



Usefulness of qSOFA and SIRS scores for detection of incipient sepsis in general ward patients: A prospective cohort study

Jingchao Luo^{a,b}, Wei Jiang^a, Li Weng^a, Jinmin Peng^a, Xiaoyun Hu^a, Chunyao Wang^a, Guangyun Liu^a, Huibin Huang^a, Bin Du^{a,*}

^a Medical Intensive Care Unit, Peking Union Medical College Hospital, 1 Shuai Fu Yuan, Beijing 100730, China

^b Department of Critical Care Medicine, Zhongshan Hospital, Fudan University, 180 Fenglin Road, Shanghai 200032, China

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ABSTRACT

Purpose: To prospectively assess the diagnostic value of quick Sequential Organ Failure Assessment (qSOFA) and systemic inflammatory response syndrome (SIRS) scores for sepsis in ward patients with infections.

Materials and methods: Consecutive patients admitted with infection or developing infection during hospital stay were included. All variables for calculating qSOFA, SIRS, and SOFA scores were collected, and the maximum scores were determined until hospital discharge, death, or day 28, whichever occurred earlier. The primary outcome was sepsis at 28 days. Diagnostic and prognostic values were assessed using the area under the receiver operating characteristic curve (AUROC) with the conventional cutoff value of 2.

Results: Of 409 general ward patients, 146 patients and 371 patients met qSOFA and SIRS criteria, 229 patients developed sepsis. Although qSOFA score had a better overall diagnostic performance of sepsis (AUROC 0.75 vs. 0.69), it had a much lower sensitivity (53% vs. 98%) and higher specificity (87% vs. 18%) than SIRS score. In addition, qSOFA score had a better prognostic value than SIRS score (AUROC 0.86 vs. 0.67).

Conclusions: Neither SIRS score nor qSOFA score could serve as an ideal screening tool for early identification sepsis, whereas qSOFA score might help to identify patients with higher risk of poor clinical outcome.

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1. Introduction

Sepsis, a clinical syndrome of physiological, pathological, and biochemical abnormalities caused by infection [1–3], is the leading cause of death in critically ill patients [4,5]. Although recent epidemiological studies have reported trends of declining hospital mortality rates, the management continues mainly supportive with a clear benefit of early appropriate antimicrobials targeting the most likely causative pathogens [6]. Early recognition and treatment are crucial for reducing the mortality associated with sepsis [7].

About one-third of patients admitted to hospital with infections are found in the general wards [8], which are therefore important outposts for diagnosis and treatment of sepsis [9–11]. The Systemic Inflammatory Response Syndrome (SIRS) criteria have long been used as a screening tool for detecting sepsis in hospitalized patients [12], but they have poor specificity [13]. In 2016, an international task force presented a new sepsis definition, Sepsis-3, and introduced the quick Sequential Organ Failure Assessment (qSOFA) score (based only on respiratory

rate, altered mentation, and blood pressure) as a bedside screening tool for use in the non-ICU setting to identify patients with incipient sepsis [3]. The diagnostic value of the qSOFA score has been confirmed in many studies on patients in emergency departments (ED) [14–17], but the applicability of qSOFA in the general wards has not yet been evaluated. All previous studies used a single assessment of qSOFA (i.e., score on arrival at the ED or the worst score attained within 1 day of arrival in the ED), and therefore reported low sensitivity [14–18]. A single measurement may be reasonable in the ED setting, because ED patients are likely to have severe manifestations at presentation [19]; however, for ward patients a single measurement will not reflect the worst condition during hospital stay. The positive rate of SIRS has reported to have increased along with hospital stay [13]. Similarly, repeated measurement of qSOFA score during hospitalization is likely to increase the chance of recognition of sepsis-induced physiological abnormalities and thus improve its sensitivity.

We hypothesized that the qSOFA score would perform better than the SIRS score for diagnosis of sepsis in the general ward and that a daily repeated screening method would improve its diagnostic accuracy. The objective of this study was to assess the diagnostic value of qSOFA and SIRS for detecting incipient sepsis in general ward patients with infections.

* Corresponding author.

E-mail address: dubin98@gmail.com (B. Du).

