Intensive Care Med (2021) 47:222–224
https://doi.org/10.1007/s00134-021-06350-0

EDITORIAL

Leaving a mark: pressure injury research in the intensive care unit

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Pressure injuries (PIs), previously known as pressure ulcers, are a common hospital-acquired condition resulting in a significant physical, emotional and financial costs [1]. Often occurring at bony prominences, PIs comprise localized lesions to the skin and/or underlying tissue caused by mechanical forces (i.e., pressure, friction, shear) or a medical device. PI risk factors across intensive care unit (ICU) studies include age, diabetes mellitus, cardiovascular disease, hypotension, vasopressor use, mechanical ventilation, and prolonged admission [2]. PIs are classified by severity and range from Stage I "non-blanchable erythema" to Stage IV "full thickness tissue loss" in addition to unstageable injury and mucosal injury [3]. Severe PIs (Stages III–IV, unstageable) are more common among ICU patients compared to general hospital patients and have the highest treatment costs [4].

Labeau, Blot and the DecubICUs research team, in collaboration with the ESICM, should be lauded for elevating the profile of PIs to mainstream status in their recent publication [5]. Prior to this study, there were no rigorous, international data to explicate the burden of PIs, their associated risk factors nor their important implications for morbidity and mortality. Through a rigorous one-day point prevalence evaluation in 1117 ICUs across 90 countries, these investigators were able to identify an overall PI prevalence of 26.6% and an ICU-acquired prevalence of 16.2%. PIs most commonly occurred on the sacrum and heels and their severity was associated in a dose–response relationship with mortality.

Patient (age, male sex, comorbidity) and treatment (mechanical ventilation) risk factors for PI observed in the DecubICUs study contribute to a clinical paradox [5]. While multicomponent prevention bundles including frequent risk assessment, repositioning, and use of pressure redistribution surfaces are believed to reduce the incidence of PIs [6], the non-modifiable nature of contributing risk factors may mean some PIs are unavoidable [7]. PI risk is logically high in the early ICU encounter when patients may be hemodynamically unstable and treated with multiple medical devices and therapies. These circumstances may preclude the use of some prevention strategies (e.g., frequent repositioning) and minimization of risk factors (e.g., vasopressors, mechanical ventilation).

The DecubICUs study identified that one in four ICU patients will have a PI [5]. Uncertainties regarding the prevention of every PI underscore the importance of research in this domain (Table 1). To date, no ICU-specific PI risk assessment scale has been validated using large sample sizes. As such, there is a need for a PI risk assessment tool able to accurately discriminate risk [2]. Adequately powered randomized controlled trials are needed to evaluate multicomponent prevention bundles to identify their efficacy among patients with complex PI risk factors. Large multisite studies and datasets capable of validating PI risk factors, incidence, and progression of severity are required [8]. The proportion of PI owing to medical device use may be high; however, research in this domain is limited [9]. For example, mucosal pressure injury is commonly linked to artificial airways, but the prevalence and outcomes of such injuries remain uncertain (Supplementary file).

Future research might also explore skin interface pressure and microclimate, critical risk factors in PI development [10]. Continuous monitoring of these parameters is currently impossible in most clinical settings. Prevention protocols that rely on intermittent physical assessment limit care providers' ability to accurately identify risk

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Table 1 Pressure injury research in the intensive care unit: examples of recent publications

