

Determining and Comparing Predictive and Intensity Value of Severity Scores – “Sequential Organ Failure Assessment Score,” “Acute Physiology and Chronic Health Evaluation 4,” and “Poisoning Severity Score” – in Short-Term Clinical Outcome of Patients with Poisoning in an ICU

Koroush Ebrahimi, Ali Akbar Vaisi Raigani, Rostam Jalali, Mansour Rezaei¹

Department of Nursing, School of Nursing and Midwifery, Kermanshah University of Medical Sciences, ¹Department of Biostatistics, School of Health, Kermanshah University of Medical Sciences, Kermanshah, Iran

Abstract

Introduction: Today, poisoning is one of the problems of society and it is always one of the ten leading causes of death among youth. This study aimed to determine and compare the predictive and intensity value of three standard criteria of “Sequential Organ Failure Assessment (SOFA) score,” “Acute Physiology and Chronic Health Evaluation (APACHE) 4,” and “Poisoning Severity Score (PSS)” in short-term clinical outcome of poisoned patients. **Methods:** The prospective study conducted on 120 patients of critical care units. Data were collected using a demographic form and three criteria forms. The researcher was visiting the critical care unit daily and was filling out the demographic form of each patient in the first 24 h of hospital admission. The data were analyzed using SPSS version 16. **Results:** The results showed the mean age of patients was 35.73 ± 18.46 years with the most frequency among male patients (66.7%). The mean of criteria scores of “SOFA score,” “APACHE 4,” and “PSS” was 7.3 ± 2.97 , $P = 0.009$; 62.43 ± 12.48 , $P = 0.58$; and 2.4 ± 0.5 , $P = 0.001$, respectively. The accuracy, sensitivity, specificity, positive and negative predictive values, and area under the curve of “SOFA score,” “APACHE 4,” and “PSS” were 86.2, 70.6, 94.4, 98.6, 36.2, 0.897; 83.5, 90.2, 44.4, 90.2, 44.4, 0.808; and 16.7, 100, 2, 100, 15.3, 0.786, respectively. Predicted mortality rate in “SOFA score” and “APACHE 4” was $18.7\% \pm 20.2\%$ and $2.63\% \pm 2.6\%$, respectively. Real mortality rate, predictive duration of hospitalization by APACHE 4 criteria, and real duration of hospitalization were 15%, 1.79 ± 1.35 , and 4.04 ± 4.08 , respectively. **Conclusion:** The study showed that “SOFA score” was more predictive in clinical outcomes due to poisoning and it is recommended to poisoning centers as effective criteria.

Keywords: Acute Physiology and Chronic Health Evaluation 4, clinical outcome, Poisoning Severity Score, poisoning, predictive value, Sequential Organ Failure Assessment score

INTRODUCTION

Toxicant refers to any substance that can harm living beings including animals and plants. Furthermore, in clinical toxicology, poisoning refers to a state that toxic destroys normal physiological function and kills or damages human beings.^[1] Although there are no comprehensive statistics of poisoning rate and its consequences in Iran, five million cases of poisoning and 12,000 deaths occur in America yearly.^[2,3] As many of poisoned patients were admitted in the Intensive Care

Unit (ICU) due to physiological instability and disruption of their vital systems including heart, kidney, and lung that careful

Address for correspondence: Dr. Rostam Jalali,
School of Nursing and Midwifery, Kermanshah University of Medical
Sciences, Kermanshah, Iran.
E-mail: ks_jalali@yahoo.com

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How to cite this article: Ebrahimi K, Vaisi Raigani AA, Jalali R, Rezaei M. Determining and comparing predictive and intensity value of severity scores – “Sequential organ failure assessment score,” “Acute physiology and chronic health Evaluation 4,” and “Poisoning severity score” – in short-term clinical outcome of patients with poisoning in an ICU. *Indian J Crit Care Med* 2018;22:415-21.

