

## Comparison Accuracy in mSIRS, NEWS and qSOFA Score to Triage Sepsis Patients in The Emergency Department at a Hospital in Thailand

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Received 12 December 2020 • Revised 2 October 2021 • Accepted 8 November 2021 • Published online 11 January 2022

### Abstract:

**Objective:** We aimed to apply the modified systemic inflammatory response syndrome (mSIRS), the quick sequential organ failure assessment score (qSOFA), and National Early Warning Score (NEWS) to triage suspected sepsis patients. Therefore, knowing the predictive performance of each scoring system, using given cut-points for triaging patients with suspected sepsis, could help predict the progression of sepsis.

**Material and Methods:** This study is a single-center retrospective chart review. The study enrolled patients older than 18 years with suspected sepsis patient at the time they presented at the triage zone. The primary outcome was to determine which scoring system were the most accurate to triage sepsis patients. The secondary outcomes were predictions of mortality related to the scoring.

**Results:** Considering the outcome to be represented by a SOFA score of  $\geq 2$ , the area under the curve of the receiver operating characteristic curves for the entire range of mSIRS, qSOFA and NEWS were 0.494, 0.669 and 0.751, respectively. Using a cut point for qSOFA of  $\geq 2$  provided a low sensitivity of 36.2% and high specificity of 93.0%; whereas, using a cut point for NEWS of  $>4$  provided a high sensitivity of 89.0% and low specificity of 33.0%.

**Conclusion:** In summary, qSOFA is the most accurate scoring system for diagnosis sepsis which was consistent with previous study. However, qSOFA had the lowest sensitivity, so is not appropriate in a triage situation. Therefore, we decided to use NEWS as the triage tool because of its better sensitivity and acceptable specificity as we need to triage almost all possible cases.

**Keywords:** Emergency Department, NEWS score, SOFA score, Triage sepsis

Part of this work was poster presented at the 18<sup>th</sup> International Conference on Emergency Medicine [ICEM] 12<sup>th</sup>–15<sup>th</sup>, June, 2019

J Health Sci Med Res .....  
doi: 10.31584/jhsmr.2021858  
www.jhsmr.org

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## Introduction

According to the Third International Consensus Definition for Sepsis and Septic Shock (Sepsis-3), sepsis is defined as a “life-threatening organ dysfunction caused by a dysregulated host response to infection” and organ dysfunction is defined as “an increase in the Sequential (Sepsis-related) Organ Failure Assessment (SOFA) score of 2 points or more.” which is a gold standard nowadays.<sup>1</sup> However, in reality, triaging patients with suspected sepsis is difficult because sepsis is internal organ damage that cannot be seen with the naked eye. We need many laboratory investigations to diagnose sepsis according to Sepsis-3, such as arterial blood gas results, complete blood count, and electrolyte and liver function test results. Therefore, we cannot triage patients with suspected sepsis at the triage zone with the Sepsis-3 definition.

A parsimonious clinical model developed from Sepsis-3 with multivariable logistic regression indicated that any 2 of 3 clinical variables (i.e. Glasgow Coma Scale (GCS) score  $\leq 13$ , systolic blood pressure  $\leq 100$  mm Hg, and respiratory rate  $\geq 22$ /min) offered predictive validity similar to that of the full SOFA score outside the intensive care unit (ICU).<sup>1,2</sup>

But outside the ICU sepsis group, only 58.3% met the quick SOFA (qSOFA) criteria<sup>3</sup> and a recent systematic review and data from a meta-analysis showed that the qSOFA criteria used as a screening tool in the emergency room had poor sensitivity (0.51).<sup>4</sup> However, recent data seemed to indicate that the sensitivity of the national early warning score (NEWS) was superior to the modified early warning score and the qSOFA score. The sensitivity of NEWS  $\geq 5$  is similar to the systemic inflammatory response syndrome criteria of  $\geq 2$  and higher than qSOFA  $\geq 2$ . Furthermore, NEWS had a similar Area Under the Receiver Operating Characteristics (AUROC) to qSOFA.<sup>5</sup>

We found few studies on triage score comparisons that were accurate and easy to apply in patients with

suspected sepsis, especially in the emergency triage zone. Moreover, no such study has been reported in Asia including Thailand. Therefore, we performed a retrospective comparison between the SIRS, NEWS, and qSOFA scores to triage septic patients in the Emergency Department (ED) at Songklanagarind Hospital in southern Thailand.

