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CE- SYSTEMATIC REVIEW

Quick Sequential Organ Failure Assessment as a prognostic factor for infected patients outside the intensive care unit: a systematic review and meta-analysis

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Abstract
Quick Sequential Organ Failure Assessment (qSOFA) was proposed to replace SIRS as a new screening tool for the identification of septic patients at high mortality. However, researches from infected patients outside of ICU especially in Emergency Department (ED) drew contradictory conclusions on the prognostic value of qSOFA. This systematic review evaluated qSOFA as a prognostic marker of infected patients outside of ICU. The primary outcome was hospital mortality or 28- or 30-day mortality. Data were pooled based on sensitivity and specificity. Twenty-four trials with 121,237 participants were included. qSOFA had a poor sensitivity (0.58 [95% CI 0.47–0.67], 0.54 [95% CI 0.43–0.65]) and moderate specificity (0.69 [95% CI 0.48–0.84], 0.77 [95% CI 0.66–0.86]) for prediction of mortality in patients outside of ICU and ED patients only. Studies that used in-hospital mortality showed a higher sensitivity (0.61 [95% CI 0.50–0.71] vs 0.32 [95% CI 0.15–0.49]) and lower specificity (0.70 [95% CI 0.59–0.82] vs 0.92 [95% CI 0.85–0.99]) than studies that used 28 or 30-day mortality. Studies with overall mortality < 10% showed higher specificity (0.89 [95% CI 0.82–0.95] vs 0.62 [95% CI 0.48–0.76]) than studies with overall mortality ≥ 10%. There is no difference in the accuracy of diagnosis of sepsis between positive qSOFA scores and SIRS criteria. qSOFA was poor sensitivity and moderate specificity in predicting mortality of infected patients outside of ICU especially in ED. Combining qSOFA and SIRS may be helpful in predicting mortality.

Keywords qSOFA · Emergency Department · Mortality · Sepsis · Meta-analysis

Background

Sepsis, a life-threatening organ dysfunction caused by dysregulated host response to infection, affects millions of people around the world and kills as many as one in four each year [1–3]. The Emergency Department (ED) is often the initial setting for the diagnosis and treatment of acute sepsis, and has up to nearly 850,000 emergency department visits annually in the United States [4]. Prompt identification and appropriate treatment of sepsis in ED are crucial to improve the patient outcome [5]; therefore, early and specific marker of sepsis would be useful in

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ED, especially when clinical signs and symptoms are still insufficient for diagnosis [6].

Systemic inflammatory response syndrome (SIRS) was used as a screen criteria to patients with infection for the diagnosis of sepsis since 1992 [7]; however, more and more evidence pointed out its high false-positive rates in the diagnosis of sepsis [8]. Recently, the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) Task Force proposed the new quick Sequential (Sepsis-related) Organ Failure Assessment (qSOFA) to replace SIRS as a new screening tool for the identification of patients with sepsis [9]. The qSOFA score ranges from 0 to 3 points (one point for each of the following: respiratory rate >21 breaths/min; systolic arterial blood pressure ≤ 100 mmHg; or altered mental status), and an increase of at least two points indicates a high mortality of sepsis patients. Several studies were recently published to compare the predictive performance of qSOFA with SIRS score for mortality in these patients [10]. However, conflicting conclusions were generated, especially in the patients in ED, and a meta-analysis was needed to verify the predictive performance of qSOFA score.

Several meta-analyses on the prognostic or diagnostic accuracy of qSOFA or SIRS were indeed published [11–14]; however, meta-analysis specially focusing on the ED patients was not yet published. The aim of this study was to obtain summary estimates of prognostic and diagnostic performance of qSOFA in outside ICU especially ED patients with infection. We also analyzed different subgroups of ED patients to make more precise conclusions.

Methods

Search strategy

We performed a comprehensive database searching in Medline (via PubMed), the Cochrane Library, ISI Web of Knowledge, and Science Direct for studies that evaluated the qSOFA score and/or SIRS as a tool for predicting the prognosis of sepsis in ED patients from the inception of each database through Dec 2017. The following terms were used: Quick Sepsis-related Organ Failure Assessment (qSOFA), systematic inflammatory response syndrome (SIRS), sepsis, septic, infection, prognosis. We also searched the reference list of each primary study identified and articles dealing with literature review. We also conducted searches of abstracts from major conferences. The titles and abstracts of studies which were potentially relevant were scanned and the full articles were reviewed when the studies seemed to meet the criteria or when information was insufficient to exclude them.

Study selection criteria

Studies were included if they met the following criteria.