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10.4103/ijccm.IJCCM_238_17

nursing and monitoring are required, immediate decisions and nursing interventions are very essential in the treatment of these poisoned.^[4-6] The predictive criteria of the disease intensity have been increased since 30 years ago and have been applied in ICU medical system vastly.^[7] Nurses can use predictive criteria of the disease outcomes in prioritizing of patient's needs, qualitative assessment of the disease, assessment of severity of poisoning, creation of standards of care, allocation of the best facilities to the most critically patients, and prediction of disease consequences.^[4-6,8,9] Moreover, using these criteria leads to successful determination of effective management strategies, comparison of various centers together and with the international standard, and improvement of the functions of therapies centers.^[4,9,10] Poisoning Severity Score (PSS) is one of the criteria submitted by Persson *et al.* in 1998. This criterion was standardized for scoring poisoning severity and qualitative assessment of side effects, identifying the real risks, and comparing the data.^[8] Moreover, the World Health Organization (IPCS/EC/EAPCCT) recommends it for assessing the poisoning.^[4]

Acute Physiology and Chronic Health Evaluation (APACHE) 4 is another criterion that the simplest version applied by Knaus *et al.* in 1985.^[11,12] These criteria were reviewed up to 2003, and at the end, APACHE 4 was introduced.^[13] This system is based on physiologic disorders and it has been successful in estimating the severity of the disease in a critical patient.^[14]

The third criterion is Sequential Organ Failure Assessment (SOFA) score introduced by Vincent *et al.* in 1996. This criterion evaluated six main body systems (neurologic, aspiration, cardiovascular, liver, renal, and coagulation systems).^[15] Although in some previous researches the performance of SOFA was weaker than APACHE 4 and other predictive criteria of death, it is applied in different groups of patients including internal and surgical patients.^[16] Since these instruments have been not compared together in poisoned patients and there are not any definite opinion about top criteria in patients with poisoning, this research aimed at comparing the predictive and severity value of SOFA score, APACHE 4, and PSS criteria in short-term clinical outcomes of patients with poisoning (full recovery, make poison, discharge side effects, death, or brain death) and determining sensitivity, specificity, accuracy, and positive and negative predictive values.

METHODS

The current research is a prospective, analytical descriptive study. The samples were 120 patients with poisoning in a Medical Research Center in Kermanshah who were selected according to the inclusion criteria by convenience sampling within 6 months. The research environment in this study consists of 14 beds and a respiratory isolation bed. The inclusion criteria consisted of all poisoned patients aged 16 years, toxicity of drugs, poisoning by pesticides, poisoning with a variety of drugs, poisoning with alcohol (methanol or ethanol), gas poisoning, poisoning with snakebites and scorpion, and

other types of poisoning. The patients who go to the hospital after 72 h and cut the ICU treatment in <24 h were excluded from the study. The criteria using in this study were SOFA, APACHE 4, and PSS.

The data were collected using a three-part form including (1) demographic information (age, sex, type of poisoning, way make poison, and duration of prehospitalization); (2) criteria; and (3) registered form of final condition due to poisoning (dead or survive [full recovery or side effects] and the real duration of staying in ICU). These data were registered for each patient while transferring from the ICU at the end of the treatment or at the end of 14th day of the study. The researcher visited the hospital daily and he/she filled the information form (demographic information, three criteria) for the poisoned patients who admitted in the ICU and had the inclusion criteria at the early 24 h of hospitalization. Afterward, the scores of poisoning severity of three criteria, the percentage of death probability in SOFA and APACHE 4, and the predictive duration of admitted in the ICU with APACHE 4 were calculated. The researcher observed the patient up to the death, while transferring from the ICU or up to maximum 14 days without treatment interference to complete the information of final poisoning condition (dead or survive or the staying duration in the ICU); then, finally, he/she filled the relevant information form. The data were analyzed using SPSS version 16 (Chicago, SPSS Inc.). Independent *t*-test, Pearson's correlation coefficient, and ANOVA were used for normal quantitative data. Moreover, Mann-Whitney U-test, Kruskal-Wallis test, and Spearman correlation coefficient were used for abnormal quantitative data and rating data. Kolmogorov-Smirnov test was used to test the normality of the qualitative data. Receiver operating characteristic curve was used to determine the cut point and calculate the diagnostic indicators. The linear regression was used to determine the effect of SOFA component on the patients' clinical outcome. Furthermore, sensitivity, specificity, positive and negative predictive values, and accuracy of "SOFA score," "APACHE 4," and "PSS" were also calculated.

