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BRIEF COMMUNICATION

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Retrospective analysis of thermographic imaging in early detection of pressure injuries

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Abstract

Pressure injuries in critically ill patients present a significant healthcare burden. Traditional methods, such as the Braden score, assess the risk of developing pressure injuries by evaluating factors like sensory perception, moisture and mobility. In contrast, thermographic imaging, which measures variations in skin temperature, offers a promising tool for not only assessing risk but also enabling earlier identification of pressure injuries. This study assessed thermographic imaging's ability to detect existing and evolving pressure injuries in surgical intensive care unit (SICU) patients and compared its accuracy with the Braden score. Among 465 patients, 76 underwent thermographic evaluations of the sacrum and/or heel. Of 25 patients with pressure injuries at admission, 23 had abnormal thermographic scores. Fifteen patient developed pressure injuries during SICU admission. Logistic regression showed that abnormal thermographic scores significantly increased the likelihood of detecting both existing and new injuries, while the Braden score was not a significant predictor. Thermographic imaging appears to be a superior predictor of pressure injuries, offering earlier detection and potentially improving patient outcomes while reducing healthcare costs.

KEYWORDS
Braden score, deep-tissue pressure injuries, early detection, early intervention strategies, economic burden, healthcare costs, healthcare technology, infrared thermography, non-invasive diagnostics, pressure injuries, pressure ulcers, surgical intensive care unit, thermographic imaging

1 | INTRODUCTION

Pressure injuries, also known as bedsores, decubitus ulcers, or pressure ulcers, are localised damage to the skin and underlying tissues.[1] They occur due to sustained pressure and friction, typically affecting areas over bony prominences.[2] Pressure injuries remain a significant challenge within healthcare environments, particularly among critically ill patients in intensive care units (ICUs).[3] The economic burden of hospital-acquired pressure injuries (HAPIs) is substantial, with and estimated national cost burden of $26.8 billion.[4] Deep-tissue pressure injuries (DTPIs) are among the most severe types of pressure injuries. Unlike bruises, which show immediate colour changes, these injuries impact the muscle-bone interface and visible signs, such as a purple or maroon discoloration, typically emerge about 48 h after the injury. The standard approach of visually inspecting for DTPIs can be unreliable, particularly when it comes to detecting injuries beneath the surface or in patients with darker skin tones, where early signs such as

Abbreviations: DTPI, deep-tissue pressure injury; ICU, intensive care unit; SICU, surgical intensive care unit.

redness or discoloration may not be apparent.[5] This can lead to delays in diagnosis and treatment, increasing the risk of more severe outcomes.[6]

The use of thermographic imaging or infrared thermography has shown promise in the early detection of pressure injuries.[7] Infrared thermography provides a non-invasive, contact-free method to assess skin temperature variations, which are indicative of underlying issues such as poor blood flow or tissue damage.[8–10] To reduce the influence of external and internal factors on skin temperature readings, the relative temperature differential method is used. This approach compares the temperature of a suspected wound area to that of adjacent, unaffected skin.[11] This control point has been validated in previous studies and is defined as intact tissue near the wound, free of visible signs of injury or inflammation. Specific distances are not standardised to allow flexibility based on individual anatomy.[12] The aim of this study is to (1) evaluate the effectiveness of thermographic imaging in detecting both clinically evident and developing pressure injuries in patients admitted to the surgical intensive care unit (SICU), and (2) compare the accuracy of thermographic imaging with the Braden score in assessing pressure injury risk. By assessing the effectiveness of this technology in a critical care setting, we hope to determine its potential to improve early detection and intervention, thereby reducing the incidence of late stage (Stage 3 and 4) pressure injuries and enhancing patient outcomes.

2 | MATERIALS AND METHODS

This retrospective study of the University of Miami's surgical intensive care unit (SICU) was conducted over a period of 6 months. All patients admitted to the SICU undergo a comprehensive skin assessment via a Braden Score, alongside a temperature examination using a thermographic tool (The Scout, WoundVision LLC, Indianapolis, Indiana).[13] This device enables the detection of skin temperature variations, which can indicate underlying issues such as pressure injuries or infections. Nurses in the SICU have been thoroughly trained to use *The Scout*, including setting a control point to establish baseline measurements and accurately documenting the resulting thermographic scores as part of their routine assessment. A temperature range outside of $+1.1$ to $-1.1°C$ was considered abnormal, as recommended by WoundVision based on prior research and internal data, to identify pre-visual thermal anomalies. This threshold reflects findings from studies indicating that localised temperature changes are early indicators of pressure injury development in high-risk populations.[11,14–18]

Patients aged 18 years or older were included in the study if they met the following criteria: upon admission to the University of Miami Surgical ICU, they underwent a Braden Score assessment immediately followed by a skin examination using a thermographic tool (The Scout, WoundVision LLC, Indianapolis, Indiana).[13] Both evaluations specifically evaluated the sacrum and or heel. Patients were excluded if they did not undergo both a clinical and a thermographic evaluation of the same area, performed within 15 min of each other. A total of 465 patients were admitted to the SICU over the course of 6 months. A subset of 76 patients met all inclusion criteria and were included in this analysis.

