Background Identifying predictors of length of stay in the intensive care unit can help critical care clinicians prioritize care in patients with acute, life-threatening injuries.

Objective To determine if systemic inflammatory response syndrome scores are predictive of length of stay in the intensive care unit in patients with acute, life-threatening injuries.

Methods Retrospective chart reviews were completed on patients with acute, life-threatening injuries admitted to the intensive care unit at a level I trauma center in the southeastern United States. All 246 eligible charts from the trauma registry database from 1998 to 2007 were included. Systemic inflammatory response syndrome scores measured on admission were correlated with length of stay in the intensive care unit. Data on race, sex, age, smoking status, and injury severity score also were collected. Univariate and multivariate regression modeling was used to analyze data.

Results Severe systemic inflammatory response syndrome scores on admission to the intensive care unit were predictive of length of stay in the unit \( (F=15.83; P<.001) \), as was white race \( (F=9.7; P=.002) \), and injury severity score \( (F=20.23; P<.001) \).

Conclusions Systemic inflammatory response syndrome scores can be measured quickly and easily at the bedside. Data support use of the score to predict length of stay in the intensive care unit. (American Journal of Critical Care. 2009;18:339-347)
Length of stay in the intensive care unit (ICU) is recognized by the Joint Commission on Healthcare Organizations as an important outcome measure for ICU treatment, which is one of the most costly and resource-intensive aspects of caring for patients. Mean costs are more than $10,000 on the first day of admission and nearly $5,000/day afterward. Careful attention to ICU length of stay by critical care nurses, combined with targeted adjustments in patient care planning, can help reduce associated costs and complications.

ICU length of stay for patients with acute, life-threatening injuries can vary widely. Factors that influence ICU length of stay include patients’ demographic variables such as age and physiological changes that occur within the first 24 hours of admission. An example of an important physiological change that occurs within the first 24 hours is the quality of the systemic inflammatory response to injury.

In the hours after an acute life-threatening injury, patients are at risk for development of the systemic inflammatory response syndrome (SIRS), a severe hyperinflammatory condition observed in 29% to 61% of patients after life-threatening injury. The occurrence and severity of SIRS are determined by calculating a SIRS score. This score is increasingly being used to predict injury outcomes. Studies have shown validity for the SIRS score in predicting deadly complications seen in the ICU, including infection and sepsis. The predictive validity of the SIRS score for ICU length of stay has not been tested, however.

A valid and easy-to-use bedside tool (such as the SIRS score) that could be used to predict ICU length of stay could help nurses maximize planning efficiency for interventions aimed at preventing complications, reducing ICU costs, and improving patients’ outcomes. In contrast, existing predictor tools such as the Acute Physiology and Chronic Health Evaluation (APACHE) and the injury severity score (ISS) are not helpful to bedside nurses. These tools were designed to be used at the system level by health care administrators and require complicated computer software to estimate ICU lengths of stay. The purpose of this study was to investigate the validity of the SIRS score as well as demographic and clinical variables for predicting ICU length of stay in patients with acute life-threatening injuries.

**Methods**

**Design and Sample**

The institutional review board for the Medical College of Georgia and MCGHealth gave approval to conduct the study. A retrospective chart review was conducted to measure the usefulness of the SIRS score in predicting ICU length of stay. The study sample consisted of charts entered into the trauma registry database (National Trauma Registry of the American College of Surgeons, Version 4.1.14, Forest Hill, Maryland) at MCGHealth, a level I trauma center, between 1998 and 2007. Inclusion criteria were (1) age between 18 and 44 years, (2) presence of acute, life-threatening injuries defined as an ISS of 15 or greater, and (3) admission to the ICU for at least 24 hours. Exclusion criteria were (1) blood transfusion; (2) spinal cord injury; (3) comorbid diseases that could affect immune function and inflammatory response, including HIV infection, cancer, and autoimmune disease; (4) regular use of...
nonsteroidal anti-inflammatory drugs; and/or (5) missing data required to calculate the SIRS score. The age range of 18 to 44 years was chosen to be consistent with the injury-reporting age ranges for adults defined by the Centers for Disease Control and Prevention. All patients who met inclusion and exclusion criteria, regardless of SIRS score, were included in the study. Charts were screened and data were collected by the primary author.