Sepsis is an important public health problem in many countries. The incidence of sepsis varies in many studies. The incidence of sepsis is 77 per 100,000 in Australia and New Zealand<sup>6</sup> and 240 per 100,000 in the United States of America (USA).<sup>7</sup> The running costs of sepsis were 20 billion US dollars or equal to 5.2% of all running costs of hospitals in the USA in 2013<sup>1</sup> and has also become the 10th leading cause of death in the USA.<sup>8</sup>

Rapid recognition, early resuscitation, early antibiotics, and eradication of the source of infection are the key components in the quality of sepsis care and have been proven significant in decreasing mortality<sup>9-11</sup> but the definition of Sepsis-3 delays the management of sepsis because it is based on laboratory data. Therefore, this study aimed to find tools to help in the early detection of sepsis.

We aimed to apply the modified systemic inflammatory response syndrome (mSIRS), qSOFA, and NEWS scores as guidelines to triage patients with suspected sepsis. Therefore, knowing the predictive performance of each scoring system, using given cut-points for triaging patients with suspected sepsis in our setting, could help predict the progression of sepsis. This would lead to a treatment guideline which is rapid, correct, and appropriate for patient care.

## Material and Methods

This study is a single-center retrospective chart review. The study was conducted in the ED of Songklanagarind Hospital which is an academic, tertiary care hospital on the campus of Prince of Songkla University in southern Thailand. The hospital is also the referral center

in southern Thailand for critically ill and complicated patients. The ED treats approximately 25,000 patients per year. The institutional review board of the Faculty of Medicine, Prince of Songkla University approved this study (EC. 60-416-20-4).

We reviewed the charts of patients who visited the ED from January 2017 to May 2018. The study enrolled patients older than 18 years, with suspected sepsis from vital signs, history taking, physical examination and investigation at the time they presented at the triage zone, or were detected soon after arrival in the ED. We excluded trauma patients, patients without at least two bottles for hemoculture, and patients whose final diagnosis was not bacterial infection. Also excluded were those patients whose vital signs or triage scores were not completely recorded in the chart.

The initial vital signs and clinical presentation data at the triage zone were recorded by a triage nurse. The mSIRS, qSOFA, and NEWS scores were calculated by two researchers. Other data reviewed were the arrival time, time in the emergency room (ER), time to receive antibiotics, time to receive fluid resuscitation, diagnosis, hemoculture results, organ-specific morbidity, and discharge status. The scores were registered in the electronic medical record. The data were cross-checked before encoding into the database by a research assistant.

The charts were reviewed until the patient was discharged from the hospital after the same ED visit. The primary outcome was to determine which scoring system (mSIRS, qSOFA and NEWS) were the most accurate to triage sepsis patients compared with SOFA score, which is currently the gold standard. The secondary outcomes were predictions of mortality related to the scoring.

Initial vital signs were defined as body temperature, pulse rate, respiratory rate, blood pressure, oxygen saturation, and GCS score at the initial presentation in the

triage zone. The mSIRS score cut-point was identified as any 2 of 3 clinical variables [i.e. tachycardia [heart rate >90 beats/min], tachypnea (respiratory rate >20 breaths/min), and fever or hypothermia (temperature >38 °C or <36 °C)]. We excluded white blood cell counts because they were not available in the triage area. The qSOFA score cut-point was identified as any 2 of 3 clinical variables (i.e. GCS score of ≤13, systolic blood pressure of 100 mm Hg or less, and respiratory rate ≥22/min). The NEWS cut-point was identified as a summation of NEWS >4 (5 or more), which was the medium score according to The United Kingdom, Royal College of Physicians 2012. Immunocompromised patients were defined as immunodeficiency from any cause or the use of immunosuppressive drugs or both. Central venous access was defined as permanent catheter insertion at the jugular vein, subclavian vein or femoral vein. End-stage renal disease was defined as patients undergoing dialysis via permanent catheter, arteriovenous fistula or peritoneal dialysis. Diabetes mellitus included insulin-dependent and non-insulin-dependent types. Cancer was defined as a neoplasm of any type. Chemotherapy was defined as last chemotherapy within the previous 6 months. Immunosuppressive drug use was defined as prednisolone >15 mg/day or on oral chemotherapy. Acquired immunodeficiency syndrome was defined as cluster of differentiation 4 (CD4) cell count <200 cells/mm<sup>3</sup>.

