Quick SOFA Scores Predict Mortality in Adult Emergency Department Patients With and Without Suspected Infection

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Study objective: The Quick Sequential Organ Failure Assessment (qSOFA) score (composed of respiratory rate ≥ 22 breaths/min, systolic blood pressure ≤ 100 mm Hg, and altered mental status) may identify patients with infection who are at risk of complications. We determined the association between qSOFA scores and outcomes in adult emergency department (ED) patients with and without suspected infection.

Methods: We performed a single-site, retrospective review of adult ED patients between January 2014 and March 2015. Patients triaged to fast-track, dentistry, psychiatry, and labor and delivery were excluded. qSOFA scores were calculated with simultaneous vital signs and Modified Early Warning System scores. Patients receiving intravenous antibiotics were presumed to have suspected infection. Univariate and multivariate analyses were performed to explore the association between qSOFA scores and inpatient mortality, admission, and length of stay. Receiver operating characteristics curve analysis and *c* statistics were also calculated for ICU admission and mortality.

Results: We included 22,530 patients. Mean age was 54 years (SD 21 years), 53% were women, 45% were admitted, and mortality rate was 1.6%. qSOFA scores were associated with mortality (0 [0.6%], 1 [2.8%], 2 [12.8%], and 3 [25.0%]), ICU admission (0 [5.1%], 1 [10.5%], 2 [20.8%], and 3 [27.4%]), and hospital length of stay (0 [123 hours], 1 [163 hours], 2 [225 hours], and 3 [237 hours]). Adjusted rates were also associated with qSOFA. The *c* statistics for mortality in patients with and without suspected infection were similarly high (0.75 [95% confidence interval 0.71 to 0.78) and 0.70 (95% confidence interval 0.65 to 0.74), respectively.

Conclusion: qSOFA scores were associated with inpatient mortality, admission, ICU admission, and hospital length of stay in adult ED patients likely to be admitted both with and without suspected infection and may be useful in predicting outcomes. [Ann Emerg Med. 2017;69:475-479.]

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INTRODUCTION

Recently, a panel of experts derived and validated a novel scoring system for patients with suspected sepsis: the Quick Sequential Organ Failure Assessment (qSOFA) score.[1] This score was calculated by assigning 1 point each for a respiratory rate greater than or equal to 22 breaths/min, systolic blood pressure less than or equal to 100 mm Hg, and any alteration in mental status. The total score was then calculated by adding the individual scores for the 3 elements. In their cohort, the ability of the qSOFA score to predict mortality was even greater than that of the more detailed SOFA score.[1] To the best of our knowledge, this novel score has not been assessed as a generic predictive score in the overall emergency department (ED) patient population.

The availability of a simple, generic tool that can be rapidly calculated in all ED patients, without the need for any laboratory or advanced testing, would be of great benefit to ED practitioners. We determined whether the qSOFA was predictive of poor outcomes in all ED patients both with and without suspected infection.

MATERIALS AND METHODS
Study Design, Setting, and Selection of Participants

We searched the electronic ED database at a suburban academic medical center (January 2014 to March 2015) for adult (>18 years) patients for whom a qSOFA score could be calculated according to simultaneous (within 2 minutes

Editor's Capsule Summary

What is already known on this topic

The Quick Sequential Organ Failure Assessment (qSOFA) was recently introduced as an easy tool to identify infected patients with high risk of deterioration.

What question this study addressed

The association between qSOFA scores and subsequent outcome in emergency department (ED) patients both with and without infection.

What this study adds to our knowledge

In this retrospective study of 22,530 (of 67,475 eligible patients) who had sufficient data to permit analysis, increasing qSOFA scores were associated with death, ICU admission, and hospital length of stay in both infected and noninfected patients admitted to the hospital from the ED.