2. Materials and methods

2.1. Design and setting

This prospective, single-center, cohort study was approved by the ethics committee (ZS-1142) of Peking Union Medical College Hospital and conducted in 10 non-ICU wards (6 medical and 4 surgical wards, with a total of 353 beds) from October 1, 2016, to March 31, 2017, which were selected from 46 general wards based on relatively higher incidence of infection and organ dysfunction according to the pilot study. The average rates of infection and acute organ dysfunction in these wards were 10.0 and 5.6 per 100 admissions per year, respectively (Supplementary: pilot study for ward selection).

2.2. Study population

All adult patients admitted to any of the 10 study wards during the study period with suspected infection or those who developed infection during hospital stay were eligible for inclusion in the study. Patients were excluded if they had 1) age < 18 years, 2) hospital length of stay (LOS) < 24 h, or 3) developed infection after admission to the ICU. All included patients were followed up until hospital discharge, death, or day 28, whichever was earlier.

2.3. Data collection

The patients were monitored by three experienced, specifically trained, intensivists who visited all study wards every day. At the first visit a special case report form, which included demographic data, was completed. At each visit in the general ward the following were recorded: 1) systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, respiratory rate, axillary temperature, blood oxygenation (SpO₂), Glasgow coma scale score, and qSOFA score; 2) laboratory test results (white cell count, platelet count, serum bilirubin, and serum creatinine) required to calculate SIRS and SOFA scores; 3) use of any critical care resource (e.g., ICU admission, oxygen therapy, mechanical ventilation, vasopressor agents, and renal replacement therapy); and 4) site of infection and the blood culture results. All clinical decisions were made by ward doctors, without interference from the study investigators.

2.4. Definitions

Infections were diagnosed by investigators according to predefined criteria (Supplementary Table S3). Sepsis was defined as suspected or documented infection associated with an acute increase in total SOFA score ≥ 2 points (a proxy for organ dysfunction) [3]. The baseline SOFA score (SOFA_{baseline}) was assumed to be 0, unless the patient was known to have preexisting (acute or chronic) organ dysfunction before the onset of infection [3]. For patients without arterial blood gas results (ABG), the partial pressure of arterial oxygen (PaO₂) was estimated by using the approximation formula of hemoglobin–oxygen dissociation curve [20]. A qSOFA or SIRS score of ≥ 2 points was considered positive [2,3]. Altered mentation was defined as Glasgow coma scale score < 15 [3]. Day 0 was defined as the date of hospital admission for patients with community-acquired infection, or as the date of onset of infection for patients with hospital-acquired infection. The severity of comorbidities was assessed by the Charlson comorbidity index [21]. The dose of vasopressor agents was expressed as the inotropic score [22].

2.5. Outcome measures

The primary endpoint was development of sepsis (until day 28). The secondary endpoints were 28-day mortality, hospital mortality, hospital LOS, hospital-free days at day 28, and a composite endpoint of 28-day mortality or ICU LOS ≥ 3 days.

2.6. Reliability, validity, and generalizability

During the study period, two concurrent surveys were performed (in five study wards from December 1 to December 14, 2016, and in the other five study wards from February 16 to March 1, 2017) to examine the interobserver agreement for diagnosis of infection and calculation of SIRS, SOFA, and qSOFA scores. For patients with ABG results, we also recorded SpO₂ measured at the same time the blood was drawn, based on which we calculated estimated PaO₂ according to the above formula [20]. Then the respiratory component of the SOFA score was calculated based on actual and estimated PaO₂, and compared to examine the validity of estimated PaO₂ as a surrogate of actual PaO₂. The kappa (κ) statistic was calculated as a measure of interobserver agreement. A κ value of 0.40–0.75 denoted good agreement, and a value >0.75 denoted excellent agreement. To estimate the generalizability of our data, we also performed a 2-day (January 9 to 10, 2017) prevalence study among new adult hospital admissions. Our main goal was to compare the rates of infection, SIRS, sepsis, and septic shock in the 10 study wards with the rates in the 36 non-study general wards.