All data were entered into Epidata software version 3.1 and the statistical analysis used R software version 3.2.2 and STATA software version 14.1. The continuous variables were analyzed and reported as mean and median while categorical variables were reported as percentage. The numbers were rounded up or down to the nearest 0.5 integer.

Receiver operating characteristics (ROC) curves were constructed for each of the scoring scales, and areas under the curve (AUC) were compared. Cut-point values

of each scoring scale, as reported in the literature, were initially applied to provide a binary test, sensitivity, specificity, likelihood ratio positive and negative estimation. Predictive values for the outcome of a SOFA score of  $>2$  of a positive or negative test result, as applied to the current dataset, were calculated for each scoring system.

Mortality associated with positive and negative test results of each scoring system, with initial and subsequent additional cut-points, was estimated and also reported as likelihood ratios and risk ratios, and for the current dataset as predictive values. A  $p\text{-value} < 0.050$  was considered statistically significant.

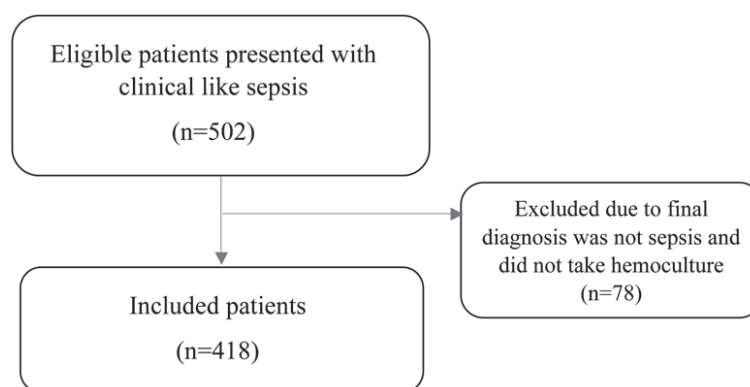
## Results

A total of 502 patients were screened for the study and 38 patients were excluded because the final diagnosis was viral infection (e.g., influenza, dengue fever, and common cold). We also excluded 46 patients who did not have at least two bottles for hemoculture. Finally, 418 patients were enrolled into the study. The flow chart of patient enrollment is shown in Figure 1.

Four hundred and eighteen subjects were enrolled into this study. The median age was 66 years old. Men comprised 54.8% of the 418 patients while 50.7% were immunocompromised hosts. Advanced cancer or previous chemotherapy or both within the previous 6 weeks comprised 23.7% of the immunocompromised hosts. The median mSIRS was 3, median qSOFA was 1, median NEWS was 6, and the median SOFA was 2. The most common organ-specific infection was pulmonary (27.3%) followed by urinary tract (25.8%). The mortality rate was 11.2% (Table 1).

From the 418 patients analyzed, 218 (52.2%) had a SOFA score  $\geq 2$ , and were considered as actually having sepsis.

Considering the outcome to be represented by a SOFA score of  $\geq 2$ , the AUC (95% confidence interval) of the ROC curves for the entire range of mSIRS, qSOFA and NEWS were 0.494 (0.445, 0.543), 0.669 (0.630, 0.709) and 0.751 (0.705, 0.797), respectively. This revealed the mSIRS scales lack of discriminating ability (Figure 2).