How this is relevant to clinical practice

This informs clinical practice by suggesting that qSOFA may be an easy and quick tool to help identify patients at risk of deterioration. However, further validation of qSOFA is important before widespread use.

or less) reporting of vital signs (systolic blood pressure, respiratory rate, pulse rate, temperature, and oximetry) and a Modified Early Warning System score. We excluded fast-track, dental, psychiatric, and labor and delivery patients because they are generally at low risk or managed by nonemergency practitioners. The Modified Early Warning System is a tool for nurses to help monitor their patients, allowing early detection of a sudden decline in their condition,[2-6] which, in our institution, is supposed to be documented for all ED patients. The Modified Early Warning System version we used included respiratory rate, pulse rate, temperature, pulse oximetry, systolic blood pressure, and level of consciousness. The study was approved by our institutional review board and exempt from informed consent.

Maximal Modified Early Warning System scores were obtained for each patient, and vital signs (systolic blood pressure, respiratory rate, pulse rate, oximetry, and temperature) entered within 2 minutes of when the Modified Early Warning System scores were entered into the computer were identified. A "calculated" Modified Early Warning System score was determined from the vital signs, and a patient was assumed to have an altered mental status if the calculated score was less than the actual one.

Outcome Measures

The primary outcome was inhospital mortality. Secondary outcomes were hospital admission, ICU admission, and total hospital length of stay from ED triage to discharge from the hospital.

Primary Data Analysis

Descriptive statistics were used for baseline characteristics and outcomes. Univariate χ^2 tests were used to compare categorical variables, and t tests and ANOVA were used to compare continuous variables. Multivariate analyses were used to adjust for age, sex, and presence of suspected infection. Multivariate analyses included logistic regression for dichotomous outcomes (death or admission) and linear regression for continuous outcomes (length of stay). Receiver operating characteristics analysis was used to assess the predictive ability of qSOFA scores. Sensitivities, specificities, and negative predictive values were calculated for ICU admission and inhospital mortality with a cutoff of greater than 2 or greater than 1, respectively, on qSOFA scores. Planned subgroup analyses were performed separately for patients with and without suspected infection. We assigned patients to the group with suspected infection if intravenous antibiotics were administered in the ED. All analyses were performed with SPSS (version 23.0; IBM, Armonk, NY).

RESULTS
Characteristics of Study Subjects

There were 67,475 ED adult visits meeting study criteria during the study period; 3,569 patients (5.3%) were without any Modified Early Warning System score and 41,376 (61.3%) were without independently documented vital signs within 2 minutes of entering the Modified Early Warning System, leaving 22,530 study patients, of whom 10,048 were admitted. Excluded patients were younger (50 versus 54 years) and they appeared to be less severely ill, as indicated by lower rates of hospital admission (27% versus 47%), ICU admission (3% versus 7%), and inhospital death (0.6% versus 1.6%). The mean age of the included study patients was 54 years (SD 21 years), 53% were women, 45% were admitted, 7% were admitted to an ICU, and the inhospital mortality rate was 1.6%. Intravenous antibiotics were administered in the ED to 4,149 patients (18%) who were classified as having a suspected infection. Intravenous antibiotics were not administered to the remaining 18,381 patients classified as being without a suspected infection.

Of the 22,530 study patients, 16,507 (73%) had a qSOFA score of 0, 5,290 (23%) had a score of 1, 649 (3%) had a score of 2, and 84 (0.4%) had a score of 3. The percentage of men increased with qSOFA scores (47%,

42%, 54%, and 64% for qSOFA scores 0, 1, 2, and 3, respectively), as did age (53, 56, 63, and 69 years for qSOFA scores 0, 1, 2, and 3, respectively).

Main Results

The mortality rates for the entire group of patients (both with and without suspected infection) according to qSOFA scores were 0.6% (95% confidence interval [CI] 0.5% to 0.8%), 2.8% (95% CI 2.4% to 3.3%), 12.8% (95% CI 10.4% to 15.7%), and 25.0% (95% CI 16.5% to 35.9%) for scores of 0, 1, 2, and 3, respectively (Table). Age (odds ratio 1.042 [95% CI 1.035 to 1.049] per year), female sex (odds ratio 0.78 [95% CI 0.63 to 0.97]), suspected infection (odds ratio 2.14 [95% CI 1.69 to 2.71]), and qSOFA (odds ratio 3.05 [95% CI 2.66 to 3.49]) were associated with mortality after adjusting for covariates (Table). The sensitivity and specificity of a qSOFA score greater than or equal to 2 for predicting mortality were 29% (95% CI 25% to 34%) and 97% (95% CI 97% to 97%), respectively, with a negative predictive value of 99% (95% CI 99% to 99%). A qSOFA score greater than or equal to 1 had 71% sensitivity (95% CI 66% to 76%), 74% specificity (95% CI 73% to 75%), and 99% negative predictive value (95% CI 99% to 99%).

