

## The SOFA Score and EWS: Is It Time for an Update?

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### ABSTRACT

**Background:** Intensive care unit (ICU) functions as a structured environment dedicated to providing intensive medical attention to patients in critical condition, monitoring, and organ support to treat life-threatening organ failure. Sepsis occurs when the immune system reacts severely to infection, leading to damage to the body's tissues and organs. Data from The Global Burden of Disease Sepsis Report estimates 48.9 million sepsis cases annually, with 11 million cases leading to death. Therefore, the early warning score (EWS) and sequential organ failure assessment (SOFA) score systems have the potential to estimate the follow-up of patients treated in the ICU. Evaluation of prognosis based on SOFA and EWS scores is not yet confirmed for the medical state of individuals with sepsis.

**Objective:** To determine the correlation of SOFA score and EWS by the duration of ICU stays for sepsis patients at Rumah Sakit Umum Imelda Pekerja Indonesia Medan.

**Methods:** This study used an analytical observational approach employing cross-sectional design. The method of gathering data relies on medical records and samples are collected through total sampling.

**Result:** On 64 patients diagnosed with sepsis and treated in the ICU of Rumah Sakit Umum Imelda Pekerja Indonesia Medan are obtained employing the Spearman correlation test revealed a significant correlation between EWS length of time sepsis patients spend in the ICU ( $p=0.001$ ). However, a lack of notable correlation was found between the SOFA score and length of time sepsis patients spend in the ICU ( $p=0.719$ ).

**Conclusion:** No correlation exists between the SOFA score and the duration of stay among sepsis patients, whereas a correlation exists between EWS and duration of stay among sepsis patients.

**Keywords:** EWS; ICU; length of stay; sepsis; SOFA

## INTRODUCTION

The intensive care unit (ICU) is a structured system that provides care for critical patients with specialized medical and intensive care, improves monitoring capabilities, and uses various means of supporting physiological organ functions to support life in the presence of critical organ system insufficiencies. Intensive services employ various technologies to assist malfunctioning organs, especially the kidneys, cardiovascular system, and lungs. The main focus of intensive care is to avert additional physiological damage as the primary illness is addressed and cured.<sup>1</sup>

Sepsis is a critical condition caused by damage to the body's own tissues due to the body's resistance reaction to excessive infection. Sepsis is often the cause of death for many infectious diseases around the world. Sepsis is still a one among diseases that often occur and are rarely recognized in developed or developing countries. Shock, organ paralysis, and death can be caused by sepsis if not treated promptly.<sup>2</sup>

In January 2020, The Global Burden of Disease Sepsis Report approximated that 48.9 million individuals experience sepsis annually, with 11 million of them dying. One in five deaths globally is associated with sepsis. Sepsis occurrence and fatality rates show significant variation among regions, with the highest incidence observed in Southeast Asia, sub-Saharan Africa, Oceania, South Asia, and East Asia.<sup>3</sup>

While in Indonesia according to findings reported by Kahar et al, the mortality rate of sepsis patients in the ICU at Dr. M. Djamil Padang Regional General Hospital in 2022, there was an increase in sepsis patient mortality from 11,53% to 19.64% in the last six months.<sup>4</sup> Furthermore, ICU admissions for sepsis showed a high case fatality rate (69%) and a high hospitalization cost per admission.<sup>5</sup> Aside from this, Mayr et al found that discovered that the most influential predictor of death was organ failure, considering both the number of organ failures and the extent of organ dysfunction.<sup>6</sup>