RESULTS

Out of 120 patients with poisoning, 80 patients were male (66.7%) and 40 patients were female (33.3%).

The mean age of the patients was 35.73 ± 18.46 years and the mean duration of prehospitalization (from poisoning to going to hospital) was 0.472 ± 0.45778 days with 0.02–2 fluctuation.

Drug toxification was the most common reason for poisoning (52 cases, 43.3%). The real registered rate of mortality was 15%. Ninety poisoned patients were hospitalized due to suicide (75%), 28 patients due to accidental poisoning (23%), and two patients due to biting (1.66%). According to the results of the study, the mortality rate raised due to increasing the severity of poisoning. Seventeen patients (30.9%) from Grade 3 poisoning were died [Table 1].

According to the results, the mean score of death group was greater than surviving group. According to the independent *t*-test, the results were significant in 0.001 level in the three criteria [Table 2].

The SOFA score with the highest accuracy, specificity, and positive predictive value and with sensitivity = 70.6 was better than other scores in predicting the clinical outcome [Table 3].

The SOFA score covers most samples with the highest surface area under the curve (AUC) [Table 4 and Figure 1].

By increasing the severity of poisoning, the mean of scores (PSS, SOFA, and APACHE4) also increased [Table 5].

After converting the data (clinical outcomes of the patients) to the normal logarithm, linear regression test was used to determine the effect of SOFA component on dependent variable (clinical outcomes of patients). The model summary showed *R* = 0.697 and the regression model also showed the fit of this model (*P* ≤ 0.001). The results of various regression coefficients are presented in Table 6.

Table 1: The frequency distribution of clinical outcomes on the basis of Poisoning Severity Score outcome

Poisoning severity	Outcome			
	Recovery	Discharging side effects	Dead	Total
1	2	0	0	2
2	58	4	1	63
3	15	23	17	55
Total	75	27	18	120

Table 2: The mean score of criteria in both death and surviving groups

Criterion	Clinical outcome	Frequency of samples	Criteria average
SOFA	Dead	18	11.5±3.5
	Survive	102	6.5±2.1
APACHE 4	Dead	18	72.9±10.1
	Survive	102	60.57±11.6
PSS	Dead	18	2.94±0.2
	Survive	102	2.34±0.5

SOFA: Sequential Organ Failure Assessment; APACHE: Acute Physiology and Chronic Health Evaluation; PSS: Poisoning Severity Score

DISCUSSION

The results revealed that all three criteria determined the severity of poisoning and are able to predict the clinical outcomes due to poisoning. However, SOFA performed better than other criteria. Out of 120 poisoned patients of ICU, there were 80 men (66.7%) and 40 women (33.3%). The mean age of the samples was 35.73 ± 18.46 years ranging between 16 and 86 years. However, in another study, these numbers were 38 ± 13 and 41% of the samples were men, indicating that in all these studies, the number of women was greater than men.^[17] In another research, the percentage of men with poisoning (76%) was greater than the percentage of women with poisoning and the mean age was 31.2 years that showed the prevalence of poisoning problem among youth.^[16] It is not possible to deny the role of several crises including emotional and personality, addiction, economical problems, and unemployment in the prevalence of poisoning among youth.

