Pressure ulcers are one of the most underrated conditions in critically ill patients. Despite the introduction of clinical practice guidelines and advances in medical technology, the prevalence of pressure ulcers in hospitalized patients continues to escalate. Currently, consensus is lacking on the most important risk factors for pressure ulcers in critically ill patients, and no risk assessment scale exclusively for pressure ulcers in these patients is available.

**Objective**
To determine which risk factors are most predictive of pressure ulcers in adult critical care patients. Risk factors investigated included total score on the Braden Scale, mobility, activity, sensory perception, moisture, friction/shear, nutrition, age, blood pressure, length of stay in the intensive care unit, score on the Acute Physiology and Chronic Health Evaluation II, vasopressor administration, and comorbid conditions.

**Methods**
A retrospective, correlational design was used to examine 347 patients admitted to a medical-surgical intensive care unit from October 2008 through May 2009.

**Results**
According to direct logistic regression analyses, age, length of stay, mobility, friction/shear, norepinephrine infusion, and cardiovascular disease explained a major part of the variance in pressure ulcers.

**Conclusion**
Current risk assessment scales for development of pressure ulcers may not include risk factors common in critically ill adults. Development of a risk assessment model for pressure ulcers in these patients is warranted and could be the foundation for development of a risk assessment tool.

Development of pressure ulcers is complex and multifactorial. In critical care patients, pressure ulcers are an additional comorbid threat in patients who are already physiologically compromised. In fact, pressure ulcers are one of the most underrated medical problems in critical care patients. Despite advances in medical technology and the use of formalized prevention programs based on clinical practice guidelines, the prevalence of pressure ulcers during hospitalization continues to increase. In 2008, Russo et al of the Health Care Cost and Utilization Project reported an 80% increase in the occurrence of pressure ulcers from 1993 to 2006 in hospitalized adult patients and estimated that total associated health care costs were $11 billion. Among all hospitalized patients, prevalence rates of acquired pressure ulcers are the highest in patients in the intensive care unit (ICU), from 14% to 42%. 

In 2006, the Centers for Medicare and Medicaid Services declared that hospital-acquired stage III or stage IV pressure ulcers are adverse patient safety events, or “never events,” that could reasonably be prevented by implementing evidence-based prevention guidelines. As a result, beginning in 2008, reimbursement limitations were enacted for acute care hospitals for care associated with stage III or stage IV pressure ulcers not documented as present when a patient was admitted. This change has sparked a renewed urgency and awareness related to preventing pressure ulcers. Although the implementation of comprehensive prevention programs can reduce the prevalence of hospital-acquired pressure ulcers, pressure ulcers do develop in hospitalized patients, despite quality care and best practice. Furthermore, the risk for pressure ulcers may be greater for ICU patients than for other patients. 

The first step in preventing pressure ulcers is determining what constitutes appropriate risk. Many risk factors have been identified empirically; however, consensus on the most important risk factors is lacking. 

Review of Relevant Literature

The lack of a risk assessment scale exclusively for determining the risk for pressure ulcers is an impediment to accurately determining risk in critical care patients. In the United States, the Braden Scale is the most widely used risk assessment tool in most care settings, including the ICU, and current clinical practice guidelines recommend its use. With the Braden Scale, derived from the conceptual framework of Braden and Bergstrom, 6 subscales are used to measure risk for pressure ulcers: sensory perception, activity, mobility, nutrition, moisture, and friction/shear. Potential scores range from 6 to 23; lower scores indicate greater risk. Scores of 15 to 18 indicate risk or mild risk; scores of 13 to 14, moderate risk; scores of 10 to 12, high risk; and scores of 9 or less, very high risk. Stratification of risk for pressure ulcers can be useful clinically for determining and implementing the appropriate level of prevention.

Although evidence supports the total score on the Braden Scale as a predictor of pressure ulcers in critical care patients, investigation of the contributions of the subscale scores has been limited, and the findings have been inconclusive. Although the subscales of sensory perception, moisture, mobility, and friction/shear have been found to be significant predictors of pressure ulcer development in ICU patients, the activity and nutrition subscales have not. Other factors not included in the Braden Scale may also increase a patient’s level of risk for pressure ulcers and thus be important determinants in adult critical care patients. Empirical evidence suggests that the following factors can be predictive of pressure ulcers in critical care patients: advanced age, low arteriolar pressure, prolonged ICU stay, severity of illness as indicated by scores on the Acute Physiology and Chronic Health Evaluation (APACHE) II; comorbid conditions, including diabetes mellitus, sepsis, and vascular disease; and iatrogenic factors, such as the use of vasopressor agents. Although research has indicated that many of these factors are significantly related to the development of pressure ulcers in ICU patients, the findings were not consistent in all of the studies in which these relationships were tested.

Pressure ulcers are one of the most underrated medical problems in critical care patients.