2.7. Statistical analysis

Continuous variables were expressed as medians (with interquartile range [IQR]), and compared between groups with the Wilcoxon rank-sum tests. Categorical variables were expressed as numbers (and percentages) and compared with Fisher's exact test. To minimize instability and maximize the mathematical expectation, the highest SIRS and qSOFA scores (SIRS_{max} and qSOFA_{max}, respectively) from day 0 to day 28 were calculated. To assess diagnostic performance, we constructed receiver operating characteristic (ROC) curves and calculated the area under the ROC curve (AUROC). The sensitivity, specificity, predictive value, likelihood ratio, and the 95% confidence intervals (CI) were calculated based on the conventional cutoff value of 2, and compared by nonparametric tests or weighted generalized score statistic [23]. We analyzed the diagnostic values of qSOFA and SIRS scores based on cutoff values determined by Youdenx index. We also assessed the usefulness of qSOFA_{max} and SIRS_{max} for predicting 28-day mortality and the composite endpoint (28-day mortality or ICU LOS ≥ 3 days), respectively. All statistical tests were 2-tailed, and $p < .05$ indicated statistical significance. Statistical analysis was performed using R, version 3.4.1 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Study population

During the 6-month study period, a total of 4045 patients were admitted to the 10 study wards. Of the 4045 patients, 485 were excluded (82 because they were <18 years old and 403 because hospital LOS was <24 h), leaving 3560 patients in the cohort. During the 28-day follow-up, another 3141 patients were excluded because they did not have infection and 10 because they developed infection and/or sepsis during ICU stay. The remaining 409 patients were included in the final analysis (Supplementary Fig. S1). The median age of these patients was 55 years (IQR 40–67). There were 225 male patients (55%); 59 patients (14%) were surgical admissions. The median Charlson comorbidity index was 1 (IQR 0–2) (Table 1).

3.2. Characteristics of patients with sepsis

There were 229 patients (56%) who met Sepsis-3 criteria at a median of 0 (IQR 0–1) days after onset of infection (day 0). Compared with nonsepsis patients, sepsis patients were more likely to have comorbidities (e.g., cardiovascular disease, neurological disease, and hematological malignancy); physiologic derangements (e.g., tachycardia, tachypnea, high temperature, altered mental status); and laboratory

Table 1
Characteristics and clinical outcomes of sepsis versus nonsepsis patients.

Characteristic and outcome measurements	All patients (n = 409)	Sepsis patients (n = 229)	Nonsepsis patients (n = 180)	p value
Male	225 (55%)	124 (54%)	101 (56%)	0.764
Age (year)	55 (40–67)	58 (43–68)	53 (38–67)	0.302
Charlson comorbidity index	1 (0–2)	2 (0–2)	1 (0–2)	0.047
Comorbidities				
Solid tumor	112 (27%)	68 (30%)	44 (24%)	0.265
Hematological malignancy	57 (14%)	43 (19%)	14 (8%)	0.001
Cardiovascular disease	51 (12%)	38 (17%)	13 (7%)	0.004
Respiratory disease	46 (11%)	28 (12%)	18 (10%)	0.531
Chronic kidney disease	39 (10%)	26 (11%)	13 (7%)	0.177
Neurological disease	28 (7%)	21 (9%)	7 (4%)	0.047
Liver disease	8 (2%)	4 (2%)	4 (2%)	0.735
Surgical admission	59 (14%)	33 (14%)	26 (14%)	>0.999
Site of infection				
Lung	234 (57%)	140 (61%)	94 (52%)	0.087
Abdomen	89 (22%)	46 (20%)	43 (24%)	0.399
Skin and soft tissue	37 (9%)	10 (4%)	27 (15%)	<0.001
Urinary tract	27 (7%)	10 (4%)	17 (9%)	0.046
Neurological	14 (3%)	8 (3%)	6 (3%)	>0.999
Other	53 (13%)	41 (18%)	12 (7%)	<0.001
Patients with positive blood culture				
Hospital-acquired infection	119 (29%)	71 (31%)	48 (27%)	0.381
Time interval from hospital admission to hospital-acquired infection (day)	10 (5–16)	9 (5–13)	10 (7–16)	0.136
Time interval between consecutive SOFA scores (days)	2 (2–3)	2 (2–3)	3 (2–4)	<0.001
Vital signs				
SBP (mm Hg)	117 (105–131)	114 (101–129)	119 (109–132)	0.015
DBP (mm Hg)	69 (60–78)	66 (59–75)	71 (66–80)	<0.001
MAP (mm Hg)	85 (77–95)	82 (74–93)	88 (79–96)	<0.001
HR (beats/min)	97 (86–110)	100 (90–112)	92 (84–104)	<0.001
RR (breaths/min)	21 (20–24)	22 (20–24)	20 (19–22)	<0.001
Temperature (°C)	37.1 (36.6–38.4)	37.3 (36.7–38.6)	36.9 (36.5–38.1)	<0.001
GCS	15 (15–15)	15 (15–15)	15 (15–15)	<0.001
Laboratory tests				
WCC (10 ⁹ /L)	8.2 (5.1–12.9)	8.6 (4.7–13.4)	7.5 (5.4–10.9)	0.411
Platelets (10 ⁹ /L)	194 (122–282)	164 (88–246)	235 (168–323)	<0.001
Bilirubin (umol/L)	10 (7–16)	11 (8–17)	9 (7–14)	0.002
Creatinine (umol/L)	67 (53–87)	68 (51–98)	66 (55–83)	0.391
Vasopressor	46 (11%)	46 (20%)	0 (0%)	<0.001
Inotropic score	5 (2–10)	5 (2–10)	NA	
Mechanical ventilation	30 (7%)	30 (13%)	0 (0%)	<0.001
Renal replacement therapy	7 (2%)	7 (3%)	0 (0%)	0.020
Clinical outcome				
28-day mortality	30 (7%)	30 (13%)	0 (0%)	<0.001
Hospital mortality	32 (8%)	32 (14%)	0 (0%)	<0.001
Hospital LOS (day)	22 (12–30)	24 (13–32)	19 (11–29)	0.013
Hospital-free days at day 28 (day)	6 (0–16)	4 (0–15)	9 (0–17)	0.008
Patients with ICU LOS ≥ 3 days	29 (7%)	29 (13%)	0 (0%)	<0.001
Composite endpoint ^a	56 (14%)	56 (24%)	0 (0%)	<0.001