A doctor must consistently select the most precise treatment strategy for a patient, taking into account the severity and prognosis of the individual's illness. Therefore, having the correct criteria to prioritize patients is essential enabling the delivery of specialized care to critically ill patients and help reduce the burden of disease and treatment costs.<sup>7</sup> Therefore, scoring systems such as sequential organ failure assessment (SOFA) and early warning score (EWS) can be used to estimate follow-up a patient in the ICU.<sup>8</sup> SOFA is commonly utilized in emergencies, surgical procedures, cases of internal medicine, and ICUs to assess disease conditions as well as the estimated prognosis of patients experiencing multiple organ failure, providing a dynamic reflection of changes in organ function. The SOFA score evaluates the performance of six organ systems – respiratory, hepatic, renal, coagulation, cardiovascular and brain – assigning a score ranging from 0 (indicating normal function) to 4 (signifying extremely abnormal), as seen on Table.<sup>9</sup>

**Table 1. SOFA score**

Parameters	Score: 0	Score: 1	Score: 2	Score: 3	Score: 4
PaO <sub>2</sub> /FIO <sub>2</sub> , mmHg (kPa)	≥400 (53.3)	<400 (53.3)	<300 (40)	<200 (26.7) with the help of respiration	<100 (13.3) with the help of respiration
Coagulation, Platelets, × 10 <sup>3</sup> /mm <sup>3</sup>	≥150	<150	<100	<50	<20
Hepar, Bilirubin, mg/dL	<1.2	<1.2-1.9	2.0-5.9	6.0-11.9	>12.0
Cardiovascular	MAP ≥ 70 mmHg	MAP < 70 mmHg	DOP<5 or Dobutamine (any dose)	DOP 5.1 – 15 or Epi≤0.1 or NorEpi ≤ 0.1 µg/kg/min	DOP>15 or Epi>0.1 or NoreEpi>0.1 µg/kg/min
Glasgow Coma Scale (GCS)	15	13-14	10-12	6-9	<6
Creatinine,mg/dL	<1.2	1.2-1.9	2.0-3.4	3.5-4.9	>5.0
Urine output, mL/day	-	-	-	<500	<200

The SOFA score offers a straightforward, objective, and dependable means of daily organ dysfunction assessment in sepsis trials. Nevertheless, this scoring system has certain limitations. It evaluates each organ system using only a single parameter, overlooking other indicators of organ dysfunction. Additionally, the scores for organ dysfunction can be affected by administered therapies, potentially reflecting the degree of treatment given or withheld.<sup>9</sup>

Early warning score (EWS) is a scoring system designed to identify physiological changes and aid in recognizing patients at risk of additional deterioration.<sup>10</sup> The scoring mechanism produced a straightforward weighted score based on the bedside evaluation of five physiological parameters, comprising respiratory rate, systolic blood pressure, temperature, heart rate and responsiveness to stimuli as seen on Table 2.<sup>11</sup>

**Table 2. EWS**

Physiological parameters	Score						
	3	2	1	0	1	2	3
Respiration, times per minute	<8		9-11	12-20		21-24	>25
Oxygen Saturation Air or Oxygen	≤91	92-93 Oxygen	94-95	≥96 Air			
Temperature (°C)	<35.0		35.1-36	36.1-38	38.1-39	≥39.1	
Systolic Blood Pressure, mm Hg	≤90	91-100	101-110	111-219			≥220
Pulse rate, times per minute	≤40		41-50	51-90	91-110	111-130	≥131
Level of Consciousness				A			V, P, U

A significant merit of the EWS clinical tool is their simplicity and the capacity to compute scores through regular bedside observations, offering a universal language across healthcare specialties and providers. However, there are various limitations, including the validity of measures employed and the implementation challenges to abnormal scores can compromise the advantages of these systems.<sup>11</sup>

Safari et al cross-sectionally prospectively analyzed 140 critically ill patients coming to the emergency room from 3 hospitals. Basic characteristics, variable SOFA scores, and patient 1-month outcomes were recorded as well as screening performance characteristics scores calculated using STATA 11 software. From the results of the analysis, it was concluded that the SOFA scoring system demonstrated satisfactory accuracy in predicting one-month mortality among critically ill patients.<sup>7</sup> On the other side, Wang et al retrospectively analyzed 152 patients meeting the diagnostic criteria for sepsis-3, were admitted to the ICU at the Affiliated Hospital of Guizhou Medical University between January 2015 and December 2016. Curve receiver operating characteristics (ROC) is applied to evaluate the predictive effectiveness of the SOFA score. Wang et al concluded that the SOFA score cannot substitute the conventional evaluation indices in assessing the prognosis of sepsis patients.<sup>12</sup>