About the Author
Jill Cox is an advanced practice nurse and a wound, ostomy, continence nurse at Englewood Hospital and Medical Center, Englewood, New Jersey.
Corresponding author: Jill Cox, RN, PhD, APN, CWOCN, Englewood Hospital and Medical Center, 350 Engle St, Englewood NJ, 07631 (e-mail: jill.cox@ehmc.com).
The purpose of my study was to determine which risk factors derived from the Braden Scale and the empirical literature are the best predictors of pressure ulcers in adult critical care patients. The following risk factors were examined: total Braden score, mobility, activity, sensory perception, moisture, nutrition, friction/shear, ICU length of stay, age, arteriolar pressure, vasopressor administration, score on APACHE II, and comorbid conditions.

**Methods**

This study received exempt status from the hospital’s institutional review board. The study posed no risk to the participants because the variables abstracted reflected care parameters implemented and recorded during routine patient care. All patient information recorded was deidentified to ensure patient anonymity.

**Study Design and Setting**

A retrospective descriptive, correlational design was used. The setting was an intensivist-led, 12-bed medical-surgical ICU (MSICU) in Englewood Hospital and Medical Center, a suburban Magnet teaching hospital in Englewood, New Jersey.

**Sample**

All adult patients admitted to the MSICU from October 2008 through May 2009 who met the inclusion criteria were included in this convenience sample. Patients were included if they were 18 years or older and had an MSICU stay of 24 hours or greater. Patients were excluded if they had an MSICU stay of less than 24 hours or had a pressure ulcer at the time of admission to the MSICU. A power analysis was conducted for regression analysis to determine an appropriate sample size. In order to achieve a power of 80%, a minimum sample size of 163 was needed for a moderate effect size, a significance level of $\alpha = .05$, and 22 predictor variables.

**Data Collection**

Data were abstracted from the hospital’s existing computerized documentation systems and included the following study variables: pressure ulcer (recorded as present or absent at discharge from the MSICU); score on Braden Scale at the time of admission to the MSICU; scores on Braden subscales at admission to the unit; age; arteriolar pressure (defined as the total number of hours in the first 48 hours that the patient had mean arterial pressure <60 mm Hg, and/or systolic blood pressure <90 mm Hg, and/or diastolic blood pressure <60 mm Hg); length of MSICU stay; total number of hours of administration of any of the following vasopressor agents during the MSICU stay: norepinephrine, epinephrine, vasopressin, dopamine, and phenylephrine; severity of illness according to the APACHE II score; and presence or absence of any of the following comorbid conditions: diabetes mellitus, cardiovascular disease, peripheral vascular disease, and concomitant infection/sepsis. During the study period, routine protocols for prevention of pressure ulcers were in place in the MSICU. The protocols were based on the clinical practice guidelines current at that time.

Demographic data and patient characteristics included ethnicity, sex, and admitting MSICU diagnosis. In addition, for patients in whom a pressure ulcer developed, the number of hours into the admission the pressure ulcer occurred and the anatomical location and stage of the pressure ulcer according to the 2007 National Pressure Ulcer Advisory Panel staging system (Table 1) were recorded.

### Table 1

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected deep tissue injury</td>
<td>Purple or maroon localized area of discolored intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear. The area may be preceded by tissue that is painful, firm, mushy, boggy, and warmer or cooler than adjacent tissue.</td>
</tr>
<tr>
<td>I</td>
<td>Intact skin with nonblanchable redness of a localized area, usually over a bony prominence. Darkly pigmented skin may not have visible blanching; its color may differ from that of the surrounding area.</td>
</tr>
<tr>
<td>II</td>
<td>Partial-thickness loss of dermis manifested as a shallow, open ulcer with a red-pink wound bed, without slough. May also be manifested as an intact or open/ruptured serum-filled blister.</td>
</tr>
<tr>
<td>III</td>
<td>Full-thickness tissue loss. Subcutaneous fat may be visible, but bone, tendon, or muscle are not exposed. Slough may be present but does not obscure the depth of tissue loss.</td>
</tr>
<tr>
<td>IV</td>
<td>Full-thickness tissue loss with exposed bone, tendon, or muscle. Slough or eschar may be present on some parts of the wound. Often includes undermining and tunneling.</td>
</tr>
<tr>
<td>Unstageable</td>
<td>Full-thickness tissue loss in which the base of the ulcer is covered by slough (yellow, tan, gray, green, or brown) or eschar (tan, brown, or black) in the wound bed.</td>
</tr>
</tbody>
</table>

*a Based on data from the National Pressure Ulcer Advisory Panel.*

---

**Braden subscales of activity and nutrition have not been useful as risk predictors in intensive care patients.**
Results
Description of the Sample
Of the 579 patients admitted to the MSICU during the study period, 347 met the inclusion criteria and were included in the final sample. The patients were 20 to 97 years old (mean, 69; SD, 17). The top 3 admitting diagnoses were respiratory failure or distress (20.7%), sepsis or septic shock (17.3%), and neurological problems (15%). Demographic characteristics of the sample are summarized in Table 2.

Descriptive Statistics of the Study Variables
Descriptive statistics of the study variables are summarized in Table 3. Among the 347 patients in the sample, a pressure ulcer developed in 65 (18.7%). Of these ulcers, most (35%) were stage II, and the sacrum was the most common anatomical location (58%). Mean time until development of a pressure ulcer was 133.61 hours (median 90.0; range, 5-573; SD, 120.13). The distribution of pressure ulcers by stage and hours to development is summarized in Table 4.

