 0.05$.

Results

Demographics

Over the four month enrolment period 77 children were entered in the study and 560 Braden Q Scale assessments were completed. Over half (n = 42, 54.5%) of children were male and the biggest age group was children under one year of age (n = 37, 48.1%). Five children were admitted twice to the PICU during the study period and are therefore included twice in the study. The median (IQR) duration of PICU was 6 (4–10.50) days. The majority (n = 56; 73.7%) of parents identified their children's ethnic group as white Irish, followed by white other (n = 6; 7.9%). Most children were admitted for medical reasons (n = 59, 77.6%). The most common medical reasons for admission were respiratory (n = 18/59, 30.5%) and oncology (n = 8/59; 13.6%). The remaining 17 (22.4%) children were admitted post-surgery, primarily for gastroenterology management, for example due to volvulus and duodenal atresia. The median (IQR) percentage score for Paediatric Index of Mortality 3, across the whole cohort, was 2.50% (1.20% to 4.90%). The majority (n = 54, 70.1%) of children were invasively ventilated and 20 (26.0%) received non-invasive ventilation support, Table 1.

At point of admission most children were assessed as being at mild (n = 43, 55.8%), or moderate (n = 17, 22.1%), risk of developing a PU. For all admissions the degree of physical activity was the most common risk factor, with a median (IQR) score of 1 (1–2) for all children. Skin exposure to moisture was the least common risk factor, with a median (IQR) score for all children of 4 (3–4).

We did compare the Braden Q Scale completed by the bed-side nurse to the second nurse to assess if all children were awarded the same score for each risk factor and if the total score was the same. Differences of scoring was noted but this was mainly one nurse scoring a two and the other nurse scoring a three. The final overall score did not change the child's risk category (severe, high, moderate, mild and low) of developing a PU.

Pressure ulcer incidence

One child was admitted with a grade 3 PU and no deterioration occurred while in the PICU. Nine (11.7%) children, all male, developed a PU while in the PICU. Four (44.4%) of all PUs occurred in children under one year of age. All but one PU was a grade 1. Seven (77.8%) PUs were on the facial and scalp area and all seven children required airway support.

Risk factors for pressure ulcer development

Children that developed a PU were in the PICU for a median (IQR) of 3 (1–5) days prior to the PU developing, Table 1. None of the children who developed a PU were assessed as being at a high, or severe risk, of PU development. The total median (IQR) Braden Q Scale score, on admission, was lower for children who developed a PU, compared to those who did not develop a PU (15.00 (12.50–18.00) versus 18.00 (15.00–22.00), $p = 0.21$, respectively).

In stratifying the risk factors by PU (yes/no), the most common risk factor for developing a PU was the child's degree of physical activity. The degree to which the skin was exposed to moisture remained the least common risk factors for developing a PU. The total median (IQR) nutrition risk score, on admission, was lower for children who developed a PU, compared to those who did not develop a PU (1.00 (1.00–2.00) versus 3.00 (2.00–3.00), $p = 0.008$, respectively) Table 2.

Table 1
Study characteristics.

	All N = 77	Developed PU N = 9	Did not develop PU N = 68	P-Value
Gender: Male	42 (54.5%)	9 (100%)	33 (48.5%)	0.004
Age (months)	14.40 (0.25, 87.77)	31.17 (0.63, 142.27)	13.33 (0.23, 99.57)	1.00
Paediatric Index of Mortality 3 (%)	2.50% (1.20%, 4.90%)	2.35% (1.62%, 3.56%)	2.53% (0.83%, 5.37%)	1.00
Age: Neonate	24 (31.2%)	2 (22.2%)	22 (28.6%)	0.95
Age: Infant	13 (16.9%)	2 (22.2%)	11 (16.2%)	
Age: 1–5 years	16 (20.8%)	2 (22.2%)	14 (20.6%)	
Age: 6–10 years	10 (13.0%)	1 (11.1%)	9 (13.2%)	
Age: 11–15 years	11 (14.3%)	2 (22.2%)	9 (13.2%)	
Age: ≥16 years	2 (2.6%)	0 (0%)	2 (2.9%)	
Low risk of developing PU	8 (10.4%)	0 (0%)	8 (11.8%)	0.44
Mild risk of developing PU	43 (55.8%)	4 (44.4%)	39 (57.4%)	
Moderate risk of developing PU	17 (22.1%)	3 (33.3%)	14 (20.6%)	
High risk of developing PU	6 (7.8%)	2 (22.2%)	4 (5.9%)	
Severe risk of developing PU	1 (1.3%)	0 (0%)	1 (1.5%)	
Invasive airway support: Yes	54 (70.1%)	6 (66.7%)	48 (70.6%)	0.76
Non-invasive airway support: Yes	20 (26.0%)	5 (55.6%)	15 (22.0%)	0.03
Duration (days) of stay in the PICU	6 (4, 10)	7 (5, 31)	6 (3, 10)	0.74