Churpek et al analyzed 30,677 hospitalized patients who first met criteria for suspicion of infection in hospital inpatient rooms from November 2008 to January 2016 and EWS were compared with other scores to predict mortality and ICU transfer. Churpek et al

concluded EWS is more accurate for predicting ICU deaths and transfers in non-ICU patients.<sup>13</sup> Nonetheless, Hamilton et al analyzed 298 patients with sepsis calculated using EWS and study quality assessed using QUADAS-2. Summary estimates are obtained using HSROC analysis. Hamilton et al found that the EWS was not accurate enough to determine or rule out death in patients with sepsis.<sup>14</sup>

It remains unclear whether SOFA and EWS scores are accurate in evaluating the prognosis of sepsis patients. Thus, researchers were motivated to conduct research on how the correlation between SOFA and EWS scores with the duration of sepsis patients stay in the ICU.

## METHOD

This study adopts an analytical observational approach and the design used is cross-sectional. The data collection method relies on secondary data in the form of medical records at Rumah Sakit Umum Imelda Pekerja Indonesia Medan from August 2021 to February 2023 and samples are taken using total sampling techniques. Of the 82 samples, 64 samples were taken in accordance with the inclusion criteria. Adult patients aged between 18-65 years were included as samples, while the exclusion criteria included patients without data that could be used to assess EWS and SOFA scores. The data was then analyzed using the spearman correlation test.

## RESULT

From the results of data collection from the 82 samples, 64 samples that met the criteria for inclusion of researchers were taken. Table 3 displays the sample frequency according to the age and gender of the patient.

**Table 3.** Characteristics of the patient

	Frequency (n=64)	Percentage (%)
Age		
<30	6	9.4
30-40	9	14.1
41-50	12	18.8
51-60	23	35.9
>60	14	21.9
Gender		
Male	28	43.8
Female	36	56.3

According to Table 3, it was observed that the majority of sepsis patients were in the age range of 51-60 years reaching 23 individuals (35.9%) while the lowest number was in the age category of <30

years with 6 individuals (9.4%). Then based on the gender of patients, it was found that female was the largest group in the data, with 36 (56.3%), while male were 28 people (43.8%).

**Table 4.** Frequency distribution of patients based on intervention

Intervention	Frequency (n=64)	Percentage (%)
Ventilated	13	20.3
Not Ventilated	51	79.7

Based on Table 4 above, data were obtained showing that 13 people (20.3%) with sepsis were subjected to ventilation interventions, while 51 people (79.7%)

did not undergo ventilation interventions. These data results indicate that more sepsis patients are not ventilated.

**Table 5.** Characteristics of SOFA score, EWS and length of stay

Variable	N	Lowest Value	Highest Value	Average	Standard Deviation
SOFA Score	64	7	15	10.50	2.21
EWS	64	2	18	9.39	4.13
Length of Stay (day(s))	64	1	16	4.36	3.61

Table 5 presents data on the demographic characteristics of 64 samples. From the overall sample, the SOFA score with the lowest score was 7 while the highest SOFA score was 15, with an average total sample SOFA score of 10.5 and standard deviation of 2.21. While the EWS score, the lowest EWS score was 2 and the highest score was 18,

with the mean EWS score in the total sample was 9.39 with a standard deviation of 4.13. Meanwhile, the shortest length of hospitalization of patients with sepsis was 1 day and the longest duration of treatment reached 16 days, with mean stay of 4.36 days and the standard deviation for the duration of hospitalization was 3.61 days.

