Comparison of NEWS, SIRS, and qSOFA Score as Predictors of Mortality and Length of Stay in Patients Pneumonia with Sepsis

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Abstract

Background: Pneumonia is a major health problem in all age groups and often related with sepsis. In 2021, Surviving Sepsis Campaign Guidelines mentioned several clinical scoring systems to identify patients with potentials of developing sepsis, such as systemic inflammatory response syndrome (SIRS), national early warning score (NEWS), quick sequential organ failure assessment (qSOFA) and sequential organ failure assessment (SOFA). The guideline stated that there is no gold standard for diagnosing sepsis, contradicting The Sepsis-3 Guideline in 2016 that mentioned SOFA score as a gold standard for diagnosing sepsis.

Methods: Subjects were all patients with pneumonia and sepsis who were treated in Dr.Moewardi Hospital within 1 January to 31 December 2022. Data from subjects' medical records were collected to assess their NEWS, SIRS, qSOFA, and SOFA score on the day of admission. Since evaluation of SOFA score needs a number of components requiring laboratory results and takes longer time so they made a simpler tool called qSOFA to avoid delayed treatment of the patients.

Results: NEWS is more consistent with SOFA compared to SIRS and qSOFA (Kappa value = 0.726 vs 0.320 vs 0.22; respectively). NEWS, SIRS, and qSOFA were all significantly correlated with mortality ($P<0.001$) with NEWS having the strongest correlation (r=0.482 vs 0.216 vs 0.175; respectively). Only NEWS showed significant correlation with the length of stay (r=0.129; $P<0.001$).

Conclusion: NEWS was the most consistent score to SOFA compared to SIRS and qSOFA. NEWS was also the best predictor for mortality and was the only score correlated with length of hospital stay.

Keywords: length of stay, mortality, NEWS, pneumonia, qSOFA, sepsis, SIRS, SOFA

INTRODUCTION

Pneumonia is a major health problem with high morbidity and mortality in all age groups globally.[1] Pneumonia is classified into community acquired pneumonia or hospital acquired pneumonia.[1] Pathogens that cause pneumonia include bacteria, viruses, and fungi.[2] Sepsis is a life-threatening organ dysfunction as a consequence of dysregulated response to infection.[3] Sepsis is also a global health problem with high mortality and morbidity.[4]

In United States (US), before 2000, mortality was as high as 50% in patients with sepsis and septic shock.[5] Increasing prevalence of sepsis highlights the importance of early identification to enable prompt management and prevention of further deterioration.[3] Pneumonia, according to data from Global Burden of Disease (GBD) in 2013, occupies in between main reason in sepsis causing >2.5 million mortality globally.[4]

Sepsis is more precisely a syndrome rather than a disease.[3] The Sepsis-1 guideline in 1991 defined sepsis as clinical infection accompanied with systemic inflammatory response.[6] Sepsis-3 explained that not all patients with Systemic Inflammatory Response Syndrome (SIRS) is sepsis.[7] In 2021, the guideline Surviving Sepsis Campaign recommended some scores to help identifying septic conditions and determining patients with potentials to fall into worsening codition.[3] Systemic inflammatory response syndrome represents condition in general manner yet very sensitive and not very specific.[8]

Clinical scoring system is a tool to recognize early signs of clinical deterioration to alarm medical team and facilitate timely management.[9] Clinical scoring system can be used to identify sepsis, assess patient's degree of disease severity and determine

prognosis.[9] A number of clinical scoring systems require laboratory result and take a lot of time.[10] Currently available tools to assess sepsis include SIRS, Quick Sequential Organ Failure Assessment (qSOFA), Sequential Organ Failure Assessment (SOFA), New Early Warning Signs (NEWS) and Modified Early Warning Score (MEWS).[3,11]

Sepsis-3 re-defined sepsis as a life-threatening organ dysfunction caused by dysregulated response of hosts against infection.[3] Sepsis-associated organ failure was assessed through patient's history, physical examination, and SOFA score ≥2.[3] SOFA score is recommended based on physical examination and laboratory results since it represent organ failure in patients with infection.[3]