In the current research, drug toxification was the most common cause of poisoning with 52 cases (43.3%), opium 27 cases (22%), and poisoning by pesticides 22 cases (18.3%), which was different with the results of the another study (drug 33.4%, pesticides 30%, and alcohol 10%).^[18] In another study, 66.5% cases poisoned with drugs.^[19] In the all three mentioned researches, drug toxification was the main cause of as the result

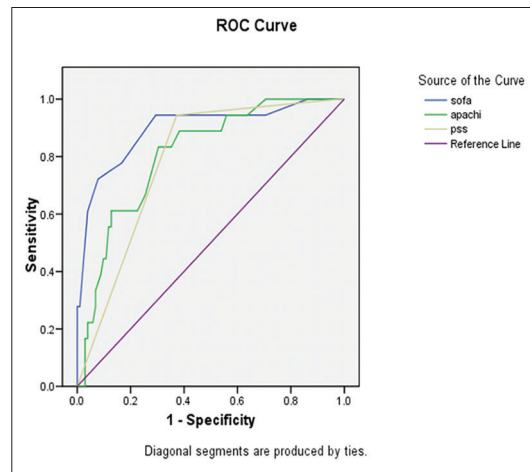


Figure 1: Area under the curve of Sequential Organ Failure Assessment, Acute Physiology and Chronic Health Evaluation 4, and Poisoning Severity Score

Table 3: The accuracy, sensitivity, specificity, and positive and negative predictive value in studied scores

Scores	Value				
	Accuracy (%)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
SOFA	86.2	70.6	94.4	98.6	36.2
APACHE 4	83.5	90.2	44.4	90.2	44.4
PSS	16.7	2	100	100	15.3
PMR with SOFA	58.33	52	94.4	98.1	25.8
PMR with APACHE 4	-	100	-	85	-

SOFA: Sequential Organ Failure Assessment; APACHE: Acute Physiology and Chronic Health Evaluation; PSS: Poisoning Severity Score; PMR: Predicted mortality rate

of availability of drugs. In another study, opium was the main cause of death (45.9%).^[20] However, in the present research, pesticides were the main cause of poisoning (31.8%) that the amount of consumed pesticides was the reason of differences in the results. In this study, 91.6% of the poisoning was due to one type of pesticides, but in another study, it was 72%.^[19]

The most common way of poisoning was suicide (75%), accidental poisoning (23.33%), and then biting (1.66%), which was consistent with the study by Tsaousi et al. (73% suicide).^[19] Moreover, in another studies by "Sam et al.," committing suicide was the main cause of poisoning (87.3%),^[4] and also, in a study by Vincent and Sakr, committing suicide was the main cause of

poisoning (52.2%).^[20] Another ways of making poison in a study were accidental (7%), employment problems (4.2%), and murdering (1.4%). Cultural issues (parental learning) and easiness (no pain and less terribleness) are some reasons of committing suicide.

In the current research, the real duration mean of hospitalization was 4.04 ± 4.8 days and varied between 1 and 14 days. However, in a study by "Cholongitas et al.,"^[17] the real duration mean of hospitalization of the patients was 6 days (1–103 days); in the study by "Taghaddosinejad et al.,"^[21] this number was 6 days; and in another study by "Abd El-Salam et al.,"^[22] the duration mean of staying in hospital was 1.65 ± 1.28 days (ranges: 1–9). The difference of the results may be due to the differences of the samples and poisoning factors, duration of prehospitalization, and lack of similar protocol in transferring the patients from ICU.