Data are presented as median (interquartile range) or number (%) and compared with the Wilcoxon rank sum test or Fisher's exact test, respectively.

Abbreviations: DBP diastolic blood pressure, GCS Glasgow coma scale, HR heart rate, ICU intensive care unit, LOS length of stay, MAP mean arterial pressure, NA not available, RR respiratory rate, SBP systolic blood pressure, WCC white cell count.

^a 28-day mortality or ICU LOS ≥ 3 days.

abnormalities (e.g., elevated bilirubin, low platelet count). Sepsis patients were also more likely to be admitted to the ICU and to receive life-sustaining therapies. Sepsis patients had significantly higher 28-day mortality rate (13% vs. 0%, $p < .001$) and longer hospital LOS

(24 days [IQR 13–32] vs. 19 days [IQR 11–29], $p = .013$) than nonsepsis patients. Composite endpoint (i.e., death at day 28 or ICU LOS ≥ 3 days) was achieved in 56 sepsis patients vs. 0 nonsepsis patients (Table 1).

3.3. Diagnostic performance of SIRS and qSOFA scores

The AUROC of both SIRS and qSOFA scores increased with each passing day, and the difference between the two scores became statistically significant from the 5th day onward (Supplementary Fig. S3). With cutoff values of 2, the sensitivities and specificities also changed with time: the sensitivities of both increased continuously as expected and specificities decreased slightly, especially for qSOFA (Supplementary Fig. S3). As for performance over 28 days, qSOFA_{max} (0.75 [95% CI: 0.71–0.79]) had greater AUROC than SIRS_{max} (0.69 [95% CI: 0.64–0.73], $p = .012$) (Fig. 2). qSOFA_{max} had significantly lower sensitivity (53% [95% CI: 47%–60%] vs. 98% [95% CI: 95%–99%], $p < .001$) and higher specificity (87% [95% CI: 81%–91%] vs. 18% [95% CI: 13%–23%], $p < .001$) than SIRS_{max} (Table 3).