Study title	Participants	Findings
The national cost of hospital-acquired pressure injuries in the United States [1]	2,500,000	Pressure injury cost $10,708 per patient; $26.8 billion in the United States annually. Stage III–IV pressure injury accounted for 58% of all costs. Decreasing the probability of pressure injury progression across stages has the greatest effect on lowering costs
Pressure injury risk factors in adult critical care patients: a review of the literature [2]	9,789	Independent risk factors for pressure injury were age, prolonged ICU admission, diabetes mellitus, cardiovascular disease, hypotension, prolonged mechanical ventilation, and vasopressor administration. Most risk factors are considered non-modifiable. Development and testing of an ICU PI risk tool is needed to accurately discriminate PI risk and guide application of evidence-based prevention strategies
Incidence and prevalence of pressure injuries in adult intensive care patients: a systematic review and meta-analysis [4]	8,168–13,144	ICU pressure injury incidence and prevalence were 10.0–25.9% and 16.9–23.8%, respectively. The most commonly occurring sites for pressure injury were the sacrum, buttocks, and heels
Prevalence, associated factors and outcomes of pressure injuries in adult intensive care unit patients: the DecubICUs study [5]	13,254	Overall pressure injury prevalence 26.6%; ICU-acquired prevalence 16.2%. Age, male sex, being underweight, emergency surgery, higher acuity score, ICU stay > 3 days, comorbidities, organ support, and being in a low or lower–middle-income economy were associated with pressure injury. The most commonly occurring sites for pressure injury were the sacrum and heels. Gradually increasing associations with mortality were identified for increasing severity of pressure injury (odds ratio 1.5–2.8)
The effectiveness of multicomponent pressure injury prevention programs in adult intensive care patients: a systematic review [6]	78–399	Multicomponent programs were associated with decreased pressure injury incidence. Common components include repositioning, staff/patient education, support surfaces use, pressure injury risk assessment, skin assessment, nutrition assessment, documentation, and mobilization
The effect of adhesive tape versus endotracheal tube fastener in critically ill adults: the endotracheal tube securement (ETTS) randomized controlled trial [9]	500	The use of an endotracheal tube fastener reduced the incidence of lip ulcers, facial skin tears, and tube dislodgement compared to adhesive tape

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levels, deliver personalized care and measure the effectiveness of interventions. A recent study by Waters et al. evaluated the ability of a Smart Surface Platform to measure interface pressure and skin microclimate simultaneously [11]. The platform's ability to continuously monitor mobility, temperature and moisture may facilitate individualized PI prevention and free up valuable nursing time. Such technologies may also serve as the basis for artificial intelligence (AI) applications to support prevention and improve resource allocation [12].

The coronavirus disease 2019 (COVID-19) pandemic has heightened attention to ICU patient (age, comorbidity, frailty) [13] and treatment risk factors (prone positioning, prolonged ventilation) which may contribute to poor outcomes, including PI development [14]. With the continued 'greying' of society, patients entering our critical care units are older, have a greater burden of comorbid disease, may have pre-existing frailty, poor functional status and limited resilience. These factors and outcomes emphasize the importance of making PI a priority concern for all ICU patients, including the chronically critically ill. Although all members of the ICU interprofessional team are well aware that PIs may be major and consequential complication of a protracted critical illness and an important source of long-term morbidity, greater attention to this problem is warranted.

Despite the valuable contribution of the DecubICUs study to the PI evidence base, there are some notable limitations to knowledge development related to the study design [5]. First, point prevalence methodology does not offer any insight on the progression of PIs over time. Second, the study's 12-week follow-up period represents an important limitation in our understanding of longer-term patient and family-important outcomes. Third, while associations between severity of PI and mortality are compelling and potentially important, the study design cannot infer causality. There may be influential contextual factors contributing to PI prevalence which were not known or measured as part of the study protocol.

PIs are important, morbid and may represent an independent risk for mortality. They have a consequential impact on outcomes after an episode of critical illness, but, like frailty, are not currently captured as part of the post intensive care syndrome [15]. PIs are associated with many risk factors common to ICU patients and yet, prevention of all wounds may not be an attainable goal. However, there is significant opportunity to improve interprofessional ICU team practice in PI risk ascertainment, prevention and long-term follow-up. With an older and increasingly complex and vulnerable ICU patient population, it will be necessary to continue to expand the evidence base informing PI risk prevention

and treatment to include long-term functional outcomes, quality of life, economic evaluation, and patient/family-identified research priorities.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1007/s00134-021-06350-0.

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Compliance with ethical standards

Conflicts of interest
The authors report no conflict of interest.

Publisher's Note

Received: 27 November 2020 Accepted: 8 January 2021
Published online: 27 January 2021

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