(1) Adult patients outside of ICU with suspected or confirmed infection or sepsis.
(2) RCT, propensity-matched cohort study (prospective or retrospective), or historically controlled study.
(3) qSOFA as a predictive tool for predicting mortality or diagnosis of sepsis.
(4) Sufficient data to calculate absolute numbers of true-positive, false-positive, false-negative, and true-negative results.

Data extraction and quality assessment

Following the initial screening, full articles were independently reviewed by two reviewers (Y-CL, Y-YL) with application of the same inclusion criteria. Disagreements were resolved by consensus. A predefined form was used to extract data from each study. We only included publications written in English. Two reviewers (Y-CL, Y-YL) independently assessed risk of bias of the included studies using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS)-2 tool [15]. Disagreements were resolved by consensus. The qSOFA (positive if ≥ 2) and SIRS (positive if ≥ 2) score were defined following the proposed guideline [16, 17].

Statistical analysis

We presented the data as mean values for continuous variables and as frequencies for categorical variables. Results of individual studies were presented graphically by plotting sensitivity and specificity estimates on one-dimensional forest plots. Meta-analysis was performed by fitting bivariate models to our data. The estimates of pooled sensitivity, specificity, positive and negative likelihood ratios, with their 95% confidence intervals (CI) were calculated starting from parameter estimates obtained from bivariate models [18]. The effect of some predefined sources of heterogeneity (prospective vs retrospective study design; single-center vs multi-center; in-hospital mortality vs 28- or 30-day mortality; scores measured at ED arrival vs worst value; suspected vs confirmed infection; sepsis vs septic shock; overall mortality $\geq 10\%$ vs overall mortality $< 10\%$) was assessed by fitting bivariate meta-regression models with the inclusion of covariate terms. Bivariate meta-regression random effect model was also used in verifying the prognostic accuracy of qSOFA and SIRS

criteria in diagnosis of sepsis. We performed all analysis using Review Manager (RevMan), and Stata15. A P value < 0.05 was considered statistically significant.

Results

Search results and description of studies

After screening titles and abstracts and completing full-text reviews, 24 studies met the inclusion criteria and were selected (Fig. 1). Table 1 described the characteristics of the 24 studies selected [9, 19–41]. Of the included studies, five studies (21%) were prospective studies, and the remaining were retrospective studies or hoc analysis. Seventeen studies (71%) included patients only in ED [19, 20, 25–29, 31, 33–41].

In the 17 studies from ED patients, 13 studies (76%) used in-hospital mortality as outcome measure, and four studies (24%) used 28- or 30-day mortality. Ten studies (59%) included patients with diagnosis of suspected or confirmed infection, and seven studies (41%) followed the diagnosis of sepsis or septic shock. Eleven studies (65%) measured the qSOFA at ED arrival, and six studies (35%) measured at the worst value during ED stay. The overall mortality rate in nine studies (53%) were over 10%, while eight studies (47%) were less than 10%. The mean age of patients in eight studies (47%) were over 65, and seven studies (41%) were less than 65, and data were not shown in the other two studies.

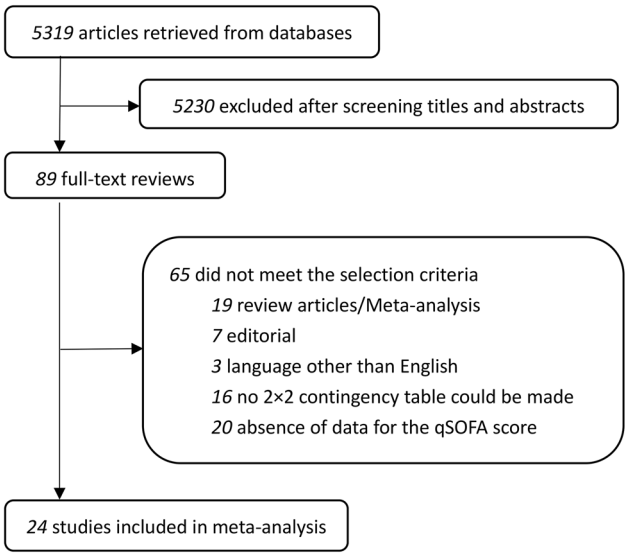

Fig. 1 Study selection. Some studies were excluded for more than one reason

Quality assessment

Quality assessments using QUADAS-2 criteria are summarized in Fig. 2. Overall, the quality of the studies was deemed satisfactory.