Mean Braden Scale scores were 14.28 (SD, 2.68; range, 6-23) for the entire patient sample, 12.73 (SD, 2.65) for patients in whom pressure ulcers developed, and 14.63 (SD, 2.65) for patients who remained ulcer-free. Of the 65 patients in whom a pressure ulcer developed, 28% (n = 18) were classified as at risk, 28% (n = 18) as at moderate risk, 35% (n = 23) as at high risk, and 9% (n = 6) as at very high risk. Predictive validity of the Braden Scale was measured by using sensitivity and specificity values in addition to negative and positive predictive values (Table 5). At a cut-off score of 18, the sensitivity was 100%, specificity was 7%, positive predictive value was 20%, and negative predictive value was 100%. According to the scores on the Braden Scale, 94% of the sample was predicted to be at risk for pressure ulcers; the actual occurrence rate was 18.7%.

Logistic Regression Analyses
Independent variables significantly associated with the dependent variable development of a pressure ulcer were included in direct logistic regression (Table 6). The following risk factors were significant predictors of pressure ulcers: mobility \( (B = 1.082; P = .04) \) odds ratio \([OR] = 0.439; 95\% \text{ confidence interval} \{CI\}, 0.21-0.95\), age \( (B = 0.033; P = .008) \), race \( (B = 1.064; P = .009) \), ethnicity \( (B = 1.053; P = .01; OR = 1.007; 95\% \text{ CI, 1.03-1.08} ) \), length of ICU stay \( (B = 1.082; P = .007; OR = 2.952; 95\% \text{ CI, 1.3-6.4} ) \), and cardiovascular disease \( (B = 1.082; P = .007; OR = 2.952; 95\% \text{ CI, 1.3-6.4} ) \).

A pressure ulcer developed in 18.7% of the sample; most were stage II sacral ulcers.
Braden Scale led to successful identification of patients at risk, subsequently mobilizing clinicians to implement appropriate strategies to prevent pressure ulcers and thus averting the occurrence of the ulcers, or potentially unnecessary strategies to prevent pressure ulcers were implemented, resulting in excessive health care costs and potential inefficient use of caregivers’ time.

Of the 6 Braden subscales, only mobility and friction/shear were significant predictors of pressure ulcers. Mobility is defined on the Braden Scale as the ability of a patient to turn and control body movement. Compared with patients who were ulcer-free, patients in whom pressure ulcers developed had significant lower scores on the mobility subscale, with a mean subscale score of 2.0, defined as $B = 1.218; P = .02; OR = 3.380; 95\% CI, 1.223-9.347; Table 7$.

**Discussion**

In this study sample, a Braden Scale score of 18 was not predictive of the development of a pressure ulcer. In fact, 75% (n = 261) of the patients were classified as at risk for pressure ulcers (Braden Scale score ≤18) but remained ulcer-free (see Figure). When the Braden Scale was used, the risk for pressure ulcers was overpredicted, as indicated by the low specificity and low positive predictive value. Because of the overprediction, drawing any important conclusions about the capability of the scale in predicting development of pressure ulcers in the patients in the study is difficult. Either use of the Braden Scale led to successful identification of patients at risk, subsequently mobilizing clinicians to implement appropriate strategies to prevent pressure ulcers and thus averting the occurrence of the ulcers, or potentially unnecessary strategies to prevent pressure ulcers were implemented, resulting in excessive health care costs and potential inefficient use of caregivers’ time.

Of the 6 Braden subscales, only mobility and friction/shear were significant predictors of pressure ulcers. Mobility is defined on the Braden Scale as the ability of a patient to turn and control body movement. Compared with patients who were ulcer-free, patients in whom pressure ulcers developed had significant lower scores on the mobility subscale, with a mean subscale score of 2.0, defined as $B = 1.218; P = .02; OR = 3.380; 95\% CI, 1.223-9.347; Table 7$.

**Table 3**

Descriptive statistics of study variables and comparison of patients with acquired pressure ulcers and patients without pressure ulcers