The scores of poisoning severity using SOFA in the patients with poisoning were around 1–18 and the mean was 7.31 ± 2.97 . The overall score of SOFA can be 0–24. Calculated cut point of SOFA was 7.5 (the patients with the score of >7.5 might lead to death and the score of <7.5 might lead to surviving). The percentage predictive death probability in the evaluated patients using SOFA was 4%–95% and the mean was 18.76 ± 20.26 that was close to real number (15% mortality). In the study by

Table 4: Area under the curve in studied scores

Scores	Value			
	Mean ROC	Minimum ROC	Maximum ROC	Significance level
SOFA	0.897	0.807	0.986	0.001
APACHE 4	0.808	0.711	0.905	0.001
PSS	0.786	0.693	0.880	0.001

SOFA: Sequential Organ Failure Assessment; APACHE: Acute Physiology and Chronic Health Evaluation; PSS: Poisoning Severity Score; ROC: Receiver operating characteristic

Table 5: Comparison of clinical outcomes and severity of poisoning according to Poisoning Severity Score

Variable	PSS				
	1	2	3	Mean	Significance level
Mean SOFA	3±1.4	5.6±1.6	9.3±2.8	7.3±2.9	0.001
Mean APACHE 4	67±1.4	58.8±10.1	66.3±13.4	62.4±12	0.003
PMR with SOFA (%)	4.5±0.7	8.4±7	31.1±23.6	18.7±20	0.001
PMR with APACHE4 (%)	2.4±0.6	1.6±2.1	3.7±2.8	2.6±2.6	0.001
Recovery	2	58	15	75	-
Complications during discharge	0	4	23	27	-
Death	0	1	17	18	-
Length of the actual hospitalization	1.4±0.4	2.9±2.7	5.4±4.9	4±4	0.002

SOFA: Sequential Organ Failure Assessment; APACHE: Acute Physiology and Chronic Health Evaluation; PSS: Poisoning Severity Score; PMR: Predicted mortality rate

Table 6: Regression coefficients of Sequential Organ Failure Assessment Score components with patients' clinical outcome

Model	Coefficients ^a				Significant
	Unstandardized coefficients		Standardized coefficients	t	
	B	SE			
Model 1					
Constant	0.419	0.170		2.470	0.015
Respiratory system	0.158	0.094	0.152	1.687	0.094
Nervous system	0.098	0.076	0.121	1.298	0.197
Cardiovascular system	0.198	0.069	0.230	2.869	0.005
Coagulation	0.137	0.064	0.180	2.148	0.034
Liver	0.233	0.073	0.249	3.170	0.002
Kidneys	0.079	0.068	0.088	1.164	0.247

^aDependent variable: Clinical outcome. SE: Standard error

“Cholongitas *et al.*,”^[17] the mean score of SOFA was 11 (2–9) that was consistent with the present study. In this research, maximum and minimum of coefficient correlation of SOFA was relevant to neurological system (0.684) and coagulation system (0.227), respectively, which was inconsistent with the results of the study by “Halim *et al.*” (cardiovascular = 0.969 and liver system = 0.03).^[23] The side effects of the surgery on the body (Halim *et al.*'s study) and poisoning (current study) and finally its reflection in the relevant criterion may be the reasons of the differences.

Regression model showed a significant effect, but this significance was not for all components. It was significant for components of the liver, cardiovascular and coagulation, but not for other components (respiratory system, nervous system and kidneys). Perhaps, the cause is related to the variable being measured; for example, in the respiratory system, PaO₂ can be altered by changing tidal volume and minute volume, or in the kidneys, creatinine is measured, which by improving the blood pressure and renal perfusion, creatinine will be reduced. However, other more vital variables such as mean arterial blood, bilirubin, and platelet count are also measured in other components.

The scores of poisoning severity using APACHE 4 varied in the patients with poisoning (38–105) and the mean was 62.43 ± 12.24 . Maximum of creatinine variables (correlation coefficient = 0.3), maximum of urea (correlation coefficient = 0.29), and maximum of heart rate (correlation coefficient = 0.4) had the higher correlation with the score of APACHE 4. The cut point of this criterion was 65.5. The condition of the patients with APACHE score of 65.5 and higher may lead to death and the condition of the patients with APACHE score of lower than 65.5 may lead to surviving.