Since SOFA score evaluation requires several laboratory results and takes long time, experts developed a simpler tool called qSOFA to avoid delayed treatment of the patients. Based on recommendation of SSC in 2021 without changing the previous definition of sepsis, the guideline recommended using fast and simple clinical scoring systems for better care.[3] Surveillance Sepsis Campaign 2021 does not recommend using qSOFA for single screening tool for diagnosing sepsis and septic shock.[3]

Srzić et al in 2022 explains that in accordance with definition of sepsis-3, sepsis diagnosis approach may use SOFA score for patient with organ failure associated with infection, however because SOFA score need longer time, SSC 2021 recommends to use simpler and faster screening tool.[12] Surveillance Sepsis Campaign 2021 is yet to determine the recommended screening tool for identifying patient with sepsis.[3] Surveillance Sepsis Campaign 2021 explain that currently there is no gold standard for diagnosing sepsis.[3]

This study conducted to investigate NEWS, SIRS, and qSOFA score's consistency to SOFA score for diagnosing sepsis and comparing them as predictor of mortality and length of hospital stay in pneumonia patients with sepsis. The study result is expected to help determining the best clinical scoring system for use in medical care.

METHODS

The study was retrospective through collecting medical record of patient with pneumonia and sepsis from 1st of January 2022 through 31st of December 2022 at Dr. Moewardi Surakarta Hospital. Study population was patient with pneumonia and sepsis during from 1st of January 2022 through 31st of December 2022. Consecutive sampling was used to determine study sample.

The inclusion criteria of the study were patient aged >18 years, patient diagnosed with pneumonia and sepsis based on history and physical examination, laboratory result, chest X-ray, and SOFA score ≥2 which was diagnosed by a doctor. Exclusion criteria was incomplete data in medical record.

Assessment of NEWS, SIRS, and qSOFA scores was based on physical examination and laboratory results from medical record at the time patient diagnosed with pneumonia and sepsis. The three scores were rated for their consistency to SOFA scores and as predictors of mortality and length of stay in pneumonia patients with sepsis. Ethical clearance was issued by the ethics committee of Faculty of Medicine of Sebelas Maret University on March 10th, 2023 (112/UN.27.06.7.5/PP/2023). Statistical Product and Service Solution (SPSS) 21 for Windows was used to analyse data. This study aimed to analyse suitability of NEWS, SIRS, and qSOFA to SOFA score for diagnosing sepsis and their comparison as predictors of mortality and length of stay in pneumonia patients with sepsis.

RESULT

This study involved secondary data from medical record of 762 patients who was treated from January 1st through December 31st 2022 by at dr. Moewardi hospital in Surakarta. As much as 615 pneumonia patients with sepsis met the inclusion criteria and were recruited with total sampling method. The result indicates the mean age of pneumonia patients with sepsis was 57.51 years with standard deviation of 11.41 years. There were 312 male patients (50.6%) and 304 female patients (49.4%).There were 252 patients (40.9%) treated in

HCU, 200 patients (32.5%) were in ICU, and 164 patients were in non- intensive care (26.6%).

Table 1. Participant Characteristics

Variable	Mean	%
Age	57.51	11.41%
Sex		
Male	312	50.6%
Female	304	49.4%
Care unit		
Non- intensive	164	26.6%
HCU	252	40.9%
ICU	200	32.5%
Comorbidity		
DM	138	22.4%
Stroke	77	12.5%
Heart disease	88	14.3%
Malignancy	192	31.2%
Pneumonia		
CAP	477	77.4%
HAP	126	20.5%
VAP	8	1.3%
Confirmed Covid		
Yes	28	4.5%
No	588	95.5%
Sepsis/ septic shock		
Septic Shock	171	27.8%
Sepsis	445	72.2%
Length of Treatment		
>7 days	303	49.2%
≤7 days	313	50.8%
Outcome		
Survive	251	40.7%
Deceased	365	59.3%