3.4. Causes for failed diagnostic test

Among the 409 patients, 146 patients (36%) and 371 patients (91%) met qSOFA and SIRS criteria, respectively (Fig. 1). More sepsis patients met qSOFA (53% vs. 13%, $p < .001$) and SIRS criteria (98% vs. 82%, $p < .001$) than nonsepsis patients (Table 2). This corresponded to false-negative and false-positive rates of 41% (107/263) and 16% (24/146), respectively. Among the 122 qSOFA-positive sepsis patients, both qSOFA and sepsis criteria were met on the same day in 64 patients (53%). The qSOFA criteria were met at 3 days (IQR 2–7) earlier than sepsis criteria in 15 patients (12%), and sepsis criteria were met at 4 days (IQR 1–9) earlier than qSOFA criteria in 43 patients (35%). Of the 371 patients who met the SIRS criteria (≥2), 224 patients (59%) developed sepsis at a median of 0 day (IQR 0–1). This corresponded to false-negative and false-positive rates of 13% (5/38) and 40% (147/371), respectively. Among the 224 SIRS-positive sepsis patients, both SIRS and sepsis criteria were met on the same day in 148 patients (66%). The SIRS criteria were met at 4 days (IQR 2–9) earlier than sepsis criteria in 58 patients (26%), and sepsis criteria were met at 2 days (IQR 1–3) earlier than SIRS criteria in 18 patients (8%).

3.5. Sensitivity analyses

The cutoff value of 2 remained unchanged for qSOFA_{max}, whereas a new cutoff value of 3 was determined for SIRS_{max} by Youden index. Based on this new cutoff value, the sensitivity and specificity of SIRS_{max} for the diagnosis of sepsis were 86% (95% CI: 81%–90%) and 43% (95% CI: 35%–51%), respectively (Table 3). With this new cutoff SIRS exhibited higher sensitivity and lower specificity than qSOFA for the diagnosis of sepsis (Table 3).

3.6. Prognostic performance of SIRS and qSOFA scores

Prognostic performances of SIRS and qSOFA scores are reported in Supplementary Table S1. SOFA_{max} had the highest AUROC for both 28-day mortality and for the composite endpoint (0.93 [95% CI: 0.91–0.96] and 0.94 [95% CI: 0.91–0.96], respectively), followed by qSOFA_{max} (0.86 [95% CI: 0.82–0.89] and 0.86 [95% CI: 0.82–0.89], respectively) and SIRS_{max} (0.67 [95% CI: 0.62–0.71] and 0.69 [95% CI: 0.64–0.74], respectively).

Compared with qSOFA-positive sepsis patients, both qSOFA-positive nonsepsis patients and qSOFA-negative sepsis patients had lower 28-day mortality (22% vs. 0% vs. 3%, $p < .001$), as well as lower rate of composite endpoints (41% vs. 0% vs. 6%, $p < .001$). Results were consistent when SIRS score was used instead of qSOFA (28-day mortality: 13% vs. 0% vs. 0%; rate of composite endpoints: 25% vs. 0% vs. 0%, for SIRS-

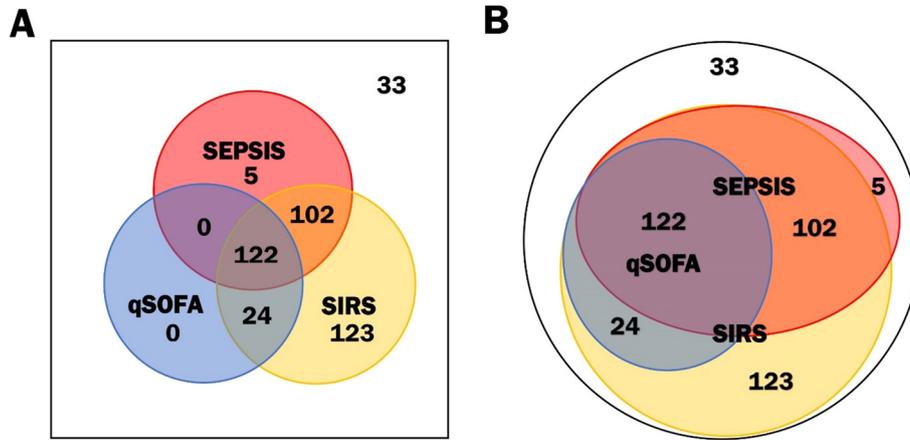


Fig. 1. The diagram of patients' distribution. Panel A. Patients' distribution painted by conventional way. Panel B. Patients' distribution painted in accordance with actual ratios.

positive sepsis patients, SIRS-positive nonsepsis patients, and SIRS-negative sepsis patients, respectively; both $p < .001$.

3.7. Reliability, validity, and generalizability analyses

During the concurrent surveys, 238 patients were recruited in the database for assessment of interobserver reliability. The κ statistics

Table 2
SOFA, qSOFA, and SIRS scores in sepsis and nonsepsis patients.