Prognostic accuracy for mortality using positive qSOFA scores

Figures 3 and 4 showed the forest plots and the 95% confidence regions of the sensitivity and specificity of qSOFA criteria reported in the 24 included studies. The pooled sensitivity of qSOFA across all included studies was 0.58 (95% CI 0.47–0.67), and the specificity was 0.69 (95% CI 0.48–0.84). The pooled estimates of positive and negative likelihood ratios were 1.8 (95% CI 1.1–3.0) and 0.62 (95% CI 0.51–0.70), respectively (Table 2).

In seventeen studies specially focused on the ED patients, the pooled sensitivity of qSOFA across all included studies was 0.54 (95% CI 0.43–0.65), and the specificity was 0.77 (95% CI 0.66–0.86). The pooled estimates of positive and negative likelihood ratios were 2.4 (95% CI 1.8–3.2) and 0.6(95% CI 0.51–0.70), respectively (Table 2). The forest plots and the 95% confidence regions of the sensitivity and specificity are shown in Figs. 5 and 6.

Subgroup analysis for positive qSOFA scores in predicting mortality

Table 3 show the results of univariate meta-regression analysis (prospective, retrospective, single-center, multi-center, in-hospital mortality, 28- or 30-day mortality, scores measured at ED arrival or worst value, suspected or confirmed infection, sepsis or septic shock, overall mortality $\geq 10\%$, overall mortality $< 10\%$) in identifying potential sources of heterogeneity in studies specially focused on ED patients. Results showed that outcome definition and overall mortality were important sources of heterogeneity. Studies that used in-hospital mortality showed a higher sensitivity and lower specificity than studies that used 28- or 30-day mortality. Studies with overall mortality $< 10\%$ showed higher specificity than studies with overall mortality $\geq 10\%$.

Diagnostic accuracy for sepsis using positive qSOFA scores and SIRS criteria in ED patients

To determine the role of qSOFA and SIRS in the diagnostic accuracy for sepsis, we used the Sepsis3.0 criteria [16] (Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection; organ dysfunction can be identified as an acute change in total SOFA score ≥ 2 points consequent to the infection) and focused the studies on ED patients. Five studies included the diagnosis accuracy

Table 1 Studies characteristics included in the meta-analysis

Author and year	Design	Total no. of patients	Mean age, years	Male sex (%)	Patients location	Overall mortality rate (%)	QSOFA score recorded	Measured mortality	Participant selection	Primary study aim
April et al. (2017) [19]	Retrospective, single-center, cohort study	214	68	59	ED	18.2	Worst values during ED stay	In-hospital mortality	Suspected infection, admitted to ICU	Comparison of prognostic accuracy of qSOFA and SIRS for predicting in-hospital mortality
Askim et al. (2017) [20]	Prospective, single-center, observational study	1535	62	53	ED	4.4	ED arrival	30-day mortality	Suspected infection	Clinical Usefulness of qSOFA to predict severe sepsis and 7-and 30-day mortality
Churpek et al. (2017) [21]	Retrospective, single-center, observational study	30,677	58	47	ED and ward	5.4	At time of initial suspicion of infection	In-hospital mortality	Suspected infection	Comparison of qSOFA with other commonly used early warning scores for in-hospital mortality
Donnelly et al. (2017) [22]	Retrospective, multicenter, cohort study	2593	67	40	ED and ward	11.3	Worst values within 28 h of hospital admission	28-day mortality	Suspected infection	Incidence and long-term outcomes of patients diagnosed with sepsis and septic shock
Finkelsztein et al. (2017) [23]	Prospective, single-center, cohort study	151	64	55	ED and ward	19	Within 8 h before ICU admission	In-hospital mortality	Suspected infection, admitted to medical ICU	Comparison of capacity of qSOFA vs. SIRS criteria for predicting in-hospital mortality and ICU-free days
Forward et al. (2017) [24]	Retrospective, single-center, observational study	162	NA	N.S	ED and ward	15.5	Within 24 h of deterioration	In-hospital mortality	Suspected infection	Comparison of prognostic performance of qSOFA, SIRS, and SK criteria

Table 1 (continued)