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Valuea</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All patients (n = 347)</td>
<td>Pressure ulcer (n = 65)</td>
</tr>
<tr>
<td>Total Braden score</td>
<td>14.28 (2.68)</td>
<td>12.73 (2.65)</td>
</tr>
<tr>
<td>Sensory perception subscale</td>
<td>2.85 (0.936)</td>
<td>2.40 (0.884)</td>
</tr>
<tr>
<td>Moisture subscale</td>
<td>3.40 (0.756)</td>
<td>1.75 (0.729)</td>
</tr>
<tr>
<td>Activity subscale</td>
<td>1.08 (0.442)</td>
<td>1.00 (0.000)</td>
</tr>
<tr>
<td>Mobility subscale</td>
<td>2.53 (0.829)</td>
<td>2.06 (0.788)</td>
</tr>
<tr>
<td>Nutrition subscale</td>
<td>2.29 (0.655)</td>
<td>2.06 (0.555)</td>
</tr>
<tr>
<td>Friction/shear subscale</td>
<td>2.10 (0.473)</td>
<td>1.90 (0.491)</td>
</tr>
<tr>
<td>Age, y</td>
<td>69 (18)</td>
<td>73 (15)</td>
</tr>
<tr>
<td>Arteriolar pressure, h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean arterial pressure &lt;60 mm Hg</td>
<td>2.41 (4.96)</td>
<td>3.67 (5.83)</td>
</tr>
<tr>
<td>Systolic &lt;90 mm Hg</td>
<td>3.65 (6.74)</td>
<td>5.61 (7.72)</td>
</tr>
<tr>
<td>Diastolic &lt;60 mm Hg</td>
<td>23.12 (15.39)</td>
<td>30.43 (15.26)</td>
</tr>
<tr>
<td>Hours in intensive care unit</td>
<td>118.84 (155.58)</td>
<td>281.21 (256.14)</td>
</tr>
<tr>
<td>Severity of illness (APACHE II score)</td>
<td>17.268 (7.72)</td>
<td>21.89 (6.71)</td>
</tr>
<tr>
<td>Vasopressor administration, h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>13.87 (50.05)</td>
<td>54.98 (101.50)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>0.29 (3.69)</td>
<td>0.892 (0.700)</td>
</tr>
<tr>
<td>Phenylephrine</td>
<td>1.29 (8.80)</td>
<td>2.05 (7.83)</td>
</tr>
<tr>
<td>Dopamine</td>
<td>1.70 (9.44)</td>
<td>3.41 (12.16)</td>
</tr>
<tr>
<td>Vasopressin</td>
<td>3.76 (22.24)</td>
<td>16.15 (47.59)</td>
</tr>
<tr>
<td>Comorbid conditions, No. of patients (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>30</td>
<td>Yes, 4 (6)</td>
</tr>
<tr>
<td></td>
<td>No, 61 (94)</td>
<td>No, 256 (91)</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>145</td>
<td>Yes, 37 (57)</td>
</tr>
<tr>
<td></td>
<td>No, 28 (43)</td>
<td>No, 174 (62)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>97</td>
<td>Yes, 19 (29)</td>
</tr>
<tr>
<td></td>
<td>No, 46 (71)</td>
<td>No, 204 (72)</td>
</tr>
<tr>
<td>Infection</td>
<td>120</td>
<td>Yes, 36 (55)</td>
</tr>
<tr>
<td></td>
<td>No, 29 (45)</td>
<td>No, 198 (70)</td>
</tr>
</tbody>
</table>

Abbreviation: APACHE, Acute Physiology and Chronic Health Evaluation.

a All values are mean (SD) unless indicated otherwise.

b Significant at \( P \leq 0.01 \).

c Significant at \( P \leq 0.05 \).

d For all \( \chi^2 \) values, \( df = 1 \) and \( n = 347 \).
as very limited mobility. Turning and repositioning an immobile patient is a basic tenet of nursing care and is recommended in all current practice guidelines as a strategy to prevent pressure ulcers. Although evidence for the optimal frequency for repositioning immobile patients is lacking,27 the guidelines28,29 indicate that regular repositioning is vital. Some evidence30 also supports the use of low air loss mattresses for pressure redistribution in ICU patients. The use of low air loss mattresses and regular turning and repositioning of immobile patients may be 2 essential strategies for preventing pressure ulcers in critical care patients. The effect of progressive mobility programs on reduction of pressure ulcers in ICU patients is an area ripe for empirical study.

Development of a stage II or greater pressure ulcer was almost 6 times more likely in patients with higher exposure to friction/shear than in patients with low exposure. Previous studies in critical care patients have yielded inconclusive evidence for this subscale. Although Jiricka et al31 found a significance difference in the mean Braden friction/shear subscale scores between patients in whom pressure ulcers developed and patients who remained ulcer-free, other investigators32,33 found no relationship between the subscale and development of pressure ulcers in critical care patients. In a recent study34 in a surgical trauma ICU, 41 patients at high risk for pressure ulcers received an application of a silicone-bordered, nonadherent foam dressing to the sacral area to minimize the forces of friction, shear, and moisture. Application of this topical dressing significantly reduced the occurrence of pressure ulcers to zero. The study is being replicated to validate the findings.

Immobile, critically ill patients are totally dependent on caregivers for both repositioning and transfers, increasing the risk for exposure to the forces of friction/shear and subsequent development of pressure ulcers. Advocates of safe patient handling procedures recommend the use of glide sheets and patient transfer devices to reduce the deleterious effects of friction/shear on the skin and simultaneously protect staff from musculoskeletal injuries.35 Additional factors such as prolonged head elevation in critically ill, intubated patients to prevent ventilator-associated pneumonia or in enterally fed patients to prevent aspiration also increase the risk for exposure to friction/shear. Continued research into the effects of prolonged head elevation on skin integrity is warranted to better understand the sequelae of shear forces and to develop interventions to counteract these forces.