Data is reported as median (IQR) for continuous variables and n(%) for categorical variables.

Table 2
Braden Q Scale, by risk factor, on admission.

	All N = 77	Developed PU N = 9	Did not develop PU N = 68	P-Value
Total Score	17.00 (15.00, 21.25)	15.00 (12.50, 18.00)	18.00 (15.00, 22.00)	0.21
Mobility	2.00 (1.00, 2.00)	2.00 (1.00, 2.00)	2.00 (2.00, 3.00)	0.26
Activity	1.00 (1.00, 2.00)	1.00 (1.00, 1.00)	1.00 (1.00, 3.25)	0.05
Sensory Perception	2.00 (2.00, 3.00)	2.00 (2.00, 2.50)	2.00 (2.00, 3.00)	0.45
Moisture	4.00 (3.00, 4.00)	4.00 (3.00, 4.00)	4.00 (3.00, 4.00)	N/A
Friction – Shear	2.00 (2.00, 4.00)	2.00 (2.00, 3.50)	2.00 (2.00, 4.00)	0.90
Nutrition	2.00 (1.00, 3.00)	1.00 (1.00, 2.00)	3.00 (2.00, 3.00)	0.008
Tissue Perfusion and Oxygenation	3.00 (2.00, 4.00)	3.00 (2.00, 4.00)	3.00 (2.00, 4.00)	0.78

Data is reported as median (IQR) for continuous variables.

We also explored the correlation between each risk factor and the total risk score. Mobility and friction-shear showed a very strong positive relationship ($r = 0.78$, $p = <0.001$; $r = 0.72$, $p = <0.001$, respectively). Moisture showed a weak positive relationship ($r = 0.27$, $p = 0.02$). Overall, given the anatomical location of the PUs that developed, in addition to a review of the medical charts, it is suggested that medical devices may be the prime causative factor for PU in this PICU.

Discussion:

This study has demonstrated the need for paediatric specific care bundles. The facial and scalp area were most susceptible to PU and this has been reported in other studies (Barakat-Johnson et al., 2017; Kayser et al., 2018; Visscher et al., 2016). Each PU has the ability leave a permeant scar and given that most children experienced a PU on their facial and scalp area this could potentially result in negative body image and low self-esteem as they grow older (Hogeling et al., 2012; Pascall et al., 2015). As with other studies we also found that medical devices appeared to be a causative factor for PUs occurring (Barakat-Johnson et al., 2017; Kayser et al., 2018; Levy et al., 2017). This finding highlights the need to ensure that skin areas that are visual obscured by medical devices are still observed. Preventive and care management of PUs need to be place for the total surface area of the body. In comparison to the adult population (Bredesen et al., 2015; Kasikci et al., 2018) the younger the age, the higher the risk of developing a PU in the PICU. The PICU population is experiencing a raise in the number, and the severity, of chronic conditions which require more interventions with an increased length of stay (O'Brien et al., 2017; Plunkett and Parslow, 2016; Razmus, 2018). This is elevating the risk of PUs developing for this vulnerable population. Therefore, there is a need to be proactive in developing effective preventive strategies that will reduce their likelihood of developing a PU.