Author and year	Design	Total no. of patients	Mean age, years	Male sex (%)	Patients location	Overall mortality rate (%)	QSOFA score recorded	Measured mortality	Participant selection	Primary study aim
Freund et al. (2017) [25]	Prospective, multicenter, cohort study	879	67	53	ED	8.4	Worst values during ED stay	In-hospital mortality	Suspected infection	Validation of qSOFA as mortality predictor comparing SIRS with SOFA
Gonzalez et al. (2017) [26]	Prospective, multicenter, observational cohort study	1071	83.6	50.8	ED	6.7	ED arrival	30-day mortality	Diagnosis of sepsis	Predicting the value of SIRS and qSOFA on 30-day mortality in older patients in ED
Guirgis et al. (2017) [27]	Retrospective, single-center, observational study	3297	58	49	ED	10.1	ED arrival	In-hospital mortality	Diagnosis of sepsis	Devising an easy-to-use simple SOFA score for use in ED
Haydar et al. (2017) [28]	Retrospective, single-center, cohort study	200	71	54.5	ED	11.1	ED arrival	In-hospital mortality	Suspected sepsis	Comparison of qSOFA and SIRS as screening mechanism for ED sepsis
Henning et al. (2017) [29]	Post hoc analysis	7637	58	50	ED	14.2	Worst values during ED stay	In-hospital mortality	Suspected infection	Performance of qSOFA predicting in-hospital mortality
Huson et al. (2017) [30]	Retrospective, single-center, observational study	329	34	38	ED and ward	4.5	At time of initial suspicion of infection	In-hospital mortality	Suspected infection	Predictivevalue of qSOFA score for mortality
Hwang et al. (2017) [31]	Retrospective, single-center, cohort study	1395	65	56	ED	15	ED arrival and within 3, 6 and 24 h	In-hospital mortality	Severe sepsis or septic shock	Diagnostic performance of positive qSOFA score for predicting 28-day mortality among critically ill patients with sepsis
Kolditz et al. (2016) [32]	Retrospective, multicenter, observational study	9327	64	56	ED and ward	3.0	At time of initial suspicion of infection	30-day mortality	Community-acquired pneumonia	Comparison of qSOFA and CRB-65 for risk prediction

Table 1 (continued)

Author and year	Design	Total no. of patients	Mean age, years	Male sex (%)	Patients location	Overall mortality rate (%)	QSOFA score recorded	Measured mortality	Participant selection	Primary study aim
Moskowitz et al. (2017) [33]	Retrospective, single-center, observational study	24,164	63.8	50.9	ED	4.9	Worst values in first 24 h during ED stay	In-hospital mortality	Suspected infection	introducing the novel outcome of "received critical care intervention" and the relationship with qSOFA and SIRS
Park et al. (2017) [34]	Retrospective, single-center, observational study	1009	67	45	ED	15.8	ED arrival	In-hospital mortality	Suspected infection	Comparison of performance of qSOFA and SIRS to predict development of organ failure
Peake et al. (2017) [35]	Post hoc analysis	1591	63	60	ED	18.7	Worst values during ED stay	In-hospital mortality	Early septic shock	Exploration of utility and potential effects of new Sepsis-3 definitions
Quinten et al. (2017) [36]	Prospective, single-center, observational study	193	60	56	ED	4.1	ED arrival	In-hospital mortality	Suspected or confirmed infection	Comparison of predictive performance of qSOFA, CIS, and PIRO score for ICU admission
Ranzani et al. (2017) [37]	Retrospective, two-center, cohort study	6874	66	62	ED	6.4	ED arrival	In-hospital mortality	Community-acquired pneumonia	Comparison of predictive performance of SIRS, qSOFA, CRB, mSOFA, and CURB-65 for in-hospital mortality
Seymour et al. (2016) [9]	Retrospective, multicenter, cohort study	66,522	61	43	ED and ward	2.8	At time of initial suspicion of infection	In-hospital mortality	Suspected infection	Comparison of performance of qSOFA, SIRS, SOFA, and MODS score to predict sepsis

Table 1 (continued)

Author and year	Design	Total no. of patients	Mean age, years	Male sex (%)	Patients location	Overall mortality rate (%)	QSOFA score recorded	Measured mortality	Participant selection	Primary study aim
Shetty et al. (2017) [38]	Retrospective, multicenter, cohort study	12,555	N.S	N.S	ED	4.6	ED arrival	In-hospital mortality	Suspected or proven sepsis	Investigating Lactate plus qSOFA to predict mortality in suspected sepsis patients presenting to ED
Wang et al. (2016) [39]	Retrospective, single-center, observational study	477	73	62	ED	27.5	ED arrival	28-day mortality	Clinically diagnosed infection	Performance of qSOFA for predicting mortality and ICU admission
Weigle et al. (2016) [40]	Retrospective, single-center, observational study	224	N.S	N.S	ED	20.5	ED arrival	In-hospital mortality	Severe sepsis or septic shock	Comparison of the sensitivity of qSOFA to SIRS in ED patients.
Williams et al. (2017) [41]	Retrospective, single-center, observational study	8871	49	51	ED	8.7	Worst values during ED stay	30-day mortality	Suspected infection	Comparison of diagnostic accuracy of SIRS and qSOFA for organ dysfunction and mortality