**Figure 1** Patient enrollment flow chart

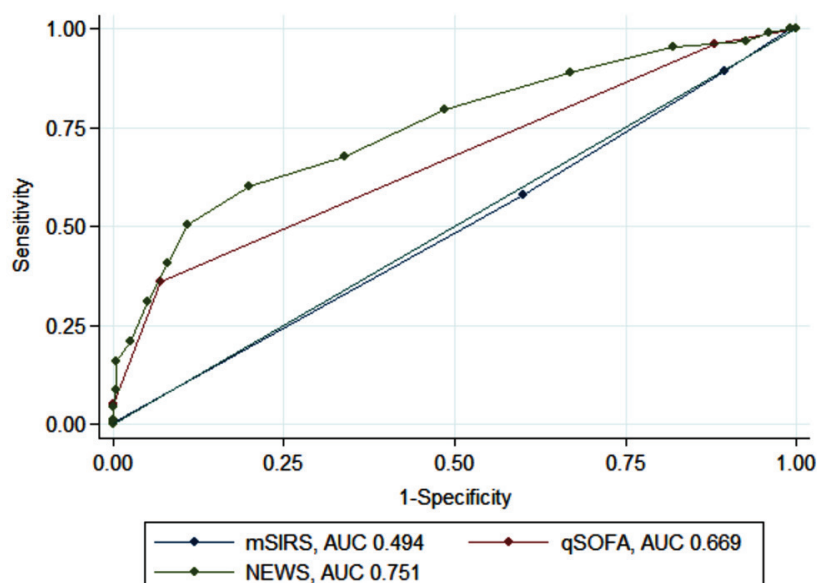
**Table 1** Demographic and baseline characteristics

Characteristics	Entire study (n=418)
Age, year, mean (S.D.)	62.3 (19.3)
Male sex, n (%)	229 (54.8)
Immunocompromised, n (%)	212 (50.7)
Central venous catheter	2 (0.9)
End stage renal disease	23 (10.8)
HCC/cirrhosis child C	7 (3.3)
Diabetes	70 (33.0)
Cancer or last chemotherapy <6 week	99 (46.7)
On immunosuppressive	16 (7.5)
Human immunodeficiency virus	5 (2.4)
Splenectomy	1 (0.5)
Emergency severity index level, n (%)	
1	20 (4.8)
2	255 (61)
3	136 (32.5)
4	7 (1.7)
Triage score, median	
SIRS score	3
mSIRS score	3
qSOFA	1
SOFA	2
NEWS	6

**Table 1** (Continued)

Characteristics	Entire study (n=418)
Source of infection, n (%)	
Primary bacteremia	42 (10.0)
Non identify	28 (6.7)
Lungs	114 (27.3)
Urinary tract	108 (25.8)
Skin	35 (8.4)
Gastrointestinal	78 (18.7)
Central nervous system	3 (0.7)
Other	21 (5.0)
Hemoculture positive, n (%)	82 (19.6)
Results, n (%)	
Discharge by improved	313 (74.9)
Death	47 (11.2)
Refer	58 (13.9)

S.D.=standard deviation, HCC=Hepatocellular carcinoma, mSIRS=modified systemic inflammatory response syndrome, qSOFA=quick sequential organ failure assessment, SOFA=sequential organ failure assessment, NEWS=National Early Warning Score

**Figure 2** ROC curves of basic scores of mSIRS, qSOFA and NEWS for prediction of sepsis, defined as SOFA  $\geq 2$

Using a cut point for qSOFA of  $\geq 2$  provided a low sensitivity of 36.2% and high specificity of 93.0%; whereas, using a cut point for NEWS of  $>4$  provided a high sensitivity of 89.0% and low specificity of 33.0%. Values of likelihood ratio both positive and negative, were 5.18 and 0.69 for qSOFA and 1.33 and 0.33 for NEWS, respectively (Table 2).

In addition, we also estimated the predictive performance of mSIRS  $\geq 2$ , qSOFA  $\geq 2$ , NEWS  $>4$ , as well as SOFA  $\geq 2$  with mortality. A SOFA  $\geq 2$  had the highest risk ratio (RR) of 6.27 (2.72, 14.49;  $p$ -value $<0.001$ ), followed by NEWS  $>4$ , with an RR of 4.02 (1.27, 12.66;  $p$ -value=

0.007); and qSOFA  $\geq 2$  with RR of 3.97 (2.35, 6.71;  $p$ -value $<0.001$ ). Meanwhile, mSIRS had the lowest RR of 1.26 (0.48, 3.36), which was not statistically significant (Table 3).