A total of 552 charts were screened: 101 (18%) were excluded for blood transfusions, 108 (20%) for missing data, 79 (14%) for ICU stays of less than 24 hours, 41 (7%) for spinal cord injury, and 6 (1%) for comorbid diseases that could influence the development of SIRS, such as HIV infection, cancer therapy, or use of anti-inflammatory medications. Some patients were excluded for meeting more than 1 of these criteria. Of the 79 patients excluded for an ICU stay of less than 24 hours, 40 were patients who died less than 24 hours after injury (7% of the 552 charts screened). Most of these deaths occurred in the emergency department before arrival in the ICU. Excluded deaths resulted primarily from severe traumatic brain injuries caused from gunshot wounds to the head or motor vehicle crashes.

**Instruments**

The independent variables for this study were (1) SIRS; (2) demographic variables including race, sex, and age; (3) smoking status; and (4) degree of acute, life-threatening injury, operationalized as ISS. ICU length of stay was the dependent variable.

SIRS was measured by using the SIRS score, an instrument developed by a panel of experts at the 1991 American College of Chest Physicians/Society of Critical Care Medicine consensus conference. This instrument has appropriate content validity. The SIRS score is determined by assigning 1 point for each vital sign measure that meets the following criteria: (1) body temperature greater than 38°C or less than 36°C, (2) heart rate greater than 90/min, (3) respiratory rate greater than 20/min or PaCO₂ less than 32 mm Hg, and (4) white blood cell count greater than 12 000/µL or less than 4000/µL or presence of 10% immature neutrophils. A SIRS score of 0 or 1 indicates absence of SIRS. A SIRS score of 2 (mild), 3 (moderate), or 4 (severe) indicates the occurrence of SIRS. Intrarater reliability for the data collector was assessed by calculating the SIRS score for the same 50 patients on 2 separate occasions. Intrarater reliability was 97%.

Demographic variables of race, sex, and age were measured by using information contained in the patient’s chart. Smoking status was measured by using data contained in the nursing admission assessment database. These data are routinely collected and documented by the admitting nurse from the patient or the patient’s next of kin.

Degree of acute, life-threatening injury was measured by using the ISS. The ISS is a statistical scoring system used by injury researchers that quantifies multiple injuries and provides guidelines for defining life-threatening injury for the purpose of scientific study. The score has predictive validity: research has validated the ISS as a classic predictor of injury morbidity and mortality since the score was defined in 1974. The ISS is calculated by the trauma registry software. Scores range from 0 to 75. A score between 0 and 15 indicates mild injury, a score of 16 to 29 indicates moderate injury, and 30 or greater indicates severe injury. ICU length of stay was measured in whole (not partial) 24-hour units by counting the number of 24-hour periods spent in the ICU, using times documented in the chart. Time units were based on hour and date of admission to the ICU and hour and date of transfer to the medical-surgical step-down unit.

**Procedures**

A report was generated from the trauma registry database for use as a screening tool to identify patients for inclusion in the study. The trauma registry database contains information on injury and demographic characteristics, as well as diagnostic and disposition data. The American College of Surgeons Committee on Trauma mandates that all trauma centers maintain a trauma registry database. The ISS was collected from the trauma registry database.

**Analysis**

Descriptive analysis of sample variables was conducted and included mean, median, and quartile data. Univariate linear regression modeling was used to examine the relationship between SIRS score and ICU length of stay. The distribution of ICU length of stay and ISS was normalized by using logarithmic transforms. Race, sex, age, smoking status, and ISS were also included in the univariate regression modeling. The multiple regression model was generated by using all variables of interest, including race, sex, age, smoking, ISS, and SIRS score. All of the models included linear and quadratic effects for the

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The SIRS score assigns 1 point for each vital sign measure that meets the criteria.
SIRS score. For effect sizes that differed by SIRS score and race, the terms were estimated separately (nested within). The models were compared by using partial and multiple partial $F$ tests. Statistical significance was determined on the basis of the $F$ statistic and an $\alpha$ less than .05.

### Results

Most patients in the final sample of 246 were white (n = 133, 54%) and male (n = 178, 72%). The mean age was 29 years (Table 1). Of the 246 patients, 118 (52%) were smokers. Two-hundred forty-one patients had blunt injuries resulting from motor vehicle crashes, falls, or assaults (98%). Five patients (2%) had penetrating injuries, all of which resulted from gunshot wounds. Thirty-five patients (14%) had severe traumatic brain injuries, defined as a score of 3 on the Glasgow Coma Scale upon admission to the ICU. The ISS ranged from 16 to 59, with a median score of 22 (moderate injury).