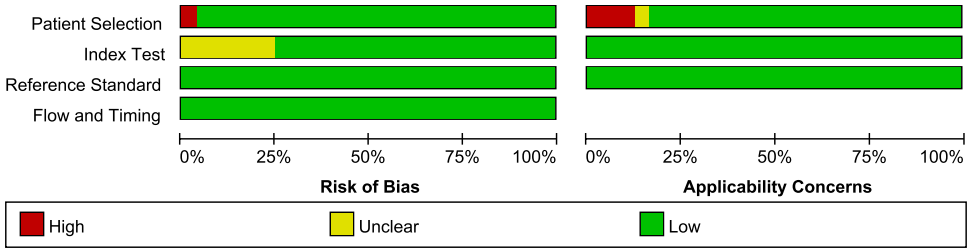

Fig. 2 Risk of bias graph for the included studies

Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Seymour 2016	1186	5381	103	0	0.92 [0.90, 0.93]	0.00 [0.00, 0.00]
Haydar 2017	20	96	2	80	0.91 [0.71, 0.99]	0.45 [0.38, 0.53]
April 2017	35	127	4	48	0.90 [0.76, 0.97]	0.27 [0.21, 0.35]
Finkelsztein 2017	26	71	3	52	0.90 [0.73, 0.98]	0.42 [0.33, 0.52]
Peake 2017	196	943	44	408	0.82 [0.76, 0.86]	0.30 [0.28, 0.33]
Huson 2017	76	112	30	240	0.72 [0.62, 0.80]	0.68 [0.63, 0.73]
Freund 2017	52	166	22	639	0.70 [0.59, 0.80]	0.79 [0.76, 0.82]
Churpek 2017	1133	10595	516	18433	0.69 [0.66, 0.71]	0.64 [0.63, 0.64]
Hwang 2017	144	573	67	611	0.68 [0.62, 0.74]	0.52 [0.49, 0.54]
Forward 2017	17	73	8	63	0.68 [0.46, 0.85]	0.46 [0.38, 0.55]
Quinten 2017	5	29	3	156	0.63 [0.24, 0.91]	0.84 [0.78, 0.89]
Park 2017	84	136	75	714	0.53 [0.45, 0.61]	0.84 [0.81, 0.86]
Henning 2017	172	1042	161	6259	0.52 [0.46, 0.57]	0.86 [0.85, 0.87]
Ranzani 2017	189	1071	187	4577	0.50 [0.45, 0.55]	0.81 [0.80, 0.82]
Williams 2017	164	741	163	7803	0.50 [0.45, 0.56]	0.91 [0.91, 0.92]
Shetty 2017	173	1596	191	10595	0.48 [0.42, 0.53]	0.87 [0.86, 0.88]
Wang 2016	56	60	75	286	0.43 [0.34, 0.52]	0.83 [0.78, 0.86]
Donnelly 2017	67	228	96	2070	0.41 [0.33, 0.49]	0.90 [0.89, 0.91]
Moskowitz 2017	465	2986	728	19985	0.39 [0.36, 0.42]	0.87 [0.87, 0.87]
Guirgis 2017	125	412	207	2553	0.38 [0.32, 0.43]	0.86 [0.85, 0.87]
Weigle 2016	17	112	29	66	0.37 [0.23, 0.52]	0.37 [0.30, 0.45]
Gonzalez 2017	20	63	52	936	0.28 [0.18, 0.40]	0.94 [0.92, 0.95]
Kolditz 2016	81	562	280	8404	0.22 [0.18, 0.27]	0.94 [0.93, 0.94]
Askim 2017	8	59	60	1408	0.12 [0.05, 0.22]	0.96 [0.95, 0.97]

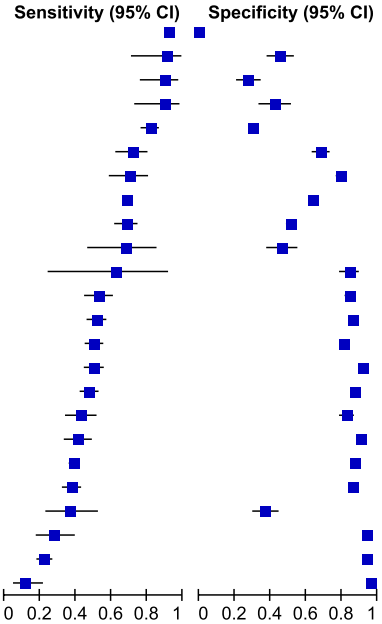

Fig. 3 Forest plots of sensitivity and specificity for qSOFA in predicting mortality in included studies