With the additional cut points for NEWS at  $>7$  and  $>8$ , the percentages of mortality in the three levels using the additional cut-point of  $>7$  were 3.3%, 4.5% and 21.6%, with, respectively, relative risks of 1, 1.34 and 6.49; and likelihood ratios of 0.03, 0.04 and 2.18 (Table 4). Using the additional cut-point of  $>8$ , the percentages of mortality were 3.3%, 4.6% and 26.5%, relative risks were 1, 1.38 and 7.95, and likelihood ratios were 0.27, 0.38 and 2.85, respectively (Table 5).

**Table 2** Scores of mSIRS, qSOFA and NEWS to predict sepsis defined by SOFA score  $\geq 2$

Scale	Level	SOFA		LR	Sepsis proportion	Sensitivity	Specificity
		$\geq 2$	$<2$				
mSIRS	$\geq 2$	195	179	1.00	0.52	0.89	0.11
	$<2$	23	21	1.00	0.48		
qSOFA	$\geq 2$	79	14	5.18	0.85	0.36	0.93
	$<2$	139	186	0.69	0.43		
NEWS	$>4$	194	134	1.33	0.59	0.89	0.33
	$\leq 4$	24	66	0.33	0.27		

LR=Likelihood ratio, mSIRS=modified systemic inflammatory response syndrome, qSOFA=quick sequential organ failure assessment, NEWS=National Early Warning Score

**Table 3** Scores of mSIRS, qSOFA, NEWS and SOFA, each with one cut-point to predict mortality

Scale	Level	Dead	Survive	LR	Mortality proportion	RR	95% CI	p-value
mSIRS	$\geq 2$	43	331	1.02	0.25	1.26	0.48, 3.36	0.630
	$<2$	4	40	0.79	0.09			
qSOFA	$\geq 2$	25	68	2.90	0.27	3.97	2.35, 6.71	$<0.001$
	$<2$	22	303	0.57	0.07			
NEWS	$>4$	44	284	1.22	0.13	4.02	1.27, 12.66	0.007
	$<4$	3	87	0.27	0.03			
SOFA	$\geq 2$	41	177	34.08	0.19	6.27	2.72, 14.49	$<0.001$
	$<2$	6	194	0.24	0.03			

LR=Likelihood ratio, RR=risk ratio, CI=confidence interval, mSIRS=modified systemic inflammatory response syndrome, qSOFA=quick sequential organ failure assessment, NEWS=National Early Warning Score, SOFA=sequential organ failure assessment

**Table 4** NEWS with two cut-points (>4 and >7) to predict mortality

Scale	Level	Dead	Survive	LR	Mortality proportion	RR	95% CI	p-value
NEWS	>7	37	134	2.18	0.22	6.49	2.06, 20.47	<0.001
	>4, ≤7	7	150	0.37	0.04	1.34	0.35, 5.04	
	≤4	3	87	0.27	0.03	1.00		

LR=Likelihood ratio, RR=risk ratio, CI=confidence interval, NEWS=National Early Warning Score

**Table 5** NEWS with two cut-points (>4 and >8) to predict mortality

Scale	Level	Dead	Survive	LR	Mortality proportion	RR	95% CI	p-value
NEWS	>8	35	97	2.85	0.26	7.95	2.52, 25.08	<0.001
	>4, ≤8	9	187	0.38	0.05	1.38	0.38, 4.97	
	≤4	3	87	0.27	0.03	1.00		

LR=Likelihood ratio, RR=risk ratio, CI=confidence interval, NEWS=National Early Warning Score