The ICU length of stay was from 1 to 74 days, with a mean of 8 days (Table 1). Eleven patients (4%) included in the sample died. All 11 patients died of traumatic brain injury or a combination of traumatic brain injury with sepsis and multiple organ failure. The ICU length of stay for these patients was from 1 to 7 days (mean, 4 days). One patient outlier had an ICU stay of 73 days. This patient died while awaiting long-term placement after acute care and was excluded from the analysis. Of the 35 patients with a score of 3 on the Glasgow Coma Scale on admission to the ICU, 17 (7% of the total sample) had ICU stays longer than the mean of 8 days.

Seventy-nine percent (n = 194) of patients met criteria for SIRS on admission to the ICU. Of these, 31% had mild SIRS (score of 2), 37% had moderate...
SIRS (score of 3), and 11% had severe SIRS (score of 4). The mean ICU length of stay for patients with severe SIRS (score of 4) on admission was 19.2 days. Patients with moderate SIRS (score of 3) stayed a mean of 8.2 days, whereas patients with mild SIRS (score of 2) stayed a mean of 6.3 days. Patients with no SIRS (score of 0 or 1) on admission stayed a mean of 4.7 days in the ICU (Table 1).

Univariate Analyses

Univariate regression analyses were performed for each SIRS score to determine predictive validity for ICU length of stay. Mild SIRS was classified as a score of 2, moderate was a score of 3, and severe was a score of 4. Severe SIRS on admission to the ICU was predictive of ICU length of stay ($F = 15.83; P < .001$), although mild and moderate SIRS were not.

Univariate regression analyses were also performed on individual variables of race, sex, age, smoking status, and ISS. White race ($F = 9.70; P = .002$) and ISS ($F = 20.23; P < .001$) were predictors of ICU length of stay (Table 2), whereas age, sex, and smoking status were not predictors.

Multivariate Analysis

Three multivariate models were analyzed. The first model included all of the dependent variables of interest regardless of their significance level in the univariate analysis, including SIRS score, race, sex, age, smoking status, and ISS. This model was not significant. A second model was analyzed that eliminated the nonsignificant variables of sex, age, and smoking from the univariate analysis and included the significant variables of SIRS score, race, and ISS. This model explained 21% of the variance ($R^2 = 0.21$) for ICU length of stay ($F = 3.51; P = .06$). The final model included only nested values for SIRS and race. This model explained 15% of the variance ($R^2 = .15$) for predicting ICU length of stay ($F = 7.7; P = .006$).

Discussion

Severe SIRS (score of 4) on admission to the ICU was a very strong predictor of ICU length of stay ($F = 15.83; P < .001$). The prevalence of SIRS found in this study (79%) is comparable to that reported by Bochicchio and colleagues11 (61%). It is higher, however, than that found in other studies12,13 of patients with acute, life-threatening injuries (29%-35%). Results of similar studies14,15 have validated severe SIRS as a predictor of hospital length of stay in patients with acute, life-threatening injuries. However, the present study is the only one in which severe SIRS (score of 4) was a predictor of ICU length of stay in patients with acute, life-threatening injuries.

### Table 2

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$R^2$</th>
<th>df</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>White race$^a$</td>
<td>0.04</td>
<td>1</td>
<td>9.70</td>
<td>.002</td>
</tr>
<tr>
<td>Sex</td>
<td>0.0003</td>
<td>1</td>
<td>0.06</td>
<td>.81</td>
</tr>
<tr>
<td>Age</td>
<td>0.003</td>
<td>1</td>
<td>0.69</td>
<td>.41</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.0001</td>
<td>1</td>
<td>0.02</td>
<td>.88</td>
</tr>
<tr>
<td>Injury Severity Score$^{a,b}$</td>
<td>0.08</td>
<td>1</td>
<td>20.23</td>
<td>.001</td>
</tr>
<tr>
<td>Severe systemic inflammatory response syndrome (score of 4)$^{a,c}$</td>
<td>0.12</td>
<td>2</td>
<td>15.83</td>
<td>.001</td>
</tr>
</tbody>
</table>

$^a$ Significance at $\alpha$ level <.05.
$^b$ Injury Severity Score calculated as $\log_{10}$.
$^c$ Calculated by using a quadratic fit.

Severe SIRS (score of 4) was predictive of length of stay with nearly the same level of significance as the ISS ($F = 15.83; P < .001$, vs $F = 20.23; P < .001$). This finding is important because the ISS serves as the reference standard in comparing the validity of the SIRS score for predicting ICU length of stay. Physicians and administrators use the ISS to predict ICU length of stay prospectively and to evaluate associated costs, resource utilization, and health outcomes.