There were 138 participants affected by diabetes mellitus (22.4%), 77 patients with stroke (12.5%), 88 patients with chronic kidney disease (14.3%), and 192 patients with malignancy (31.2%). A total of 477 patients were diagnosed with community acquired pneumonia (CAP) (77.4%), 126 patients with hospital-acquired pneumonia (HAP) (20.5%), 8 patients with Ventilator-acquired pneumonia (VAP) (1.3%), and 28 patients (4.5%) were Covid-confirmed. 171 patients (27.8%) had septic shock and 445 patients had sepsis conditions (72.2%). As much as 313 patients had length of stay <7 days (50.8%) and 303 patients had length of stay >7 days (49.2%). 365 patients (59.3%) survived and 251 patients (40.7%) were deceased. Overview of participant characteristics is described in Table 1.

Table 2. Analysis of suitability between NEWS, SIRS, and qSOFA with SOFA score

Variables	SOFA				Kappa	P
	Score >2		Score =2			
NEWS						
≥5	244	89.4%	55	16.0%	0.726	<0.001
<5	29	10.6%	288	84.0%		
SIRS						
≥2	154	56.4%	85	24.8%	0.320	<0.001
<2	119	43.6%	258	75.2%		
qSOFA						
≥2	168	61.5%	134	39.1%	0.222	<0.001
<2	105	38.5%	209	60.9%		

Kappa Coefficient test was used to analyze suitability of NEWS, SIRS, and qSOFA scores with SOFA score. Analysis of suitability between NEWS score and SOFA score obtained *Kappa* = 0.726 with value of *P*<0.001 indicating that there was a suitability between NEWS and SOFA score with high level of suitability. Analysis of suitability between SIRS and SOFA score obtained *Kappa* = 0.320 with of value *P*<0.001 implying that there was suitability between SIRS and SOFA score with low level of suitability. Analysis of suitability between qSOFA and SOFA score obtained *Kappa* = 0.222 with value of *P*<0.001 suggesting that there was suitability between qSOFA and SOFA score with low level of suitability category. Analysis of suitability between NEWS, SIRS, qSOFA and SOFA score is outlined in Table 2.

Table 3. Analysis of NEWS, SIRS, and qSOFA scores with mortality

Variables	Outcomes				r	P
	Survivor (n=251)		Non survivor (n=365)			
NEWS						
≥5	205	81.7%	94	25.8%	0.482	<0.001
<5	46	18.3%	271	74.2%		
SIRS						
≥2	130	51.8%	109	29.9%	0.216	<0.001
<2	121	48.2%	256	70.1%		
qSOFA						
≥2	150	59.8%	152	41.6%	0.175	<0.001
<2	101	40.2%	213	58.4%		

Coefficient Contingency test was used to analyse correlation between NEWS, SIRS, and qSOFA scores with length of stay and mortality in pneumonia patients with sepsis because the data was nominal. Analysis result showed significant relationship between NEWS, SIRS, and qSOFA score and mortality with value of *P*<0.05, in which NEWS score had r value of 0.482 with *P*≤0.001 which

classified as moderate (r=0.400 – 0.599), SIRS score had r value of 0.216 with $P \leq 0.001$ which classified as weak (r=0.000-0.199), and qSOFA had r value of 0.175 with $P \leq 0.001$ which classified as very weak (r=0.000-0.199). Analysis of patient with positive score inclined with *outcome* "died" on NEWS, SIRS, and qSOFA score (Table 3).

Analysis of NEWS, SIRS, and qSOFA scores indicates that NEWS had significant association with length of stay with r=0.129 and *P*=0.001 and within category of weak (r=0.000-0.199), in which patient with NEWS scores ≥5 was more likely to stay <7 days, leading to more patient deceased at length of stay <7 days; SIRS score had r=0.017 and *P*=0.672 while qSOFA had r=0.029 and *P*=0.479 which suggest no

significant correlation with length of stay. Analysis of association between NEWS, SIRS, and qSOFA scores and length of stay and mortality in pneumonia patients with sepsis is described in Table 4.