**Table 6.** Patient status characteristics based on SOFA and EWS scores

Variable	SOFA Score		EWS		
	<12	≥12	≤4	5-6	≥7
Age (mean ± SD)	48.13± 12.57	52.37 ± 11.41	49.13 ± 15.27	55.00 ± 4.60	48.50 ± 12.58
Gender n (%)					
Male	20 (44.4)	8 (42.1)	3 (37.5)	2 (25.0)	23 (47.9)
Female	25 (55.6)	11(57.9)	5 (62.5)	6 (75.0)	25 (52.1)
Length of Stay Median (min-max)	3 (1-16)	2 (1-13)	3 (2-13)	6 (1-16)	2 (1-15)
Survival n (%)	6 (13.3)		1 (12.5)	1 (12.5)	6 (12.5)
Death n (%)	39 (86.7)	17 (89.5)	7 (87.5)	7 (87.5)	42 (87.5)

Examining Table 6 data reveals that the patients with a SOFA score < 12 has an average age of 48.13 (SD 12.57) while for a SOFA score of ≥ 12 is 52.37 (SD 11.41). On the other hand, the mean age of patients with EWS ≤ 4 was 49.13 (SD 15.27), for the mean age of patients with EWS 5-6 was 55.00 (SD 4.60), and for the average age of patients with EWS ≥ 7 was 48.50 (SD 12.58).

Based on gender, there were 20 male patients (44.4%) who had a SOFA score of < 12 and 8 male patients (42.1%) who had a SOFA score of ≥ 12. As for EWS in male, there were 3 patients (37.5%) who had EWS ≤ 4, as many as 2 patients (25.0%) who had EWS 5-6, and as many as 23 patients (47.9%) who had EWS ≥7. For female, there were 25 patients (55.6%) who had a SOFA score of < 12 and 11 female patients (57.9%) who had a SOFA score of ≥12. In EWS, there were 5 female patients (62.5%) who had EWS ≤4, 6 female patients (75.0%) who had EWS 5-6, and 25 female patients (52.1%) who had EWS ≥7.

Then for the median length of hospitalization, it was obtained at 3 days on the SOFA score <12 with the shortest length of hospitalization of 1 day and the longest length of hospitalization of 16,

while on the SOFA score of ≥12 a median of two days was obtained with the shortest length of hospitalization 1 and the longest length of hospitalization of 13 days. For EWS, the median length of hospitalization was 3 in EWS ≤4 with the lowest value of 2 and the highest value of 13. The median length of hospitalization with EWS 5-6 was obtained at 6 with the highest value of 1 and the lowest value of 16 while in EWS with a score of ≥7 the median length of hospitalization was obtained at 2 with the shortest duration of treatment of one day and the longest of 15 days.

Meanwhile, there were six patients (13.3%) who survived with a SOFA score of < 12 and 39 patients (86.7%) did not survive. On the other hand, there were two patients (10.5%) who survive with a SOFA score of ≥ 12, and 17 patients (89.5%) did not survive. In the EWS group, there was 1 patient (12.5%) who survived with an EWS score of ≤ 4 and 7 patients (87.5%) did not survive. Then the same results were obtained for EWS with a score of 5-6 where 1 patient (12.5%) survived and 7 patients (87.5%) did not survive. In the EWS score group ≥7, there were 6 patients (12.5%) who survived and 42 patients (87.5%) did not survive.

**Table 7.** Distribution of patients by cause and length of hospitalization

Cause	Frequency (n=64)	Percentage (%)	Average length of stay (day(s))
AKI	8	12.5	2.5
CHF	5	7.8	4.4
DM	9	14.0	2
HIV	2	3.1	2.5
Cholangitis	3	4.7	2.3
Peritonitis	3	4.7	3.6
Pneumonia	23	35.9	6.2
COPD	3	4.7	3.6
Stroke	1	1.6	1
TB	7	10.9	5.9

Based on Table 7 of 64 samples, pneumonia was the highest cause of sepsis reaching 23 individuals (35.9%), then DM with 9 individuals (14.0%) and AKI 8 individuals (12.5%). The cause of sepsis with the longest length of hospitalization is pneumonia, with mean length of stay of 6.2 days, followed by TB with mean length of hospitalization of 5.9 days and CHF with mean length of hospitalization of 7.8 days.