In my study, patients in whom pressure ulcers developed had lower mean scores on the Braden sensory perception subscale than did patients who remained ulcer-free. However, this subscale was not a significant predictor. Diminished levels of sensory perception experienced by all patients in the sample may have rendered this risk factor nonsignificant.

---

Table 4
Analysis of patients with pressure ulcers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure ulcer</td>
<td>65 (18.7)</td>
</tr>
<tr>
<td>Pressure ulcer stage</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>20 (31)</td>
</tr>
<tr>
<td>II</td>
<td>23 (35)</td>
</tr>
<tr>
<td>III</td>
<td>1 (2)</td>
</tr>
<tr>
<td>IV</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Deep tissue injury</td>
<td>15 (23)</td>
</tr>
<tr>
<td>Unstageable</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Pressure ulcer location</td>
<td></td>
</tr>
<tr>
<td>Sacrum</td>
<td>38 (58)</td>
</tr>
<tr>
<td>Buttocks</td>
<td>22 (34)</td>
</tr>
<tr>
<td>Heels</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Hours to pressure ulcer detection</td>
<td></td>
</tr>
<tr>
<td>1-8</td>
<td>21 (32)</td>
</tr>
<tr>
<td>49-72</td>
<td>7 (11)</td>
</tr>
<tr>
<td>73-144</td>
<td>15 (23)</td>
</tr>
<tr>
<td>≥145</td>
<td>22 (34)</td>
</tr>
<tr>
<td>No. of pressure ulcers by stage and hours to detection</td>
<td></td>
</tr>
<tr>
<td>Hours to detection</td>
<td>Stage I</td>
</tr>
<tr>
<td>1-48</td>
<td>8</td>
</tr>
<tr>
<td>49-72</td>
<td>2</td>
</tr>
<tr>
<td>73-144</td>
<td>3</td>
</tr>
<tr>
<td>≥145</td>
<td>7</td>
</tr>
</tbody>
</table>

a Based on data from Bolton.36

Table 5
Predictive validity criteria of a pressure ulcer risk assessment scalea

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>What percentage of patients who actually had a pressure ulcer develop were classified as at risk?</td>
</tr>
<tr>
<td>Specificity</td>
<td>What percentage of patients who remained free of a pressure ulcer were accurately classified as not at risk?</td>
</tr>
<tr>
<td>Predictive value of a positive test</td>
<td>How accurate is the risk assessment scale as a prospective predictor of which patients will have a pressure ulcer develop?</td>
</tr>
<tr>
<td>Predictive value of a negative test</td>
<td>How accurate is the risk assessment scale as a prospective predictor of which patients will not have a pressure ulcer develop?</td>
</tr>
</tbody>
</table>

a Based on data from Bolton.36
Table 6
Bivariate correlations: independent variables and dependent variable (pressure ulcer development)

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Braden score</td>
<td>-0.276a</td>
</tr>
<tr>
<td>Mobility</td>
<td>-0.275a</td>
</tr>
<tr>
<td>Activity</td>
<td>-0.088</td>
</tr>
<tr>
<td>Sensory perception</td>
<td>-0.208b</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.104</td>
</tr>
<tr>
<td>Friction/shear</td>
<td>0.196a</td>
</tr>
<tr>
<td>Nutrition</td>
<td>-0.175b</td>
</tr>
<tr>
<td>Age</td>
<td>0.130a</td>
</tr>
<tr>
<td>Mean arterial pressure &lt;60 mm Hg</td>
<td>0.122b</td>
</tr>
<tr>
<td>Systolic pressure &lt;90 mm Hg</td>
<td>0.140a</td>
</tr>
<tr>
<td>Diastolic pressure &lt;60 mm Hg</td>
<td>0.228a</td>
</tr>
<tr>
<td>Hours in intensive care unit</td>
<td>0.502a</td>
</tr>
</tbody>
</table>

Abbreviation: APACHE, Acute Physiology and Chronic Health Evaluation.

Table 7
Logistic regression analyses

Logistic regression (n = 347)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Standard error</th>
<th>Wald</th>
<th>P</th>
<th>Exp (B)</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.033</td>
<td>0.015</td>
<td>4.725</td>
<td>.03</td>
<td>1.033</td>
<td>1.003 to 1.064</td>
</tr>
<tr>
<td>Hours in intensive care unit</td>
<td>0.008</td>
<td>0.002</td>
<td>21.996</td>
<td>&lt;.001</td>
<td>1.008</td>
<td>1.005 to 1.011</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>1.082</td>
<td>0.401</td>
<td>7.288</td>
<td>.007</td>
<td>2.952</td>
<td>1.3 to 6.4</td>
</tr>
<tr>
<td>Mobility</td>
<td>-0.823</td>
<td>0.398</td>
<td>4.262</td>
<td>.04</td>
<td>0.439</td>
<td>0.210 to 0.95</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.049</td>
<td>2.857</td>
<td>6.087</td>
<td>.01</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

Nagelkerke R² = 0.512.
Hosmer and Lemeshow test: χ² = 6.993, df = 8, P = .54.