The predictive rate of mortality using APACHE 4 was 0%–14.25% and the mean was 2.63 ± 2.65 , which was different with real mortality rate (15%). The predictive length of stay using APACHE 4 was 0.04–6.9 days and the mean was 1.79 ± 1.35 . The real duration of ICU admission was 1–14 days and the mean was 4.04 ± 4.08 . It indicated that the real staying days in the hospital is 2.25 greater than predicted rate by APACHE 4. The difference between the predicted rate of death and the real rate of death and also the difference between real duration of hospitalization and predicted duration revealed the difference of relevant unit with universal standard. Cultural problems (such as postpone going to hospital), nursing cares, ICU facilities, and treatment methods are defined as the reasons of the differences.

In a study by “Moini *et al.*,”^[24] the percentage of predicted rate of mortality, predicted duration of hospitalization (days), and real duration of hospitalization (days) were $23.85\% \pm 20.45\%$, 15.66, and 11.61, respectively. In the mentioned research, the real rate of mortality (2.7%–2.8%) was the same as predicted rate which was consistent with the results of the study by “Zimmerman *et al.*”^[25] (real mortality rate = 13.51% and predicted rate of mortality = 13.55%). However, in the current

research, the difference between real and predicted rate of mortality was 5.7. This difference might be due to the nature of disease type of the samples of both studies (ICU of internal and surgery units in comparison with ICU of poisoning unit) and the difference between caring level of very sick patients by relevant nurses and physicians. However, more calibration of APACHE 4 should be considered in different groups.

The score of severity of poisoning using PSS in 63 patients with poisoning (52.5%) was Grade 2. The condition of the patient with the severity poisoning ≥ 2 might lead to death and the condition of the patients with the severity poisoning < 2 might lead to surviving. In the present research, the severity of poisoning considering PSS in two cases (1.7%) was Grade 1, in 63 cases (52.5%) was Grade 2, and in 55 cases (45.8%) was Grade 3. The mean criteria in the surviving group were 2.34 and in the death group were 2.94, and the overall mean was 2.4 ± 0.5 . In the research by “Sam *et al.*,”^[4] however, the poisoning severity in three (4.2%) cases was Grade 1, in 30 cases (28.2%) was Grade 2, in 37 cases (52.1%) was Grade 3, and in 10 cases (14.08%) was Grade 4. Comparing the poisoning severity between men and women in both mentioned study and the current one, the poisoning in men was more severe. Moreover, the mean age in the current study was 25–34 years and in the study by “Sam *et al.*”^[4] was 21–30 years. In a research by “Churi *et al.*,”^[26] the poisoning severity in 77.9% of patients was Grade 1, in 19.8% of patients was Grade 2, in 0.5% of patients was Grade 3, and in 1.8% of patients was Grade 4 that led to death. Considering the severity of poisoning, the results of the mentioned study showed different patterns with the present study due to the method of selection of very sick patients in ICU, in that; it seems in this study that the patients were too sick. In the study by “Churi *et al.*,” moreover, the criteria mean in recovery group was 1.5 ± 0.3 and in the death group was 4.

Furthermore, the results indicated that there are an appropriate correlation between the three criteria and also between the three criteria, duration of prehospitalization, and the real duration of hospitalization, which was consistent with the study by “Sam *et al.*”^[4] However, there was more correlation between the real duration of hospitalization and prehospitalization duration (correlation coefficient = 0.24), and there was more correlation between the real duration of hospitalization and PSS (correlation coefficient = 0.23). Positive correlation indicated that increasing the poisoning severity in the samples led to increasing the criteria mean that caused increasing the hospitalization duration.