The data collected were analyzed through the use of correlation tests, with the aim of observing the correlation of SOFA and EWS scores with the length of hospitalization of adult sepsis patients. This analysis is run using the support of a statistical program that processes all three dependent and independent variables. The correlation test outcomes for the three research variables are presented in the Table 8.

**Table 8.** Normality test

Variable	P
SOFA Score	0.309
EWS	0.922
Length of Hospitalization	0.003

Based on Table 8, it was found that the SOFA and EWS score variables were normally distributed with  $p = 0.309$  and  $p = 0.922$  ( $p > 0.05$ ), while the length of

hospitalization variables were not normally distributed with  $p = 0.003$  ( $p < 0.05$ ).

**Table 9.** Correlation between SOFA and EWS with length of stay

Variable	r	P
SOFA – Length of Hospitalization	0.046	0.719
EWS – Length of Hospitalization	0.39	0.001

After a normality test, because it was found that one variable in this study did not have a normal distribution, a spearman correlation test was carried out to observe the relationship between SOFA and EWS scores with length of hospitalization.

Reviewing Table 9 data reveals that the p value for the correlation between SOFA and Length of Hospitalization is 0.719 ( $p > 0.05$ ). These findings indicate that there is no meaningful relationship between the two variables. In other words, there was no correlation between

SOFA scores and the duration of sepsis patients admitted to the ICU.

However, in the variables EWS and Length of Hospitalization, different results were found where the p value = 0.001 ( $p < 0.05$ ), showing a correlation between EWS and length of hospitalization.

## DISCUSSION

The study results indicated that there is no relationship between SOFA and duration sepsis patients admitted to ICU supports the findings reported by Lubis<sup>15</sup> with value  $p = 0.762$  and Isnaini<sup>16</sup> with value  $p = 0.158$ . Both studies stated that there was no correlation between SOFA and the duration of ICU admissions for sepsis patients. This is due to difficulties in GCS assessment especially in patients receiving sedation drugs and mechanical ventilation, which can lead to human error/bias on GCS numbers.<sup>17</sup>

The finding of an association between EWS and the duration of sepsis patients treated is in line with the research by Siddiqui et al<sup>8</sup> with value  $p = 0.008$  states that there is an association between EWS and the duration of ICU admissions for sepsis patients.

Based on these findings, it was found that majority of sepsis patients fell within the age group of 51-60 years reaching 23 individuals (35.9%), followed by the age group of 60 years and over with 14 individuals (21.9%). These findings support the results of research by Ahwini<sup>18</sup> which concluded that 58-67 year olds had the most sepsis. This is also in line with the findings found in studies by Tambajong et al<sup>19</sup>, which showed that the average age of men affected by sepsis was 56.9 years, while in women it was 62.1 years.

This study showed a higher occurrence of sepsis patients among women, with 36 cases (56.3%) of the total 64 cases while in men reached 28 cases (43.8%). These results are in line with studies by Rudd et al<sup>3</sup>, that the incidence of sepsis is higher in women than men. But it is different from research Zhang et al<sup>20</sup>, where sepsis is more common in males than females, this suggests that gender had no impact on the final assessment of the scoring system.<sup>21</sup>

In this study, a correlation was found between SOFA scores and patient age. The results of this study support research by Lubis<sup>15</sup> and Tewuh<sup>22</sup>. As a person ages, the SOFA score tends to increase. Older individuals tend to be more susceptible to infection due to changes in the body, decreased organ function and the immune system.