Secondary outcomes (hospital admission, ICU admission, and hospital length of stay) were associated with

qSOFA scores before and after adjustment for other factors, with increasing scores indicating worse outcomes (Table). Areas under the curve for mortality and ICU admission were 0.76 (95% CI 0.73 to 0.78) and 0.61 (95% CI 0.59 to 0.63), respectively (Figures 1 and 2). The sensitivity and specificity of a qSOFA score greater than 2 for predicting ICU admission were 10% (95% CI 9% to 12%) and 97% (95% CI 97% to 97%), respectively, with a negative predictive value of 94% (95% CI 93% to 94%).

Compared with patients without suspected infection, those with it were older (61 [SD 20] versus 53 [SD 20] years, respectively), more likely men (51% [95% CI 50% to 53%] versus 45% [95% CI 45% to 46%]), more likely to be admitted to the hospital (80% [95% CI 79% to 81%] versus 37% [95% CI 36% to 37%]) and the ICU (9.2% [95% CI 8.4% to 10.2%] versus 6.4 [95% CI 6.0% to 6.8%]), and more likely to die (4.5% [95% CI 3.9% to 5.2%] versus 0.9% [95% CI 0.8% to 1.1%]).

Mortality, hospital admission, and ICU admission were associated with qSOFA scores in patients both with and without suspected infection (Table). Areas under the curve for predicting mortality in patients with and without suspected infection were 0.75 (95% CI 0.71 to 0.78) and 0.70 (95% CI 0.65 to 0.74), respectively (Figure 1). Receiver operating characteristics results for ICU admissions are shown in Figure 2.

Table. Study outcomes.

qSOFA Score	Admission Rate, % (95% CI)	ICU Admission Rate, % (95% CI)	Mortality, % (95% CI)	Mean Hospital Length of Stay (95% CI), Hours*
Univariate associations (all patients)				
0	38 (37–39)	5.1 (4.8–5.5)	0.6 (0.5–0.8)	123 (119–127)
1	59 (58–61)	10.5 (9.7–11.4)	2.8 (2.4–3.3)	163 (155–171)
2	84 (81–87)	20.8 (17.8–24.2)	12.8 (10.4–15.7)	225 (192–358)
3	93 (85–97)	27.4 (18.5–38.4)	25.0 (16.5–35.9)	237 (185–288)
Univariate associations (suspected infection)				
0	72.7 (70.8–74.5)	4.8 (4.0–5.8)	1.4 (1.0–2.0)	
1	87.0 (85.1–88.6)	11.7 (10.1–13.5)	6.1 (4.9–7.5)	
2	96.1 (93.3–97.8)	25.0 (20.5–30.1)	15.8 (12.1–20.2)	
3	95.5 (86.4–98.8)	30.3 (19.9–43.0)	24.2 (14.9–36.6)	
Univariate associations (no suspected infection)				
0	32.4 (31.7–33.2)	5.2 (4.8–5.5)	0.5 (0.4–0.6)	
1	49.1 (47.5–50.7)	10.0 (9.1–11.0)	1.6 (1.2–2.1)	
2	70.9 (65.5–75.8)	16.3 (12.5–21.0)	9.6 (6.7–13.5)	
3	83.3 (57.7–95.6)	16.7 (4.4–42.3)	27.8 (10.7–53.6)	
Multivariate associations (all patients)				
	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Coefficient (95% CI)
Age, per year	1.040 (1.038–1.042)	1.023 (1.020–1.026)	1.042 (1.035–1.049)	0.5 (0.3–0.7)
Female patient (reference is male patient)	0.68 (0.64–0.73)	0.62 (0.55–0.68)	0.78 (0.63–0.97)	–17 (–26 to –9)
qSOFA (per point)	2.21 (2.08–2.36)	1.96 (1.81–2.13)	3.05 (2.66–3.49)	35 (28–42)
Suspected infection	5.57 (5.10–6.09)	0.91 (0.79–1.03)	2.14 (1.69–2.71)	34 (25–44)