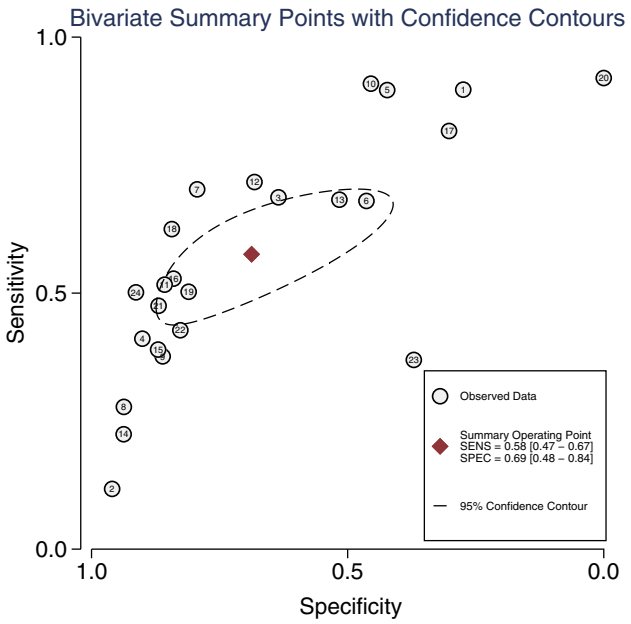

Fig. 4 Bivariate summary points of (specificity, sensitivity) and their 95% confidence regions for qSOFA in predicting mortality in included studies

of sepsis using qSOFA while three studies using SIRS; forest plots for the sensitivity and specificity analysis are shown in Fig. 7. The pooled sensitivity and specificity of positive qSOFA score for diagnosis of sepsis were 0.54 (95% CI 0.50–0.58) and 0.67 (95% CI 0.65–0.68), respectively. The pooled sensitivity and specificity of positive SIRS criteria were 0.72 (95% CI 0.67–0.77) and 0.71 (95% CI 0.69–0.73), respectively. There is no difference in the accuracy of diagnosis of sepsis between positive qSOFA scores and SIRS criteria ($P > 0.05$) (Table 4).

Discussion

Our meta-analysis evaluated the prognostic capability for predicting mortality and diagnosing sepsis of qSOFA in adult patients outside of ICU with suspected infection. We found that qSOFA was poorly sensitive but highly specific for prediction of mortality. For the studies specially focused on the ED patients, studies that used in-hospital mortality had a higher sensitivity and lower specificity than studies that used 28- or 30-day mortality. Studies with overall

Table 2 Prognostic accuracy for mortality using positive qSOFA scores

	Patients outside ICU	ED patients only
Number of studies (patients), *n* (*n*)	24 (121,237)	17 (71,331)
Sensitivity (95% CI)	0.58 (0.47–0.67)	0.54 (0.43–0.65)
Specificity (95% CI)	0.69 (0.48–0.84)	0.77 (0.66–0.86)
Positive likelihood ratio (95% CI)	1.8 (1.1–3.0)	2.4 (1.8–3.2)
Negative likelihood ratio (95% CI)	0.62 (0.51–0.74)	0.6 (0.51–0.70)

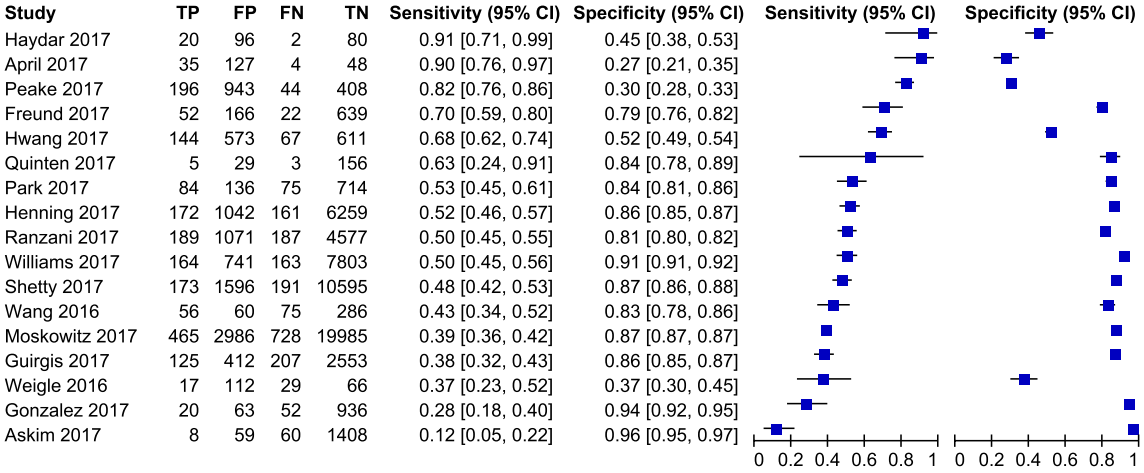

Fig. 5 Forest plots of sensitivity and specificity for qSOFA in predicting mortality in ED studies