Scores measurements	All patients (n = 409)	Sepsis patients (n = 229)	Nonsepsis patients (n = 180)	p value
SOFA score				
SOFA _{baseline}	0 (0–1)	0 (0–2)	0 (0–1)	0.004
SOFA ₀	2 (1–3)	3 (2–5)	1 (0–1)	<0.001
Δ SOFA ₀	1 (0–2)	2 (1–3)	0 (0–1)	<0.001
SOFA _{max}	3 (1–5)	4 (3–6)	1 (0–1)	<0.001
Time to SOFA _{max} (day)	0 (0–3)	1 (0–6)	0 (0–0)	<0.001
Δ SOFA _{max}	2 (1–4)	3 (2–5)	1 (0–1)	<0.001
Time from diagnosis of infection to Δ SOFA ≥ 2 (day)	0 (0–1)	0 (0–1)	NA	
qSOFA score				
qSOFA ₀	1 (0–1)	1 (0–1)	1 (0–1)	<0.001
qSOFA _{max}	1 (1–2)	2 (1–2)	1 (0–1)	<0.001
Time to qSOFA _{max} (day)	0 (0–2)	0 (0–3)	0 (0–1)	<0.001
Patients with qSOFA_{max}				
0	63 (15%)	14 (6%)	49 (27%)	
1	200 (49%)	93 (41%)	107 (59%)	
2	120 (29%)	96 (42%)	24 (13%)	
3	26 (6%)	26 (11%)	0 (0%)	
qSOFA _{max} ≥ 2	146 (36%)	122 (53%)	24 (13%)	<0.001
Time to qSOFA ≥ 2 (day)	1 (0–5)	1 (0–5)	0 (0–2)	0.220
SIRS score				
SIRS ₀	2 (2–3)	3 (2–4)	2 (1–3)	<0.001
SIRS _{max}	3 (2–4)	3 (3–4)	3 (2–3)	<0.001
Time to SIRS _{max} (day)	0 (0–2)	0 (0–3)	0 (0–2)	0.145
Patients with SIRS_{max}				
0	9 (2%)	0 (0%)	9 (5%)	
1	29 (7%)	5 (2%)	24 (13%)	
2	72 (18%)	27 (12%)	45 (25%)	
3	144 (35%)	86 (38%)	58 (32%)	
4	155 (38%)	111 (48%)	44 (24%)	
SIRS _{max} ≥ 2	371 (91%)	224 (98%)	147 (82%)	<0.001
Time to SIRS ≥ 2 (day)	0 (0–0)	0 (0–0)	0 (0–0)	0.153
SIRS _{max} ≥ 3	299 (73%)	197 (86%)	102 (57%)	<0.001

Data are presented as median (interquartile range) or number (%) and compared with the Wilcoxon rank sum test or Fisher's exact test, respectively.

qSOFA quick Sequential Organ Failure Assessment, SIRS systemic inflammatory response syndrome, SOFA Sequential Organ Failure Assessment. Subscripted baseline, 0 and max represented baseline value, value on diagnosis of sepsis and maximal value during 28-day follow-up, respectively. Time to Δ SOFA, qSOFA and SIRS ≥ 2 means the time from inclusion to first met these scores.

were 0.86 (95% CI: 0.77–0.94), 0.78 (95% CI: 0.67–0.89), 0.85 (95% CI: 0.78–0.92), and 0.84 (95% CI: 0.76–0.92), respectively, for infection diagnosis, qSOFA, SIRS, and SOFA scores. Of the 409 patients in the study, 260 patients (64%) in whom at least one ABG result was available were included in the validity study. The respiratory SOFA scores calculated by the two methods were highly concordant, with $\kappa = 0.80$ (95% CI: 0.74–0.86). There were 397 new admissions into the adult non-critical care wards. The prevalence rates of infection, sepsis, and the SIRS score were significantly higher in the study wards than in the non-study wards. However, the results were consistent with the results of the pilot study performed to select study wards.