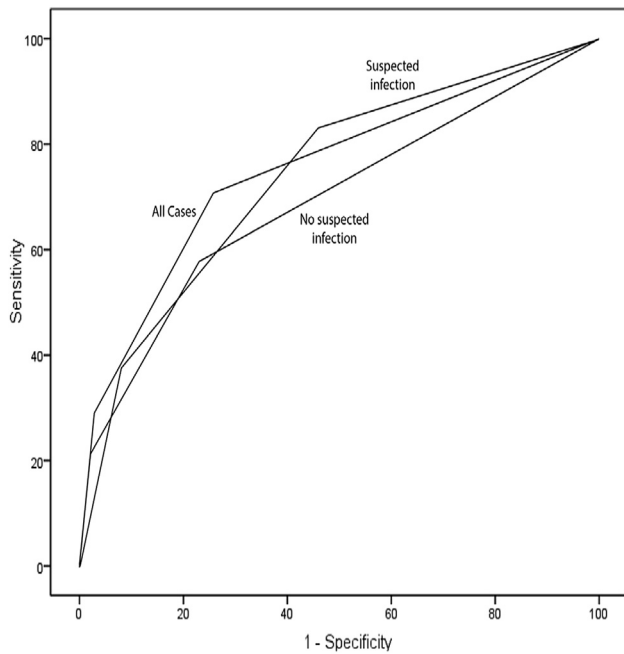*Includes only admitted patients who survived to discharge.

Figure 1. Receiver operating characteristics curve for mortality. Area under the curve: all patients 0.76 (95% CI 0.73 to 0.78), suspected infection 0.75 (95% CI 0.71 to 0.78), and no suspected infection 0.70 (95% CI 0.65 to 0.74).

LIMITATIONS

Our study had several limitations. First, this was a retrospective study, which is subject to selection bias and errors of documentation and data entry. A significant
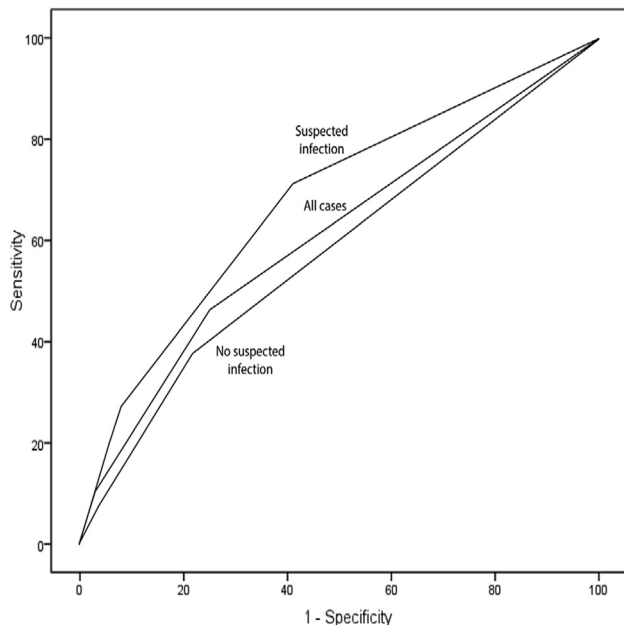

Figure 2. Receiver operating characteristics curve for ICU admission. Area under the curve: all patients 0.61 (95% CI 0.59 to 0.63), suspected infection 0.68 (95% CI 0.65 to 0.71), and no suspected infection 0.58 (95% CI 0.55 to 0.60).

number of ED patients did not have simultaneous vital signs and Modified Early Warning System scores documented and were thus excluded, introducing further potential selection bias. To control for this potential source of bias, we conducted a comparative analysis of the patients with and without near-simultaneous vital signs and Modified Early Warning System scores, which demonstrated no significant differences between the 2 groups in terms of sex and vital signs. However, lower admission rates and mortality suggest that excluded patients may have been less severely ill. Thus, our results are most representative of patients likely to be admitted. Accordingly, qSOFA may overperform in this sicker population in which the outcomes are more common.