Given the findings of this study, and that the Braden Q Scale does not account for medical devices, it was felt that the Braden Q Scale could not be recommended for use in the PICU. In 2018 the findings from a multicentre study to develop and validity the Braden QD Scale were published. The Braden QD Scale (Curley et al., 2018) was reviewed against the data collected we collected, and the Nursing Practice Development Unit has approved the Braden QD Scale for use in the PICU. The Braden QD Scale will be included in the PU audit planned for February 2019.

Table 3
Modified SSKIN care bundle.

Step	Processes to action step
Surface	• Appropriate mattress size for patient • Mattress is functioning (i.e. no tears, inflated) • Assessed the need for all adhesives being used
Skin Inspection	• Assess skin & all pressure point • Assess skin tolerance test when indicated • Check: Facial area including ears • Check: Scalp (front and back) • Check: Shoulder blades • Check: Elbows • Check: Spine • Check: Sacrum • Check: Heels • Check: Toes
Keep Moving	• Rotate medical device • Protect skin under each device
Incontinence	• Patient dry and clean • Use of appropriate skin barriers
Nutrition	• Optimise nutritional status
Action Taken	• Referred to Consultant • Referred to Registrar • Referred to Plastic Team • Referred to Shift Leader • Referred to Others • None required

The data were also re-evaluated to develop a care bundle for the prevention of PU in the PICU. This was undertaken in conjunction with reviewing current care bundles. The SSKIN (Surface; Skin Inspection; Keep Moving; Incontinence; Nutrition) care bundle appeared to be the most popular (Gibbons et al., 2006). However, the most vulnerable pressure points (as listed by the SSKIN care bundle) did not include the facial and scalp area. Based on our review it was decided to modify the SSKIN Care Bundle to make it applicable to the paediatric population, see Table 3. In modifying the SSKIN Care Bundle the following points were taken into consideration. Nearly half the PU population were under one year of age and this sub-group of children are dependent on the nursing staff for mobility. Therefore, both the use and correct management of pressure redistributing devices was incorporated into the bundle. Furthermore, not all skin adhesives that were in use could be clinically justified. As adhesives can leave the skin vulnerable to PUs nursing staff are now required to ensure that there is no excessive use of adhesives.

Nearly all PUs were graded as one. In comparing the healthcare records to the EPUAP Pressure Ulcer Staging data there was some

conflict as to whether the area was a grade one PU, or a red area of skin. Therefore, the skin tolerance test was included in the SSKIN care bundle to enable staff to differentiation between red areas of skin and grade one PUs. Each vulnerable pressure point was required to be checked and the facial area including ears and the scalp (front and back) was included. The use of medical devices and the care of the skin around and under these devices was included under the 'keep moving' element of SSKIN. Staff are also required to state what action was needed once they had completed the SSKIN care bundle. The modified SSKIN care bundle was launched in July 2018 and now forms part of nursing documentation in the PICU. The effectiveness of any preventive approach in nursing care is partly reliant on how the care bundle is delivered by nurses at the bedside. Compliance with the SSKIN care bundle is to form part of weekly Risky Huddle Audits. This will provide the PICU with the opportunity to identify any difficulties nursing staff may be having in completing SSKIN care bundle and respond with a proactive approach. A full audit of nursing skin care practices and PU rates will be undertaken six months post-implementation of the SSKIN care bundle (February 2019) to provide an evaluation of the SSKIN care bundle.

Limitations

There are limitations to our study. This was a single-centre study and did not include any cardiac patients. Our overall sample size was less than 100 children and only nine developed a PU. It should be noted that small sample sizes can limit the ability to validate risk factors, given that the rule of thumb suggests that 10 PUs are required for each risk factor (Steyerberg et al., 2001). Most pressure ulcers were graded as stage one and therefore our findings may not be applicable to PUs graded two or higher.

Conclusion

PICU patients have different risk factors for developing a PU compared to the adult population. Most PUs developed on the facial and scalp area and this is not represented in skin care bundles for the prevention of PU. For care bundles to be effective that must accurately identify a patient's risk and where they need additional support. Our study design can be easily implemented in other PICUs and our findings are generalizable to other PICUs and critical care settings that accept children.

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Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2019.04.008.

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