Table 4. Analysis of NEWS, SIRS, and qSOFA scores with length of stay

Variables	Length of Treatment				r	P
	>7 days (n=303)		≤ 7 days (n=313)			
NEWS						
≥5	127	41.9%	172	55.0%	0.129	0.001
<5	176	58.1%	141	45.0%		
SIRS						
≥2	115	38.0%	124	39.6%	0.017	0.672
<2	188	62.0%	189	60.4%		
qSOFA						
≥2	153	50.5%	149	47.6%	0.029	0.473
<2	150	49.5%	164	52.4%		

Table 5. Analysis of correlation between characteristics, length of stay and mortality in sepsis patient

Variables	Length of Treatment				r	P	Outcomes				r	P
	>7 days (n=303)		≤ 7 days (n=313)				Died (n=251)		Discharged (n=365)			
Age (Mean±SD)	57.49±11.80		57.53±11.04		0.002	0.961	57.25±10.90		57.68±11.76		0.019	0.643
Gender												
Man	155	51.3%	156	49.8%	0.016	0.683	128	51.0%	183	50.3%	0.006	0887
Woman	147	48.7%	157	50.2%			123	49.0%	181	49.7%		
Care unit												
Non- intensive	84	27.7%	80	25.6%			52	20.7%	112	30.7%		
HCU	133	43.9%	119	38.0%	0.086	0.099	103	41.0%	149	40.8%	0.126	0.007*
ICU	86	28.4%	114	36.4%			96	38.2%	104	28.5%		
DM												
Yes	63	20.8%	75	24.0%	0.038	0.346	61	24.3%	77	21.1%	0.038	0.348
No	240	79.2%	238	76.0%			190	75.7%	288	78.9%		
Stroke												
Yes	30	9.9%	47	15.0%	0.077	0.055	38	15.1%	39	10.7%	0.066	0.100
No	273	90.1%	266	85.0%			213	84.9%	326	89.3%		
Coronary disease												
Yes	35	11.6%	53	16.9%	0.077	0.056	35	13.9%	53	14.5%	0.066	0.100
Nope	268	88.4%	260	83.1%			216	86.1%	312	85.5%		
Violence												
Yes	100	33.0%	92	29.4%	0.039	0.333	72	28.7%	120	32.9%	0.044	0.270
No	203	67.0%	221	70.6%			179	71.3%	245	67.1%		
CAP												
Yes	230	75.9%	247	78.9%	0.036	0.372	193	76.9%	284	77.8%	0.011	0.789
No	73	24.1%	66	21.1%			58	23.1%	81	22.2%		
HAP												
Ya	66	21.8%	60	19.2%	0.032	0.422	53	21.1%	73	20.0%	0.014	0.736
Tidak	237	78.2%	253	80.8%			198	78.9%	292	80.0%		
VAP												
Ya	4	1.3%	4	1.3%	0.002	1.000	3	1.2%	5	1.4%	0.008	0.851
No	299	98.7%	309	98.7%			248	98.8%	360	98.6%		
Confirmed Covid												
Yes	17	5.6%	11	3.5%	0.050	0.212	6	2.4%	22	6.0%	0.085	0.033*
No	286	94.4%	302	96.5%			245	97.6%	343	94.0%		
Shock/septic shock												
Septic Shock	65	21.5%	106	33.9%	0.137	0.001*	78	31.1%	93	25.5%	0.061	0.128
Sepsis	38	78.5%	207	66.1%			173	68.9%	272	74.5%		

Note: *Significant (*P*<0.05)

The analysis of correlation between characteristics of sepsis patients and length of stay and *outcome* in this study used *Eta* test for numeric data while for *Coefficient Contingency* test was used for nominal data. Analysis of characteristics suggest that variable which had significant relationship with length of stay was sepsis and septic shock, with r=0.137 and *P*=0.001 and weak level of association (r=0.000-0.199), which directly caused mortality and cut the length of stay. Variable of age had r=0.002 and *P*=0.961, gender had r=0.016 and *P*=0.683, care unit had r=0.086 and *P*=0.099, DM had r=0.038 and *P*=0.346, stroke had r=0.077 and *P*=0.055, coronary heart disease had r=0.077 and *P*=0.056, malignancy had r=0.039 and *P*=0.333, CAP had r=0.036 and *P*=0.372, HAP had r=0.032 and *P*=0.422, VAP had r=0.002 and *P*=1000, and confirmed covid had r=0.050 and *P*=0.212, all of which had no significant relationship with length of treatment in sepsis patients.