## Discussion

This present study showed that the AUROC of the original scores of both NEWS (0.751) and qSOFA (0.669) were quite high, while that of mSIRS (0.494) showed that mSIRS totally lacked any discriminating ability for sepsis. qSOFA  $\geq 2$  had high AUROC to predict a septic patient with Sepsis-3 criteria, which is consistent with previous studies.<sup>2,12</sup> and also had the highest likelihood ratio+ (LR+) which meant that a patient with qSOFA  $\geq 2$  had a high probability for a diagnosis of sepsis. Even though qSOFA  $\geq 2$  had the highest LR+ and high AUROC, it also had the lowest sensitivity which implied that two-thirds of septic patients outside the intensive care unit could be missed, which is consistent with previous studies.<sup>13-15</sup>

mSIRS seemed to be useless for sepsis triage. It predicted mortality because its overestimated sepsis and the specificity was very low. Furthermore, the likelihood ratio showed no statistical change which was consistent with previous studies.<sup>14,15</sup>

NEWS cut at >4 had high sensitivity (0.89), but low specificity (0.33) and a LR+ of 1.33, while mSIRS cut at  $\geq 2$  had a higher specificity than mSIRS; however, it was still low. Nevertheless, in triage septic patients we need to triage almost every possible case. Therefore, we decided to use NEWS as the triage tool because it had a sensitivity as high as mSIRS although it had low specificity which was better than qSOFA with a low sensitivity. However, a high specificity is not appropriate in a triage situation.

The NEWS cut-point also indicated whether the patient should stay in the emergency zone or urgency zone as predicted by mortality. In predicting mortality, we found that SOFA  $\geq 2$  had the highest RR (6.27) followed by NEWS >4 (4.02) and qSOFA  $\geq 2$  (3.97) (Table 3). This indicated that SOFA  $\geq 2$  was the best score to predict mortality but the SOFA score cannot be evaluated by the naked eye during transfer to the ER since the SOFA score is determined from internal organ damage.



Also, NEWS could predict mortality; however, due to the high sensitivity, NEWS  $>4$  may give many false positive results. Transferring all suspected septic patients with a NEWS  $>4$  into the emergency zone may cause problems related to limited resources (e.g., equipment for monitoring, medical personnel per patient while monitoring, and close monitoring in patients with a final diagnosis of SOFA  $<2$  after investigations).

We also explored different cut-points of NEWS for predicting mortality (Tables 4 and 5). We used the NEWS cut-points  $>7$  or  $>8$  which were the optimum cut-points. We found that NEWS  $>8$  had the highest LR of 2.848 followed by NEWS  $>7$  which had a LR of 2.180 which was the same as Corfield et al.<sup>16</sup> Therefore, we suggest that patients with NEWS between 5 and 8 be transferred from the triage zone to the urgency zone and patients with NEWS  $>8$  be transferred to the emergency zone immediately.

On the other hand, we preferred to use NEWS  $\leq 4$  as the cut-point, indicating that the patient would probably have less diagnosis of sepsis, would have low mortality, and could wait in the triage zone.

Our study has some limitations. It was retrospective in nature and conducted in a single center, an academic tertiary medical center. This could possibly restrict the generalizability of our results, due to limitations of health care in smaller hospitals. In addition, patients with multiple co-morbidities in our center, especially patients with advanced cancer or post-chemotherapy or both, comprised more than one-quarter of the patients in this study. These limitations may be solved by conducting a multi-center prospective trial in the future.

## Conclusion

In summary, qSOFA is the most accurate scoring system for diagnosis sepsis which was consistent with previous study. However, qSOFA had the lowest sensitivity, so is not appropriate in a triage situation. Therefore, we

decided to use NEWS as the triage tool because of its better sensitivity and acceptable specificity, as we need to triage almost all possible cases.

## Acknowledgement

The authors thank Panita Worapratya for initiates' research, Kingkarn Waiyanak for article searches and retrieval and Glenn K. Shingledecker for his help in editing the manuscript. We also thank Alan Frederick Geater, Nannapat Pruphetkaew, and Walailuk Jitpi boon for the statistical assistance in the Epidemiology Unit, Faculty of Medicine, Prince of Songkla University.

## Conflict of interest

The authors declares that he has no conflict of interest in this study.

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