Nurses and physicians in the ICU have no such tools with which to predict ICU length of stay objectively in real time. The ISS was designed for use at the system level and is difficult to apply at the bedside because of cumbersome calculation methods and lack of data. Nurses can use SIRS scores to quickly predict ICU length of stay on admission.

Race

In the exploratory analysis, white race was also a strong predictor of ICU length of stay ($F = 9.7; P = .002$). This finding is a new and important addition to the injury literature, because race is often overlooked as a variable in injury research. A recent

Nurses can use SIRS scores to quickly predict ICU length of stay on admission.
review showed that race was measured as a dependent variable for acute outcomes of life-threatening injury in only 2% of studies (7 of 352). By comparison, race is measured more often as a dependent variable in chronic disease research, and significant findings are not uncommon.21

Age, Sex, and Smoking
Age, sex, and smoking were not predictive of ICU length of stay. The findings related to age and sex contrast with results of other research reports.5,22 One explanation for the difference in these results may be that the patients’ age ranges and means in previous studies were much wider (0-104 years old; mean, 44-46 years old) than the age range and mean for this study (18-44 years old; mean, 29 years old). In studies for which the age statistics were comparable, the results of the present study were supported.

Previous research has also shown that female sex is a predictor for decreased ICU length of stay in this population of patients, even when females were injured more severely than males.25,26 These findings may be related to recent results by Frink et al, who reported that injured females in the ICU had fewer complications related to inflammatory response. It is difficult to compare the results of Frink and colleagues directly, however, because the complications measured in their study were not measured in the present research.

The findings related to smoking in this research are inconclusive when compared with results of other injury and critical care studies. Two studies show agreement with the present study, and 2 other studies show disagreement. Consistent with the findings of the present research, Jurkovich and colleagues reported that smoking did not increase the odds for prolonged ICU length of stay in patients with acute injuries. Similarly, Delgado-Rodriguez et al reported that smoking was not a significant predictor for ICU length of stay in general surgery patients, although smokers in their study did have longer adjusted ICU lengths of stay (11.3 days vs 6.4 days). In contrast, when Baldwin and colleagues examined both medical and surgical ICU patients, smoking was a significant predictor for ICU length of stay (P = .008), as it was in a study of patients who underwent coronary bypass surgery (P < .05). All 4 of these studies were prospective analyses in which smoking status was obtained from chart documentation based on patient interviews.

Clinical Significance of Nested Model
In the multivariate analysis, the nested model, which included severe SIRS (score of 4) and white race, was a significant predictor of ICU length of stay (P = .006). Multivariable models of predictors of ICU length of stay that combine demographic characteristics such as race with physiological responses to injury such as severe SIRS have not been previously reported in the injury literature.

Implications for Practice and Research
Critical care nurses and physicians need tools that are easy to use at the bedside, like the SIRS score, to help prioritize preventive care. Based on this research, nurses can expect that patients with severe SIRS (score of 4) will spend more days in the ICU than will patients with mild or moderate SIRS (score of 2 or 3, respectively). The practical application of this information for nurses is that it provides a basis for preventive care in (1) educating and preparing patients and their families for the challenges associated with recovery from life-threatening injuries, (2) ordering specialty beds to reduce skin breakdown, and (3) prioritizing and planning for the discharge needs of patients and their families.

Unlike physicians, who recommend using the SIRS score on admission to help make practice decisions for immediate care, nurses could use the score to guide practice decisions for longer term preventive care. Further, the SIRS score on admission could be added to acuity level assessments and used by nurse managers for planning nurse staffing on the basis of predicted length of stay.

Further research is needed to evaluate prospectively the usefulness of the SIRS score as a tool for critical care nurses in planning preventive care. The present study should be replicated prospectively. All variables known to influence ICU length of stay should be included in conjunction with the physiological influence of SIRS. Additional research is needed to explore the findings of this study that race is a predictor of ICU length of stay in patients with acute, life-threatening injuries. Research is also needed to assess the practical use of the SIRS score for prioritizing nursing care in the ICU for patients with acute, life-threatening injuries.