Accuracy, sensitivity, specificity, and positive and negative predictive values of SOFA in the short-term clinical outcome in the patients with poisoning were 86.2%, 70.6%, 94.4%, 98.6%, and 36.2%, respectively. In the study by “Cholongitas *et al.*,”^[17] the numerical values of the AUC, sensitivity, specificity, and positive and negative predictive values were 79%, 67%, 80%, 74%, and 74%, respectively. Moreover, in the study by “Halim *et al.*,”^[23] the numerical values of the AUC, accuracy,

sensitivity, specificity, and positive and negative predictive values were 0.732%, 68.8%, 70.2%, 67.8%, 58.8%, and 77.6%, respectively (comparing with the present study, both researches showed relatively similar sensitivity). However, in this study, according to the AUC, SOFA showed more appropriate performance.

Accuracy, sensitivity, specificity, positive and negative predictive values, and AUC of PSS in the short-term clinical outcome in the patients with poisoning were 16.7%, 2%, 100%, 100%, 15.3%, and 0.78%, respectively. In a study by “Davies *et al.*,”^[27] the sensitivity, specificity, and the AUC value of PSS were 78%, 79%, and 0.81%, respectively. Comparing the mentioned study with the current research, according to the AUC, both studies showed similar performance. In a study by “Churi *et al.*,”^[26] PSS was equal to Glasgow coma scale in predicting the death and the poisoning side effects. It seems that in the mentioned studies, the differences in number of samples and type of poisoning affected on the results.

Comparing accuracy, sensitivity, specificity, and positive and negative predictive values of PSS, SOFA, and APACHE 4 in predicting the short-term clinical outcome in the patients with poisoning, it is revealed that the higher accuracy value was relevant to SOFA (86.2%), the higher sensitivity value was relevant to APACHE 4 (90.2%), the higher specificity value and positive and negative predictive value was relevant to PSS (100%), and the higher negative predictive value was relevant to APACHE 4 (44.4%).

The AUC in the three criteria (SOFA, PSS, and APACHE 4) was 0.897, 0.80.8, and 0.786, respectively. Although there has not been any study to be included all three criteria, the previous investigations showed the acceptable performance of the three criteria in different groups of patients and in different studies. In a study by “Mbongo *et al.*,”^[28] the AUC in the three criteria (SOFA, APACHE 2, and Saps3) was 0.846, 0.893, and 0.916, respectively. In the mentioned study, Saps3 showed better performance, but comparing the current study with a study by “Mbongo *et al.*,” SOFA indicated better performance (AUC = 0.897). In a study by “Zimmerman *et al.*,”^[25] the AUC of APACHE 4 and APACHE 3 was 0.88 and 0.87, respectively, indicating that APACHE 4 showed better performance in comparison with this study. In a study by “Peter *et al.*,”^[29] APACHE 2 (AUC = 0.77) showed better performance in comparison with Saps2 (AUC = 0.77) and PSS (AUC = 0.67). In a study by “Shrestha *et al.*,”^[30] The cut point and the AUC in APACHE 4 were calculated as 61 and 0.895 and in SOFA were calculated as 8 and 0.879, respectively. Accordingly, although the accuracy of SOFA was higher, the APACHE 3 showed more appropriate performance.

CONCLUSION

The results of this study indicated that SOFA with under the curve of 0.89 showed the best performance. Accuracy, sensitivity, specificity, and positive and negative predictive values of SOFA were calculated 86.2%, 70.6%, 94.45%,

98.6%, and 36.2%, respectively. Thus, the results showed that it is possible to use SOFA in predicting the clinical outcomes and determining the poisoning severity in poisoning centers.

Research limitations

Several limitations such as accuracy of the present information of the files including objective and subjective symptoms, accuracy of tests and examinations, the number of included samples, and the different diagnosis the time of ICU discharge by the center physicians are the factors that might effect on the results of the study. Other limitations are diseases and history of the patient’s health before to make poison that affects both death rate and the results of the research.

Acknowledgments

We would like to express our gratitude to the patients who participated in the study. We would also like to note that this paper resulted from the M. S. thesis of Mr. Koroush Ebrahimi in critical care nursing, graduated from Kermanshah University of Medical Sciences (Kermanshah, Iran).

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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