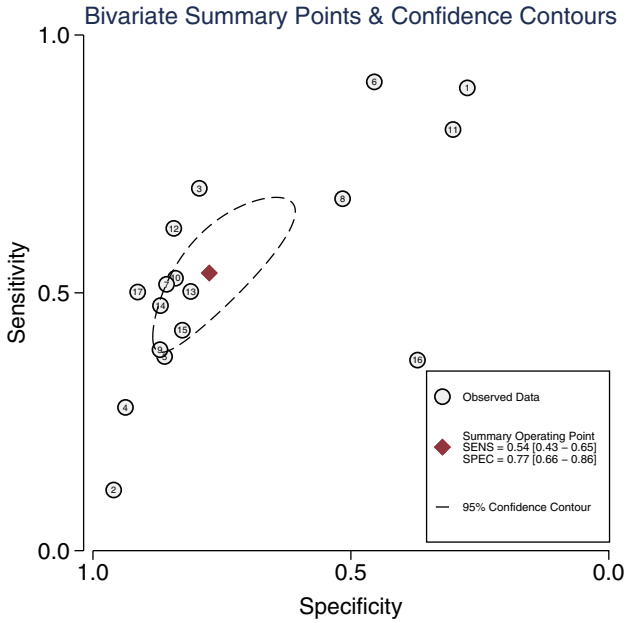

Fig. 6 Bivariate summary points of (specificity, sensitivity) and their 95% confidence regions for qSOFA in predicting mortality in ED studies

mortality < 10% had a higher specificity than studies with overall mortality ≥ 10%. We also found that there is no difference in the accuracy of diagnosis of sepsis between positive qSOFA and SIRS criteria.

Sepsis is a common emergency, and its prognosis is highly affected by the early diagnosis and treatment in the ED [6]. The Sepsis3.0 task force designed qSOFA criteria to replace SIRS to identify patients with suspected infection who would require early diagnosis and treatment [9]. Interestingly, our meta-analysis has found that qSOFA has a poor sensitivity for predicting mortality and diagnosing sepsis in outside of ICU adult patients especially ED patients. As early recognition of sepsis and promptly providing treatment is crucial to improve outcomes, our result will cause great concern about the use of qSOFA in the ED patients.

Our meta-analysis focus on the patients outside of ICU, especially subgroup analysis in ED patients, which is quite different with meta-analysis that published before [11–14]. Our study confirmed that qSOFA was poorly sensitive (0.54) and moderately specific (0.77) for prediction mortality in ED patients, which was consistent with two studies published before. In Fernando's study [11], the sensitivity and specificity of qSOFA and SIRS in ED patients subgroup are (0.467, 0.813) and (0.836, 0.306), and in Song's study [13], the sensitivity and specificity of qSOFA in ED patients subgroup are (0.47, 0.85).

Table 3 Subgroup analysis to examine the prognostic accuracy of qSOFA criteria in ED

	Number of studies (patients), *n* (*n*)	Sensitivity (95% CI)	*P*	Specificity (95% CI)	*P*
Studies types					
Prospective studies	4 (3678)	0.39 (0.17–0.60)	0.27	0.90 (0.81–1.00)	0.47
Retrospective studies	13 (67,653)	0.58 (0.47–0.70)	–	0.72 (0.60–0.84)	–
Studies types					
Single-center studies	13 (49,952)	0.55 (0.43–0.68)	0.75	0.74 (0.62–0.86)	0.08
Multi-center studies	4 (21,379)	0.49 (0.26–0.71)	–	0.86 (0.73–1.00)	–
Outcome definition					
In-hospital mortality	13 (59,377)	0.61 (0.50–0.71)	0.04	0.70 (0.59–0.82)	0.00
28- or 30-day mortality	4 (11,954)	0.32 (0.15–0.49)	–	0.92 (0.85–0.99)	–
qSOFA score recorder time					
Score (ED arrival)	11 (27,978)	0.46 (0.34–0.59)	0.10	0.80 (0.69–0.91)	0.88
Score (worst value)	6 (43,353)	0.65 (0.50–0.81)		0.72 (0.53–0.91)	
Participant selection					
Suspected or confirmed infection	10 (51,000)	0.52 (0.37–0.66)	0.58	0.83 (0.73–0.93)	0.75
Sepsis or septic shock	7 (20,331)	0.57 (0.40–0.74)	–	0.67 (0.49–0.86)	–
Overall mortality					
Overall mortality ≥ 10%	9 (16,039)	0.63 (0.51–0.76)	0.21	0.62 (0.48–0.76)	0.00
Overall mortality < 10%	8 (55,292)	0.43 (0.29–0.57)	–	0.89 (0.82–0.95)	–