Limitations
This study was conducted in 1 hospital, which limited the sample size. However, the characteristics of the patients in this study, including race, sex, mean ISS, and percentages of mild, moderate, and severe SIRS scores were comparable to characteristics of patients in other studies with similar variables and

Severe SIRS predicted length of stay with nearly the same level of significance as the injury severity score.
purpose statements.10-13 This makes it useful to inform the design of future studies to determine how other, more hospital-based variables affect the validity of the SIRS score for predicting ICU length of stay. Generalizability is limited to patients with mild, moderate, or severe SIRS (score of 2, 3, or 4). A comparison of ICU length of stay in patients with no SIRS (score of 0 or 1) was not made because of the relatively small number of patients in this subsample (n = 52). Further, ICU length of stay is affected by other variables that may not be reflected in the chart, such as communication and family issues, stress and depression, palliative care and ethical issues, 24-hour presence of a physician, and availability of a unit-specific social worker.7

Use of the SIRS score in this research is supported by (1) the outcomes of the 2001 consensus conference,18 (2) research that correlates the presence of SIRS with inflammatory biomarkers,11-13 and (3) research that validates its use for predicting outcomes in critically ill patients, including those with acute, life-threatening injuries.10-13

Conclusions

This research supports that severe SIRS (score of 4) on admission to the ICU is a valid predictor of ICU length of stay for patients with acute life-threatening injuries. This information can be used to help critical care nurses and physicians maximize resource utilization within a known time frame and reduce the possibility of poor outcomes.

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References


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1. A patient in the trauma unit has been admitted with blunt chest and abdominal trauma. He is a 55-year-old white male, with no significant past medical history. He is currently on a ventilator with an assist control rate of 14; his current respiratory rate is 28; blood pressure is 100/70 mm Hg; heart rate is 113; and his core temperature via an esophageal temperature probe is 38.8°C. His arterial blood gases reveal a pH of 7.48, PaCO2 of 31, PaO2 of 118, HCO3 of 18; the complete blood cell count reveals a hemoglobin and hematocrit of 11 and 33, and white blood cell count of 14,000. Based on this patient’s assessment, what would his SIRS score be?

   a. 1  
   b. 2  
   c. 3  
   d. 4

2. In this study, which of the following was the dependent variable?

   a. Degree of acute life-threatening injury  
   b. Intensive care unit (ICU) length of stay  
   c. SIRS score  
   d. White race

3. According to the results of this study, having severe SIRS on admission to the ICU is correlated significantly with what variable?

   a. ICU length of stay  
   b. Injury Severity Score  
   c. White race  
   d. Smoking history

4. How may an ICU nurse use the information that a trauma patient has a SIRS score of 4?

   a. To plan for preventive care  
   b. To initiate the 6-hour sepsis bundle  
   c. To plan a family conference to discuss end-of-life issues  
   d. To know the patient’s condition warrants transfer to a progressive care unit

5. The SIRS score is noted by the authors to be a validated tool. What other characteristic do the authors identify that would make this tool feasible for use in the ICU by a bedside nurse?

   a. To predict staffing needs  
   b. It is based on reliable quadratic equations  
   c. Simple and easy to use  
   d. The P value is 0.05

6. The admission into an ICU of a trauma patient on average costs how much?

   a. $1000  
   b. $5000  
   c. $10,000  
   d. $20,000

7. The research method used by the authors was which of the following?

   a. Qualitative, phenomenological  
   b. Quantitative, prospective  
   c. Qualitative, focus group  
   d. Quantitative, retrospective

8. Based on the authors’ recommendations, what further research needs to be done?

   a. No further research is needed  
   b. A meta-analysis of all studies utilizing the SIRS score  
   c. A replication of their study using a prospective sample  
   d. A replication of their study using severe sepsis patients

9. According to the results of this study, having severe SIRS on admission to the ICU is correlated significantly with what variable?

   a. ICU length of stay  
   b. Injury Severity Score  
   c. White race  
   d. Smoking history

10. This research was able to show that a severe SIRS score is a valid predictor of increased length of stay for what type of patients?

   a. Acute, life-threatening injuries  
   b. Postcardiovascular surgery  
   c. Spinal cord injuries  
   d. Comatose survivors of cardiac arrest

11. A group of trauma ICU nurses, after reading this study, would like to do further research using the SIRS score. What is one area the authors recommend for further research in the practical use of this tool?

   a. Budgeting tool for the trauma ICU nurse manager  
   b. Validation of increased staffing needs  
   c. Physician treatment decisions  
   d. Prioritizing nursing care

12. How would a severe SIRS score affect the patient and family education plan?

   a. Delaying the education plan until the patient is transferred from the ICU  
   b. Educating and preparing patients and families of the challenges related to recovering from their injuries  
   c. Focusing the education on the family as the patient would be unable to participate  
   d. Giving the family written material on the subject in the language and grade level they best understand
Systemic Inflammatory Response Syndrome Score and Race As Predictors of Length of Stay in the Intensive Care Unit
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