4. Discussion

To the best of our knowledge, this is the first prospective study to examine the diagnostic accuracy of qSOFA and SIRS scores in general ward patients with infection. For the diagnosis of sepsis, the AUROCs for qSOFA score and SIRS score were relatively low (0.75 and 0.69,

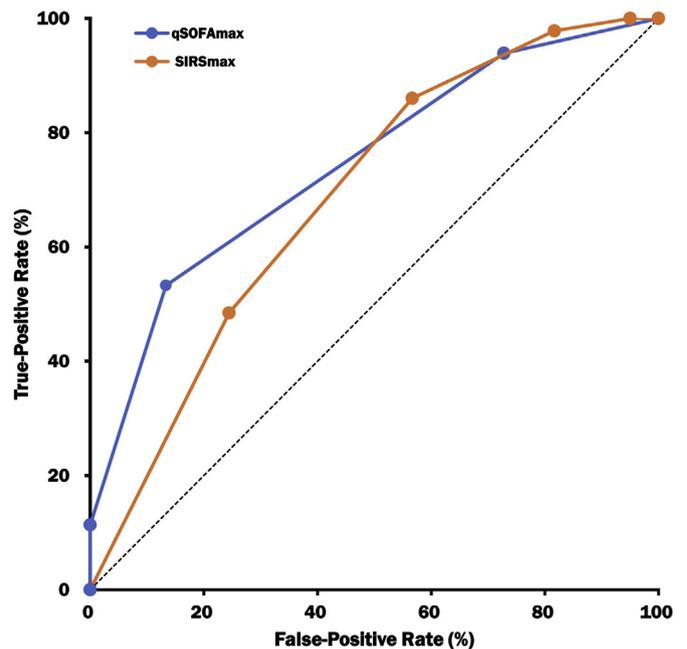


Fig. 2. ROC curves for diagnosis of sepsis-3. The area under the receiver operating characteristic curves were 0.75 (95% CI, 0.71–0.79) for qSOFA_{max} and 0.69 (95% CI, 0.64–0.74) for SIRS_{max}. qSOFA, quick Sequential Organ Failure Assessment; SIRS, systemic inflammatory response syndrome.

Table 3
Diagnostic performance of qSOFA and SIRS scores for sepsis-3.

Variables	qSOFA _{max}	SIRS _{max}	SIRS _{max}
Cutoff value	2	2	3
Sensitivity	53 (47–60)	98 (95–99)	86 (81–90)
Specificity	87 (81–91)	18 (13–23)	43 (36–51)
Predictive value			
Positive	84 (77–89)	60 (55–65)	66 (60–71)
Negative	59 (53–65)	86 (71–95)	71 (61–79)
Likelihood ratio			
Positive	4.0 (2.7–5.9)	1.2 (1.1–1.3)	1.5 (1.3–1.7)
Negative	0.5 (0.5–0.6)	0.1 (0.1–0.3)	0.3 (0.2–0.5)

Data are presented as true value (95% CI). qSOFA_{max} and SIRS_{max} denoted the maximum qSOFA and SIRS scores within 28 days. qSOFA quick Sequential Organ Failure Assessment, SIRS systemic inflammatory response syndrome, CI confidence interval.

respectively). However, qSOFA score had low sensitivity (53%) and high specificity (87%), whereas SIRS score exhibited high sensitivity (98%) and low specificity (18%).

Evaluation of all six components of the SOFA score is time consuming, labor intensive, and expensive, which makes it unsuitable for use in the general ward setting. The qSOFA score, however, can be calculated without the need for any blood tests and can be repeated several times even within a single day [3]. However, the qSOFA score was not part of the new sepsis definitions, but could rather be regarded as a screening tool of raising suspicion of sepsis in the general wards [3,24]. A recent meta-analysis of nine studies that examined the diagnostic accuracy of qSOFA outside of the ICU reported sensitivity of 47% (95% CI: 28%–66%) and specificity of 93% (95% CI: 88%–97%) [25], which is consistent with our findings.

The low sensitivity of qSOFA score is related to the fact that some forms of organ dysfunction (such as respiratory failure, acute kidney injury, or coagulopathy) might not be captured by the three parameters of qSOFA score, i.e., respiratory rate, blood pressure, and altered mentation [24]. Therefore, a negative qSOFA score does not exclude the diagnosis of sepsis, although it does lower the likelihood of clinical deterioration or a complicated course (mortality or ICU admission) [26]. We believe that these results did not support the original proposal of qSOFA score as a bedside screening tool for sepsis.