Logistic regression (n = 327), subsample of all patients excluding patients with stage I pressure ulcers

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Standard error</th>
<th>Wald</th>
<th>P</th>
<th>Exp (B)</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours in intensive care unit</td>
<td>0.008</td>
<td>0.002</td>
<td>18.063</td>
<td>&lt;.001</td>
<td>1.008</td>
<td>1.004 to 1.012</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>1.218</td>
<td>0.519</td>
<td>5.510</td>
<td>.02</td>
<td>3.380</td>
<td>1.223 to 9.347</td>
</tr>
<tr>
<td>Friction/shear</td>
<td>1.743</td>
<td>0.709</td>
<td>6.039</td>
<td>.01</td>
<td>5.715</td>
<td>1.423 to 22.95</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>0.017</td>
<td>0.008</td>
<td>4.223</td>
<td>.04</td>
<td>1.017</td>
<td>1.001 to 1.033</td>
</tr>
<tr>
<td>Constant</td>
<td>-10.512</td>
<td>3.779</td>
<td>7.737</td>
<td>.005</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

Nagelkerke R² = 0.569.
Hosmer and Lemeshow test: χ² = 5.836, df = 8, P = .67.

When analyzed with other risk factors. In 2 previous studies22,24 in critical care patients, however, scores on the Braden sensory perception subscale were predictive of pressure ulcers. Current pressure ulcer guidelines10 recommend that practitioners consider the impact of the score on the Braden sensory perception subscale when determining a patient's risk for pressure ulcers.

In my sample, the activity subscale was not related to development of pressure ulcers, a finding consistent with the results of previous studies21,22,24 in critical care patients in which the Braden activity subscale was used. Because most patients in the MSICU were bed bound, the patients in my sample had little variation in activity levels.

A possible explanation for the finding that the score on the Braden moisture subscale was not predictive of pressure ulcers in my study is the frequent use of indwelling devices that minimize skin exposure to moisture from 2 primary sources: urine (indwelling urinary catheters) and liquid stool (fecal containment devices). In 2 previous studies22,24 in ICU patients, scores on the Braden moisture subscale were predictive of pressure ulcers, and in another study, fecal incontinence was a significant risk factor for pressure ulcers. Bowel management systems, also called fecal containment devices, were introduced to the clinical market in 2004, after the aforementioned studies were published. In a study by Benoit and Watts,41 use of these devices in combination with strategies to prevent pressure ulcers decreased the prevalence of pressure ulcers for patients exposed to high levels of moisture from liquid stool incontinence.

Although scores on the Braden nutrition subscale were related to the development of pressure ulcers in my study, the scores were not a significant predictor, consistent with the findings of previous studies21,22,24 in ICU patients. The score on this subscale is a measure of the usual food intake of a patient, and most critically ill patients may have difficulty articulating a diet history or be unable to do so, especially in the initial days of an ICU admission, diminishing the value of the subscale in these patients. In a previous study26 in ICU patients, however, nutrition, measured as the number of days without nutrition, was a significant predictor of the development of pressure ulcers. Additionally, the results of measurements of many biological markers of nutrition, such as body weight, serum levels of albumin, and, in some instances, serum levels of prealbumin, may be erroneous because of fluid shifts that occur in critical illness, thus creating greater challenges in determining appropriate objective.
nutritional markers. Currently, there is a lack of consensus among researchers and clinicians regarding the best metric of nutritional status.42

In my study, risk factors not included in the Braden Scale, that is, age, length of ICU stay, norepinephrine administration, and cardiovascular disease, were all significant predictors. The mean age of patients in whom pressure ulcers developed was 73 years, whereas the mean age in patients who remained ulcer-free was 67 years. Strong empirical evidence supports the relationship between advanced age and development of pressure ulcers in critical care patients, and perhaps this risk factor should be given stronger consideration for inclusion in a risk assessment scale.1,4,21,25,26

In my study, development of pressure ulcers was more likely in patients with longer ICU stays than in patients with shorter stays. This result is consistent with the findings of previous studies.1,21,26 In my study, the mean MSICU stay was 281 hours (11.7 days) for patients in whom a pressure ulcer developed and 81 hours (3.3 days) for patients who remained ulcer-free.

The most vulnerable time for development of pressure ulcers during the MSICU stay was the first week; 66% of the sample had development of a pressure ulcer in the first 6 days of their MSICU stay, a finding consistent with the results of other studies22,23,43 in critical care patients. On the basis of this finding, the first week of a patient’s ICU stay should be a period of hypervigilance to assess the risk for pressure ulcers, and strategies to prevent such ulcers should be aggressively implemented. Paradoxically, the first week of an ICU stay may also be the most likely period in which a patient experiences the greatest physiological instability, requiring nurses and other members of the health care team to manage multiple life-saving technologies while simultaneously preventing pressure ulcers. During this time, communication among all members of the health care team of the potential for pressure ulcers is crucial. Moreover, a multidisciplinary forum can underscore the premise that prevention of pressure ulcers is the responsibility of all members of the health care team, not just nurses.