Analysis of characteristics indicate that variable which had significant correlation with mortality was type of care unit with r=0.126 and *P*=0.007 and confirmed covid with r=0.085 and value *P*=0.033, in which patient in HCU or ICU was more likely to die compared to those in non-intensive room care. Other variables including age had r=0.019 and *P*=0.643, gender had r=0.006 and *P*=0.887, DM had r=0.038 and *P*=0.348, stroke had r=0.066 and *P*=0.100, heart coronary disease had r=0.066 and *P*=0.100, malignancy had r=0.044 and *P*=0.270, community acquired pneumonia had r=0.011 and *P*=0.789, hospital acquired pneumonia had r=0.014 and *P*=0.736, ventilator acquired pneumonia had r=0.008 and *P*=0.851, and sepsis/ septic shock had r=0.061 and *P*=0.128, all of which had no significant relationship with mortality in pneumonia patients with sepsis. Analysis of association between characteristics, length of stay and mortality in pneumonia patients with sepsis is described in Table 5.

Multivariate analysis of characteristics, NEWS, SIRS, and qSOFA with length of stay and mortality in pneumonia patients with sepsis used logistic regression test. Multivariate analysis of NEWS, SIRS, and qSOFA scores as predictor of length of stay revealed OR=0.58 for NEWS with p-values=0.001 indicating that it may serve as predictor of length of stay with OR value<1 and imply that NEWS score ≥5 was associated with length of stay <7 days since mortality occurred within those 7 days.

Table 6.　Multivariate analysis

Variables	OR	95% CI	*P*
Length of Treatment			
NEWS	0.58	0.42-0.80	0.001*
SIRS	-	-	n/s
qSOFA	-	-	n/s
Outcome			
NEWS	12.73	8.24-19.86	<0.001
SIRS	1.30	0.86-1.19	0.219
qSOFA	0.88	0.57-1.36	0.566

Multivariate analysis of NEWS, SIRS, and qSOFA scores as predictor of mortality revealed OR=12.73 for NEWS with p=<0.001 as predictor of mortality in pneumonia patients with sepsis (OR>1) and suggest that NEWS score ≥5 was associated with greater risk for mortality. Multivariate analysis result is detailed in Table 6.

DISCUSSION

Pneumonia patients with sepsis in this study are mostly males, similar to a study by Nosheen et al in Pakistan.[13] Organ dysfunction is caused by inflammation reaction associated with infection and systemic cytokine release. A study by Nosheen et al described that pro-inflammatory reaction mediated by TNF-α, IL-1 and IL-6. TNF-α expression during the inflammatory process higher in men compared to women.[13] Increased IL-6 expression is associated with higher risk of inflammation.[13]

Mean age of participants was 57.51 years. Study by Martin-Loeches et al in 2019 expressed that patient with age more than 65 years had higher risk for sepsis in infectious conditions[14]. Patient older than 65 years had lower immune function, especially B cells and T cells.[14] Study by Wardi et al reported that age was mortality independent predictor in patient with sepsis.[15]

The participants had comorbidities including malignancy, diabetes mellitus, stroke, and others.