According to the revised definition, SIRS score was not included in sepsis diagnosis or screening [24]. SIRS score had long been criticized for its high false-positive rate among both ICU and general ward patients [27,28]. Our findings indicated that, even for the most recent sepsis definition, the SIRS score retains very high sensitivity to identify infected patients at high risk of developing sepsis. Furthermore, among patients who met both sepsis and screening tool criteria, early diagnosis might be possible in 92% of sepsis patients who also met SIRS criteria (i.e. meeting SIRS criteria earlier or simultaneously with onset of sepsis), compared with only 65% of sepsis patients who also met qSOFA criteria. However, despite the very high sensitivity (98%), SIRS score might neither serve as an ideal screening tool for sepsis, as indicated by the poor specificity as low as 18%, suggesting that many patients meeting SIRS criteria did not have sepsis. In addition, although SIRS score was associated with shorter time interval than qSOFA score after onset of sepsis (median 2 days vs. 4 days) in patients who met sepsis criteria earlier, this time interval in days was inconsistent with the concept of early detection, early diagnosis and early intervention in patients with sepsis, as recommended by the Surviving Sepsis Campaign Guidelines [6].

However, the fact that qSOFA score exerted a better prognostic value than SIRS score, as demonstrated by a higher AUROC (0.86 vs. 0.67 for 28-day mortality), suggested that it may help to identify sepsis patients at higher risk of poor clinical outcome. This might facilitate the recognition and treatment of tissue hypoperfusion and/or organ dysfunction while avoiding overtreatment in those at lower risk of poor prognosis.

Our study had several strengths. It was the first prospective study to assess the diagnostic accuracy of qSOFA. We have avoided the problems of selection bias and missing data that are associated with a retrospective design [29]. Second, sepsis was diagnosed in a real-world setting, i.e., by bedside physical examination and laboratory tests. In comparison, previous retrospective studies often diagnosed infection using a combination of antibiotics and body fluid cultures [30], or diagnosed sepsis incidence by International Classification of Diseases, 9th revision (ICD-9) codes [31], which was subject to substantial variability depending on the methods of database abstraction used [32]. Third, the qSOFA score was assessed daily up to day 28 rather than once or twice after admission as in previous studies [3,14,26,30,31]. The daily measurements of qSOFA score were in compliance with the ideal characteristics of a screening tool for sepsis, where case discrimination needs to be a continuous process and cannot be decided by a single evaluation.

Our study had some limitations. First, it was a single-center study of selected general wards with higher incidence of sepsis, so the results may not be generalizable to other patient populations and/or other institutions. However, the robustness of our findings was supported by the sensitivity analyses, as well as by the concordance with previous retrospective studies. Second, as in many previous studies [14,15,26,30,31], day 0 was arbitrarily defined as the date of hospital admission for patients with community-acquired infection; nevertheless, this may not necessarily be the date of disease onset. Third, the date of onset of sepsis might be inaccurate because the laboratory tests necessary to calculate the SOFA score were not performed on a daily basis. This, however, reflects common practice in the general wards. Fourth, we did not explore the association of qSOFA score with acute organ dysfunction in patients without infection. Fifth, a higher granular resolution with regards to calculation of qSOFA score (i.e. hours rather than days) merited further investigation as even one-hour delay in the administration of empiric antibiotics was associated with significantly increased mortality rate in patients with septic shock [33]. Last, we did not evaluate whether the addition of sepsis biomarkers would improve the diagnostic accuracy of qSOFA. Recently, Spoto and colleagues reported that the combination of serum procalcitonin or mid-regional pro-adrenomedullin with qSOFA score increased post-test probability from 0.62 to 0.986 and 0.915, respectively [34].

5. Conclusions

Based on our findings in a prospective cohort study of 409 patients with infections in general wards, SIRS score was highly sensitive but not specific, whereas qSOFA score was highly specific but not sensitive, for detection of sepsis. Therefore, we believe that neither score is an ideal a screening tool for sepsis, whereas a positive qSOFA score might help to identify those patients at higher risk of clinical deterioration who may require urgent empirical antibiotic therapy and initial resuscitation.

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Authors' contributions

JL, LW and BD designed the study, contributed to the interpretation of the results and critically revised the manuscript. All authors made a substantial contribution to the acquisition of the data and revised the manuscript for important intellectual content. JL and BD made a substantial contribution in writing the manuscript and interpreting the results. LW made a substantial contribution in the study design and

critically revised the manuscript for important intellectual content. All authors had full access to the data, take responsibility for the integrity of the data and the accuracy of the analysis. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jccr.2019.01.012>.

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