In my study, norepinephrine was the only vasopressor that was a significant predictor for pressure ulcers, a finding consistent with the results of previous studies27 in ICU patients. Of note, 32 of the 65 patients (49%) in my study who had a pressure ulcer develop received norepinephrine. Moreover, the mean number of hours of norepinephrine infusions in patients who had stage II or higher pressure ulcers was significantly higher (55 hours) than in patients who remained ulcer-free (4 hours). Evidence to support norepinephrine as a predictor of pressure ulcers in critical care patients is increasing.1,27

Cardiovascular disease was the only comorbid condition in my study that was a significant predictor of pressure ulcers. In my sample, 57% of patients in whom pressure ulcers developed had cardiovascular disease. Although cardiovascular disease has been associated with the development of pressure ulcers in non-ICU patients and in cardiac surgery patients,44-47 this comorbid condition has not been studied extensively as a risk factor in general ICU patients. Further research is needed to elucidate the importance of this unmodifiable risk factor in the development of pressure ulcers in general critical care patients.

In my study, patients in whom a pressure ulcer developed had significantly lower mean diastolic blood pressures, lower mean arterial pressure, and lower mean systolic blood pressures than did patients who remained free of pressure ulcers. However, none of these variables was a significant predictor. In 3 previous studies27,28,43 in ICU patients, no significant relationships were found between any measure of blood pressure and development of pressure ulcers. In another study,29 diastolic blood pressure was lower in critical care patients in whom pressure ulcers developed; however, this relationship was not statistically significant. The finding that none of the blood pressure variables was a predictor of pressure ulcers in my study and in other studies is noteworthy and may be due to the frequent monitoring of blood pressure in critical care patients, resulting in quicker implementation of interventions.
to increase arterial pressure. In my study, the finding may also represent a methodological limitation, because measurement of blood pressures was confined to the first 48 hours of the MSICU stay.

Although severity of illness was not predictive of pressure ulcers in my sample, patients in whom pressure ulcers developed had significantly higher mean APACHE II scores (21.89; SD, 6.71) than did patients who remained ulcer-free (mean, 14.63; SD, 2.65), suggesting that patients with pressure ulcers had a greater disease burden. This finding is consistent with the results of a previous study\textsuperscript{31} in ICU patients. The APACHE II score (at ≥13) was predictive of pressure ulcers in only one study.\textsuperscript{3} A total of 36 of the 347 patients in my sample died, an overall mortality rate of 10%. Among the patients who died during their MSICU stay, almost half (17) had a pressure ulcer at the time of death. Although APACHE II scores are a valid measure of severity of illness and mortality risk, they may not be a reliable empirical indicator for severity of illness as a risk for development of pressure ulcers.

Limitations

The retrospective nature of this study is a limitation. However, most of the data abstracted represent objective clinical data that would not vary on the basis of the study design. Using only the Braden Scale measurements recorded in the first 24 hours of the ICU stay may also be a limitation; however, determining risk early during a patient’s stay is crucial because the determination may result in earlier implementation of prevention strategies. The inability to assess and stage developing pressure ulcers is also a limitation of a retrospective design. Pressure ulcers were staged and recorded in the patients’ record by staff nurses who are educated annually on assessment and staging of pressure ulcers and use of the Braden Scale. Use of a single study site also diminishes the generalizability of the study findings.

Conclusions

Critical care patients are a unique subset of hospitalized patients and are the sickest patients in the health care system. ICU patients are repeatedly confronted with multiple, concomitant risk factors for development of pressure ulcers, and no consensus exists on how best to measure these factors.\textsuperscript{3,13} Although specific measures of risk for pressure ulcers are available for other populations of patients, including children, neonates, patients who receive care at home, patients who receive hospice and palliative care, and patients with spinal cord injuries,\textsuperscript{17,18,48} no such tool exists for critical care patients, creating a barrier to accurate assessment of risk for pressure ulcers in ICU patients.

Accurate identification of risk factors is a prerequisite for determining appropriate strategies to prevent pressure ulcers. However, even with consistent and ongoing skin assessment, early identification of skin changes, and the implementation of appropriate prevention strategies to minimize damage, skin and tissue damage can occur in critically ill patients.\textsuperscript{49} Certain prevention strategies, such as turning of a patient whose hemodynamic status is unstable, may be medically contraindicated, and adequate prevention of pressure ulcers in patients with multiple risk factors is difficult.\textsuperscript{50} Paradoxically, occurrence of pressure ulcers in hospitalized patients, including critical care patients, is considered an adverse event by the Centers for Medicare and Medicaid Services, leaving caregivers in a challenging situation of trying to prevent a pressure ulcer that may not realistically be preventable. Continued research on risk factors for pressure ulcers in critical care patients is imperative, not only to ultimately decrease the prevalence of pressure ulcers but also to help caregivers identify and implement risk appropriate evidence-based strategies to prevent the ulcers. Additionally, research will validate the existence of risk factors for pressure ulcers that cannot be controlled and thus are not preventable.