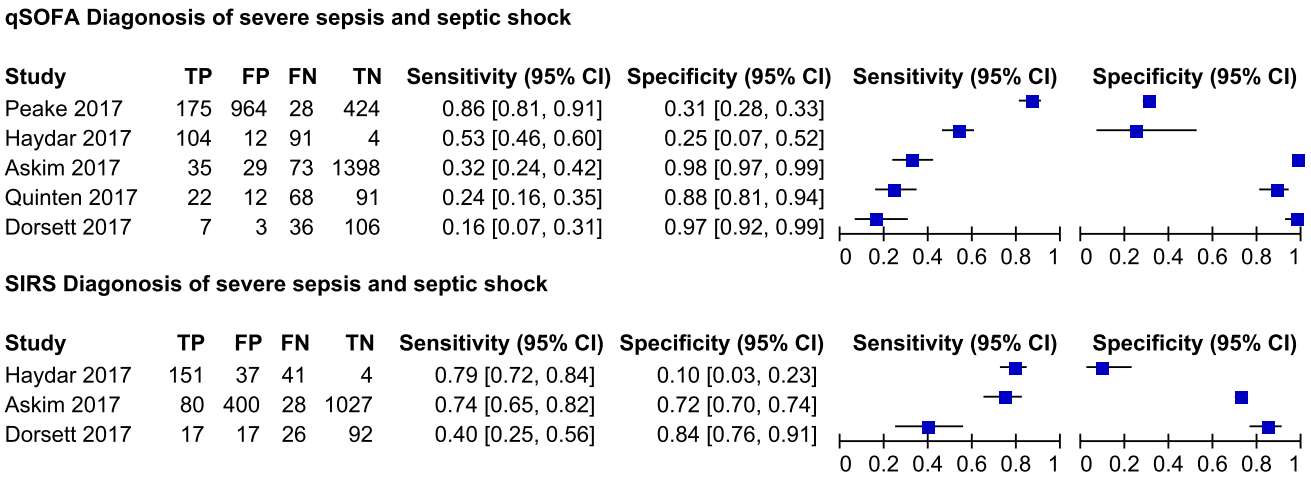

Fig. 7 Forest plots of sensitivity and specificity for qSOFA and SIRS criteria in diagnosis of sepsis in included studies

Table 4 Covariate analysis to verify the prognostic accuracy of qSOFA and SIRS criteria in ED

	Number of studies (*n*)	Sensitivity (95% CI)	*P*	Specificity (95% CI)	*P*
qSOFA	5	0.54 (0.50–0.58)	0.26	0.67 (0.65–0.68)	0.14
SIRS	3	0.72 (0.67–0.77)	–	0.71 (0.69–0.73)	–

Our meta-analysis has several limitations. First, large amount of heterogeneity still exists among the included studies, although we have investigated some source of heterogeneity through subgroup analysis. Second, the definition of suspected infection varied among studies. Third, some studies applied qSOFA or SIRS score only to specific patients, such as older patients [26], community-acquired pneumonia patients [37], ED patients admitted to intensive care unit [19,

39], which is a potential source of bias. Finally, we found only five studies using positive qSOFA and three studies using positive SIRS criteria for assessing the accuracy of diagnosis of sepsis. The conclusion from this limited data is still farfetched.

Conclusions

In conclusion, our meta-analysis found that qSOFA showed a poor performance in predicting mortality of infected patients outside of ICU, especially in ED. Both qSOFA and SIRS were moderately accurate in diagnosing sepsis. Therefore, combining qSOFA and SIRS may be helpful in predicting mortality. Future studies should focus on combining qSOFA, SIRS, and other Point of Care Testing to accurately assess the diagnosis and prognosis of ED infected patients.

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Author contributions Y-CL had the idea for and designed the study, searched the scientific literature, collected, analyzed, and interpreted data, and wrote critically revised the report. Y-YL searched the scientific literature, collected data, and drafted and critically revised the report. XZ statistically analyzed and interpreted the data. S-TS, Y-LG, BL and CL helped to search the scientific literature and collect the data. Y-FC had the idea for and designed the study, supervised the study, and gave administrative, technical, and material support.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Statement of human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent None.

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