Study by Sinapidis et al stated that comorbidity increased septic condition.[16] The study described that types of infection are varied in rate leading to sepsis and the amount of disease increased risk of sepsis and death varies depending on the underlying infection. Patient with type 2 diabetes mellitus had higher risk of sepsis, presumably associated with immunosuppression. Individual with several comorbidities such as type 2 diabetes mellitus and chronic kidney disease were at risk of sepsis in nearly all type of infection. Chronic heart disease and malignancy cause risk of sepsis in pneumonia.[16]

Most pneumonia cases are community acquired. Study by Guimarães et al in 2017 reported that hospital acquired pneumonia was associated with worse condition, higher mortality and longer length of stay than CAP.[17] Study by Kim et al in 2022 described that HAP incidents were associated with various factors including sociodemographic, clinical, and environmental. The incidence was limited only in hospital, therefore there were more cases of CAP than HAP in this study.[18]

Correlation of NEWS, SIRS, and qSOFA scores with length of stay and mortality in pneumonia patients with sepsis was tested with Coefficient Contingency. The results suggest that NEWS, SIRS, and qSOFA score had significant relationship with mortality, in which the NEWS score had r=0.482 and $P \leq 0.001$ and strongest correlation than SIRS and qSOFA with moderate category (r=0.400–0.599), while SIRS had r=0.216 and $P \leq 0.001$ with weak category (r=0.000-0.199), and qSOFA had r=0.175 and $P \leq 0.001$ with very weak category (r=0.000-0.199). Analysis with results positive score inclined with outcome died on the NEWS, SIRS, and qSOFA scores in any different level.

The analysis suggest that NEWS score had significant correlation with mortality which imply that NEWS score may serve as mortality predictor in pneumonia patients with sepsis. The result supported a study by Zhou et al in Beijing which stated that NEWS can be used as predictors in CAP patients with sepsis in the emergency department.[19] Quick sequential organ failure assessment (qSOFA) ≥2 and NEWS ≥7 scores are highly correlated with mortality

in 28 days, risk for ICU care, and risk for mechanical ventilation in community acquired pneumonia patients with sepsis at emergency department.[19]

Thodphetch et al reported that higher NEWS score was related with increased risk of mortality.[20] Higher NEWS score in pneumonia patients are at three times or more higher risk of developing severe sepsis or increasing septic shock mortality risk.[20] It is hypothesized that NEWS is comparable to qSOFA and SIRS as a tool for sepsis screening, however further found that NEWS is the most accurate screening tool for sepsis.[20] NEWS score is used in triage because no immediate availability of data such as laboratory results, need for oxygen therapy, and urine output record as found in the SOFA and SIRS scores. Some variables are eliminated to simplify the scores.[20]

Study by Zhou et al reported that based on cut-off score qSOFA ≥2 and NEWS ≥7 were highly related with bad outcomes.[19] As comparison, another study by Abbott et al reported that NEWS score of 5 or more was associated with mortality in two days after admission.[21] Khwannimit et al in 2019 explored the differences of clinical score comprising components from all scores, including CURB-65, PSI, SOFA, and MEDS that also incorporate element laboratory, which makes it difficult to get complete data in short time in emergency department.[22]

Analysis of NEWS, SIRS, and qSOFA scores suggest that only NEWS had significant association with length of stay with r=0.129 and P=0.001 and weak category (r=0.000-0.199). NEWS scores ≥5 is associated with length of stay <7 days since mortality occurred within those 7 days. SIRS score had r=0.017 with P=0.672 and qSOFA had r=0.029 and P=0.479 which indicate no significant relationship with length of stay.

Study by Thodphetch et al in 2021 reported that NEWS is a good score to be used in both emergency and non-emergency setting. Analysis regarding use of NEWS score in the emergency department shows that higher NEWS score is associated with worse patient condition, longer of hospital stay, and higher mortality rate.[20]

The study by Zhou et al in 2020 suggested that higher NEWS score was associated with longer stay and higher mortality rate compared to with lower NEWS score.[19] Contradicting author's study result, in which higher NEWS score was associated with length of stay <7 days, since this study included whole sample with outcome of both decease or survive and a number of participants deceased at <7 days.

LIMITATION

One of the major limitations of this study was the lack of complete medical record data which may affect the accuracy and reliability of the findings.

CONCLUSION

The highest suitability to SOFA score is NEWS score as predictor of mortality and length of stay in pneumonia patients with sepsis, whereas SIRS and qSOFA score has no suitability with length of stay. In health care facilities with limited resources, NEWS score can be used as predictor of mortality and length of stay.

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