My results demonstrate the multifactorial causes of pressure ulcers in critical care patients. Although scores on 2 Braden subscale risk factors (mobility, friction/shear) were predictive of pressure ulcers, other risk factors not measured by the Braden Scale, including age, length of ICU stay, norepinephrine administration, and cardiovascular disease, also were significant predictors in multivariate analysis.

My findings underscore the need for development and testing of model for assessing the risk for pressure ulcers in ICU patients, in order to provide a basis for explaining the development of pressure ulcers in these patients. This model could serve as the foundation for development of a pressure ulcer risk assessment scale for critical care patients. Although Pancorbo-Hildago et al\textsuperscript{31} have stated that use of a risk assessment scale increases the implementation of pressure ulcer initiatives, the ultimate test is the
ability to translate the findings of such an assessment into a reduction in the occurrence of pressure ulcers. Little evidence supports such a reduction when current risk assessment tools are used.16,17,18,33

Many opportunities exist for research on the effects of various prevention strategies, such as support surfaces, fecal containment devices, frequency of repositioning, the use of topical dressings applied to the sacrum to minimize friction/shear, progressive mobility programs, and the use of glide sheets and patient transfer equipment, on the development of pressure ulcers in ICU patients. Ultimately, accurately identifying the risk factors for pressure ulcers and testing and implementing evidence-based prevention strategies can lead to reductions in both the occurrence of pressure ulcers and health care costs and can promote positive health outcomes in critical care patients.

ACKNOWLEDGMENTS
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FINANCIAL DISCLOSURES
None reported.

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Now that you’ve read the article, create or contribute to an online discussion on this topic. Visit www.ajcconline.org and click “Respond to This Article” in either the full-text or PDF view of the article.

SEE ALSO
For more about preventing pressure ulcers, visit the Critical Care Nurse Web site, www.ccnonline.org, and read the article by Jankowski, “Tips for Protecting Critically Ill Patients From Pressure Ulcers” (April 2010).

REFERENCES


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Learning objectives: 1. Identify the stages of pressure ulcers as defined by the National Pressure Ulcer Advisory Panel. 2. Describe the components of the Braden Scale for assessing risk for pressure ulcers. 3. Discuss potential factors not included in the Braden Scale that can be predictors for pressure ulcers in critical care populations.

1. Which of the following is the estimated percentage of hospital acquired pressure ulcers in intensive care patients?
   a. 13% to 35%  
   b. 14% to 42%  
   c. 16% to 63%  
   d. 17% to 71%

2. Which of the following explains the reasoning for the Centers for Medicare and Medicaid Services’ limited reimbursement for “never events?”
   a. They can be prevented by implementing evidence-based preventive measures  
   b. They are grounds for malpractice against the nursing staff  
   c. They are unavoidable consequences of properly organized care  
   d. They are inexpensive to treat

3. Which of the following Braden scores belongs to the patient with a high risk for developing a pressure ulcer?
   a. 16  
   b. 13  
   c. 11  
   d. 8

4. Which of the following pressure ulcer risk factors was not included as part of the Braden Scale?
   a. Sensory perception  
   b. Mobility  
   c. Low arteriolar pressure  
   d. Nutrition

5. Which of the following was included in the definition of low arteriolar pressure in the study?
   a. Number of hypotensive hours during intensive care unit (ICU) stay  
   b. Mean arterial pressure <60  
   c. Systolic blood pressure <100  
   d. Diastolic blood pressure <70

6. In this study, which of the following were the most common anatomical location and stage of pressure ulcers?
   a. Buttocks; stage II  
   b. Sacrum; stage I  
   c. Sacrum; stage II  
   d. Buttocks; stage I

7. In this study, which of the following Braden Scale categories was significant for predicting pressure ulcers?
   a. Nutrition and mobility  
   b. Moisture and friction/shear  
   c. Moisture and nutrition  
   d. Mobility and friction/shear

8. Which of the following factors increases the risk of exposure to friction and shear?
   a. Using a glide sheet  
   b. Applying a silicone bordered dressings  
   c. Elevating the head of the bed for a prolonged period  
   d. Using a low air loss mattress

9. Use of which of the following explains the lack of predictability of the moisture subscale in this study compared to previous studies?
   a. Silicone bordered dressings  
   b. Less indwelling urinary catheters  
   c. Bowel management systems  
   d. Low air loss mattresses

10. Which of the following vasoactive drug infusions was a statistically significant predictor for pressure ulcers in the study?
    a. Neosynephrine  
    b. Norepinephrine  
    c. Vasopressin  
    d. Epinephrine

11. Which of the following comorbidities had statistical significance as a predictor for pressure ulcers in the study?
    a. Cardiovascular disease  
    b. Diabetes  
    c. Infection  
    d. Peripheral vascular disease

12. If a patient has a 5 cm shallow ulcer into the dermal layer that has a pink wound bed but no sloughing, this would be categorized as which of the following?
    a. Stage I pressure ulcer  
    b. Stage II pressure ulcer  
    c. Unstoppable  
    d. Suspected deep tissue injury
Predictors of Pressure Ulcers in Adult Critical Care Patients
Jill Cox

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