Data collection involved reviewing patient records to identify those with pressure injuries at the time of admission and or developed new pressure injuries during their ICU stay. Binary logistic regression analysis was employed to compare the utility of thermographic imaging and Braden scores in identifying pressure injury development risk. The model's performance was evaluated using the pseudo-R-squared value and the statistical significance of the coefficients.

The study was approved by the University of Miami Institutional Review Board (IRB). Informed consent was waived due to the retrospective nature of the study, and all patient data were de-identified prior to analysis to ensure confidentiality.

3 | RESULTS

Of the 465 patients assessed, 76 had their skin assessment location specified as the heel and or sacrum, along with a corresponding thermographic evaluation, and were included in the study (Table 1). Among the cohort, 25 patients presented with pressure injuries upon admission, while 15 developed new pressure injuries during their SICU stay. The existing pressure injuries on admission included 2 unspecified, 14 unstageable, 2 Stage 1, 1 Stage 2, 13 DTPIs, 2 Stage 3, and 1 Stage 4. The newly developed pressure injuries, identified after the initial assessment included 1 unspecified, 1 unstageable, 8 Stage 2 and 5 DTPIs. Notably, the newly developed pressure injuries were documented at later stages. Among the 25 patients who had a pressure injury on admission, 23 exhibited abnormal thermographic scores outside the normal range of $+1.1$ to $-1.1°C$. The sensitivity of thermographic imaging for detecting pressure injuries was calculated at 92.5%, with a specificity of 66.67%. The Positive Predictive Value (PPV) was 75.5%, and the Negative Predictive Value (NPV) was 88.9%. It is important to note that the observed sensitivity may have been negatively influenced by preventive interventions. While all patients admitted to the SICU have baseline prevention measures

TABLE 1 Demographics of patients who met inclusion into the study.

Demographics	Value ($n = 76$), No. (%)
Age (mean ± SD)	69.67 ± 10.75
Sex	
Male	45 (59.21%)
Female	31 (40.79%)
Race	
White	59 (77.63%)
Black or African American	17 (22.37%)
Other	0 (0.00%)
Ethnicity	
Non-Hispanic or Latino	38 (50.00%)
Hispanic or Latino	37 (48.68%)

in place, additional interventions are implemented as indicated based on the Braden Risk Assessment score. These include the use of specialty mattresses, offloading devices, incontinence and moisture management strategies, and ensuring adherence to all appropriate nursing pressure injury prevention interventions. Of the patients who exhibited thermographic abnormalities but did not develop pressure injuries, the majority received additional targeted preventive measures, which may have halted the progression of the injuries. This suggests that while thermographic imaging is a strong predictor of pressure injury development, early intervention based on abnormal thermographic findings may reduce the occurrence of these injuries, thereby impacting the specificity and PPV of the method. The binary logistic regression analysis revealed that an abnormal thermographic score significantly increased the odds of having a pressure injury (coefficient: 1.8770, $p = 0.006$), while the Braden score did not significantly predict pressure injuries (coefficient: 0.3241, $p = 0.546$). The model demonstrated a moderate fit with a pseudo-R-squared value of 0.1171.

For the 15 patients who developed new pressure injuries, 14 had abnormal thermographic scores at baseline. The logistic regression analysis for new pressure injury development showed that an abnormal thermographic score was a statistically significant predictor (coefficient: 2.2896, $p = 0.034$), whereas the Braden score was not (coefficient: 0.2008, $p = 0.744$). The model's pseudo-R-squared value was 0.1116, indicating a moderate fit, and the overall model was statistically significant ($p = 0.01481$). These findings highlight the potential of thermographic imaging as an early detection tool for pressure injuries, capable of identifying at-risk patients before the appearance of clinical signs.

4 | DISCUSSION

The findings of this study highlight the potential of thermographic imaging as a valuable tool in the early detection of pressure injuries in critically ill patients. Unlike traditional risk assessment methods, such as the Braden score, thermographic imaging demonstrated a significant ability to predict both existing and new pressure injuries. This suggests that thermographic imaging could be integrated into routine ICU care to enhance early detection efforts, ultimately improving patient outcomes and reducing the economic burden associated with advanced-stage pressure injuries.

These results are consistent with prior research highlighting the utility of thermography in pressure injury detection. Koerner et al. demonstrated that using thermal imaging on ICU admission could identify early-stage DTPIs, significantly reducing progression rates and associated costs.[11] Similarly, Jiang et al. showed that infrared thermography reliably detects early physiological changes, such as ischemia or inflammation, before visual signs of injury manifest.[7] These findings align closely with the present study, in which abnormal thermographic scores were significant predictors of both existing and new pressure injuries.

Further, studies have validated thermography's capacity to assess relative temperature differences in wound areas, offering an objective and reproducible method to identify at-risk tissue.[12,19] This supports the current study's results, which showed high sensitivity (92.5%) in identifying pressure injuries.

While this study underscores the utility of thermographic imaging, it is important to acknowledge its limitations. The retrospective design and relatively small sample size may limit the generalizability of the findings. Additionally, the study focused on a specific patient population within a single SICU setting, which may not be representative of broader healthcare environments. Future research should aim to validate these findings in larger, multicentre studies and explore the cost-effectiveness of implementing thermographic imaging in routine clinical practice.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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