In addition, EWS scores were found to have an association with age and mortality in sepsis patients admitted to the ICU. The findings of this study support studies by Sujarwo<sup>23</sup> where elderly patients have longer hospitalizations. This is due to the decline in the functioning of body organs that occurs with age, which results in a decrease in the immune system. The length of the patient's stay can be affected by age factors.<sup>23</sup> Age relates to exposure levels, risk, and certain types of resistance. As a person ages, the immune system's capacity to fight infection tends to decrease. The degree of susceptibility, especially in elderly patients, can be an indicator for extended hospital stay and elevated mortality rates.<sup>24</sup>

From the results of the study, a relationship was found between SOFA and EWS scores with patient mortality, where the SOFA scores  $< 12$  has a mortality rate 86.7% while SOFA score



$\geq 12$  has an increased mortality rate to 89,5%. These results are in line with research by Lubis<sup>15</sup>, where SOFA score  $< 12$  has a mortality rate of 54.2% and increases to 78.9% in the SOFA score of  $\geq 12$ . A higher SOFA score indicates an increase in the number and severity of organ dysfunction in the patient resulting in an increased risk of mortality.<sup>25</sup> Meanwhile in EWS, the same mortality rate for each score was obtained which is 87.5%. These results are not in line with research by Fauziah and Adiutama<sup>26</sup> where the average EWS value in the study showed a tendency to increase 6 hours before mortality and at mortality. This could be attributed to the limited number of samples and the brief study duration so that it does not show significant differences in mortality rates in each EWS score.

This study indicated that the average SOFA score of patients with sepsis was 10.5 (SD 2.21). The results of the score are in line with the findings found in the study conducted Maryani et al<sup>27</sup> The average SOFA score of sepsis patients was 10.12, then the study conducted by Lubis<sup>15</sup>, the average SOFA score of sepsis patients was 11.47. This difference is caused by the effect of sedation drugs that are not well recorded which results in human error/bias on GCS numbers.<sup>15</sup>

Findings from this study revealed that the average EWS score of sepsis patients was 9.39 (SD 4.13). The findings in this study do not line up with the results found in the study Siddiqui et al<sup>8</sup>, the average recorded EWS score of sepsis patients was 4.5 (SD 3.40). This difference can be caused by differences in patient chronology, differences in health facilities in each region, and the ability to handle sepsis patients by health workers.

This study showed that the average duration of hospitalization of sepsis patients was 4.36 days (SD 3.61). These findings are in line with studies by Paoli et al<sup>28</sup> reported that the duration of hospitalization for sepsis patients in United States hospitals was 4.50 days. These results are also in line with research by Tambajong et al<sup>19</sup>, where the length of hospitalization of sepsis patients is highest is 1-5 days.

From the results of the study, it was found that the cause of sepsis and the longest length of hospitalization was pneumonia with an average length of hospitalization of 6.3 days. The findings of this study support to the results reported by Isnaini<sup>16</sup> which concluded the most causes of sepsis were pneumonia then followed by stroke, DIC and tumour and in research by Tambajong et al<sup>19</sup>, the most common cause of sepsis was pneumonia in 71.4% of the total cases. The study also supports Lubis' research<sup>15</sup>, It was found that the cause of sepsis with the longest length of hospitalization was pneumonia with an average length of hospitalization of 21.5 days.

The limitation of this study is that it was only centered in a single healthcare facility with limited research samples. Additionally, the study is not a Randomized Controlled Trial (RCT), where retrospective data collection, such as data collection with GCS, tends to be assessed subjectively by the examiner, potentially leading to biased results.

## CONCLUSION

Based on the evaluation of SOFA and EWS scores, 2 points were obtained, namely there was no significant correlation ( $p = 0.719$ ;  $r = 0.046$ ) between the SOFA score and the duration of sepsis patients admitted to

the ICU while there was a significant correlation ( $p = 0.001$ ;  $r = 0.39$ ) between EWS and the duration of sepsis patients admitted to the ICU.

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