Second, we did not control for many potential confounders such as laboratory tests and comorbidities because many of these would not be available to the physician calculating qSOFA.

Third, patient assignment to the 2 study groups was based on whether intravenous antibiotics were administered in the ED. This may have led to an over- or underestimation of the number of patients with suspected infection.

Fourth, the data and results are limited to a single institution and may not be representative of other settings.

DISCUSSION

We found that qSOFA scores were significantly associated with all measured outcomes, including inpatient mortality, hospital admission, ICU admission, and overall hospital length of stay. In this cohort, the qSOFA score performed equally well in patients both with and without a suspected infection. Thus, the qSOFA score, easily calculated in accordance with vital signs, can potentially be used as a generic tool to predict clinically important outcomes for ED patients likely to be admitted regardless of whether infection is suspected. This in turn can help with resource allocation; for example, the need for an ICU admission for patients with high qSOFA scores. Although specific, a qSOFA score of 2 or greater was not sensitive. In contrast, a qSOFA score of less than 2 had excellent negative predictive value, with fair sensitivity and specificity. The performance of the qSOFA in our study was similar to that of more complex scores such as the Mortality in Emergency Department Sepsis score originally derived and validated by Shapiro et al.[7] In that study, the area under the curve for the score was 0.82 in the derivation study and 0.78 in the validation study. More sophisticated prediction scores have been reported that have even greater accuracy.[8] However, these cannot be easily calculated during the early ED phase. The advantage of the qSOFA score is its simplicity and lack of dependence on laboratory testing.

Our findings are similar to those recently reported by Seymour et al.[1] In their cohort of 148,907 patients with suspected infection, of whom 4% died, the predictive value for inpatient mortality among ICU encounters was 0.66 (95% CI 0.64 to 0.68). The predictive value among non-ICU encounters was 0.81 (95% CI 0.80 to 0.82), which was statistically greater than for SOFA or systemic inflammatory response syndrome criteria. This report has led to considerable debate in regard to the usefulness of qSOFA scores, with our findings further supporting its validity and potential utility, especially in undifferentiated ED patients.

There are several notable differences between our study and the one reported by Seymour et al.[1] Unlike their study, ours included only ED patients and used a slightly different definition for suspected infection, namely, the administration of intravenous antibiotics in the ED. In contrast, Seymour et al[1] required a combination of oral or parenteral administration of antibiotics and a body fluid culture obtained within 24 to 72 hours of antibiotic administration. Thus, our methodology may be more relevant to the ED population and those with suspected sepsis. Furthermore, we used the Modified Early Warning System score to estimate mental status, whereas Seymour et al[1] used the Glasgow Coma Scale score.

A variety of clinical tools have been evaluated for their ability to predict outcomes, including mortality, in ED patients. In a random sample of 3,000 ED patients from Pennsylvania, mean, maximum, and median ED Modified Early Warning System scores were associated with admission to the hospital, admission disposition, and mortality.[5] In contrast, Ho et al[6] applied the Modified Early Warning System to a retrospective cohort of 1,024 critically ill Asian patients and found that it was less sensitive and specific at predicting mortality than in non-Asian populations. The Rapid Emergency Medicine Score was developed for nonsurgical patients in the ED[9] and found to be superior to the Modified Early Warning System score in predicting mortality in 2,000 ED patients.[10] The advantage of the qSOFA score over the Modified Early Warning System score is that it includes only 3 binary elements and does not require a reference table or calculator.

In conclusion, qSOFA scores were associated with inhospital mortality, hospital admission, ICU admission, and hospital length of stay in adult ED patients likely to be admitted both with and without suspected infection. qSOFA is an easy tool that can be used in the ED to predict outcomes. Further prospective validation of the qSOFA is required before widespread use.

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