Prognostic Performance of Prognostic Nutritional Index, Subjective Global Assessment, and Nutritional Risk Screening 2002 as Predictors of Inpatient Sepsis Mortality: A Prospective Cohort Study

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ABSTRACT

Background: *Sepsis is a leading cause of infection-related mortality. Various factors contribute to sepsis-related mortality, including age, comorbidities, Sequential (Sepsis-Related) Organ Failure Assessment (SOFA) score, serum lactate levels, and nutritional status. Several parameters are available to assess nutritional status, including the Prognostic Nutritional Index (PNI), Subjective Global Assessment (SGA), and Nutritional Risk Screening 2002 (NRS 2002). The SGA and NRS 2002 parameters are standard tools for evaluating nutritional status, while the PNI is very simple and objective. This study aimed to evaluate the accuracy of these three nutritional parameters as predictors of in-hospital mortality in patients with sepsis and to analyze the extent to which malnutrition contributes to sepsis-related mortality among other factors.* ***Methods:*** *This was a prospective cohort study. The inclusion criteria were patients aged 18 years or older who were hospitalized with a diagnosis of sepsis. The exclusion criteria were patients who could not be interviewed or those who were pregnant. Dropout criteria included patients who were discharged against medical advice. Sampling was conducted using consecutive sampling. Nutritional status and other clinical parameters were assessed within the first 48 hours of sepsis diagnosis. In-hospital outcomes were recorded as either mortality or survival. Cut-off points for numerical variables were determined using ROC curves. Bivariate analysis was performed using Chi-square or Fisher's exact test, and multivariate analysis was conducted using binary logistic regression.* ***Results:*** *A total of 158 subjects were included in the study. The mortality rate was 62.7%. As predictors of mortality, PNI had a positive predictive value (PPV) of 72.7% and a negative predictive value (NPV) of 54.2% with a cut-off point of 30.55, while SGA had a PPV of 70.4% and an NPV of 54.0%, and NRS 2002 had a PPV of 64.7% and an NPV of 75.0%. Regarding sepsis mortality, malnutrition status based on PNI had an aRR 3.0 (95% CI 1.4-6.6), SGA had an aRR 2.4 (95% CI 1.1-5.3), and NRS 2002 had an aRR 1.6 (95% CI 0.2-10.1). Other variables that were also significantly associated with sepsis mortality included comorbidity score, SOFA score, and serum lactate level. Pathogen resistance was not identified as a significant factor contributing to sepsis-related mortality in*

*this study.**Conclusion:** Malnutrition was significantly associated with in-hospital sepsis mortality. Both PNI and SGA are equally effective in predicting sepsis mortality. The NRS 2002 is the least predictive of both PNI and SGA in predicting sepsis mortality. Other factors that also have a significant association with in-hospital sepsis mortality are the Charlson Comorbidity Index (CCI) score, the SOFA score, and serum lactate level.*

***Keywords:** Sepsis, mortality, malnutrition, Prognostic Nutritional Index, Subjective Global Assessment, Nutritional Risk Screening 2002*

INTRODUCTION

Sepsis is a condition characterized by a dysregulated immune response due to infection, leading to organ dysfunction and mortality.[1,2] A 2022 study reported a sepsis prevalence of 22.4% in Asia, with a mortality rate of more than one-third of the cases.[3] In Indonesia, the mortality rate from sepsis is even higher, reaching 58%.[4] A 2017 study conducted at Dr. Cipto Mangunkusumo National General Hospital (RSCM) found that 63% of bacterial infection cases developed into sepsis, with an in-hospital mortality rate of 48.6%.[5]

Malnutrition is a significant contributor to mortality in patients with sepsis.[6-10] Sepsis is a catabolic stress condition in which catabolic hormones such as glucagon, cortisol, and catecholamines are extensively secreted, leading to the mobilization of nutrient reserves from muscle mass and adipose tissue to produce endogenous energy.[1,6] Septic patients with malnutrition experience a 1.35 times higher risk of mortality compared to those without malnutrition.[11-14] An estimated 28–34% of hospitalized patients are malnourished.[15] A 2018 study at RSCM reported a malnutrition prevalence of 48.5% among hospitalized adult patients.[16] Given the high incidence of both sepsis and malnutrition in hospitalized adult patients, and the increased sepsis-related mortality associated with malnutrition, there is a research opportunity to evaluate the accuracy of various nutritional parameters as predictors of mortality in sepsis.

Among the various parameters used to assess nutritional status, Subjective Global Assessment (SGA) and Nutritional Risk Screening 2002 (NRS 2002) are standard tools widely used for evaluating the nutritional status of hospitalized patients, in accordance with recommendations from the American Society for Parenteral and Enteral Nutrition (ASPEN) and the European Society for Clinical Nutrition and Metabolism (ESPEN).[13,17] For predicting mortality in sepsis, SGA's sensitivity is approximately 61%, with a specificity of 72%. One of the main limitations of SGA is the lack of quantitative assessment, making it subject to examiner subjectivity.[13,18-20] The NRS 2002 has demonstrated a sensitivity of approximately 82% and specificity of 70% as a predictor of mortality in sepsis.[13,18,21] Another nutritional parameter, Prognostic Nutritional Index (PNI), is an inflammatory biomarker that considers serum albumin levels and lymphocyte count. Initially, PNI was used to evaluate the prognosis of patients with malignancies. Currently, it is considered a reflection of both the inflammatory and nutritional status of patients.[22] Due to its simplicity and high objectivity, research on PNI has expanded as a prognostic factor for mortality in various conditions, such as acute heart failure[23], Covid-19[24,25], and sepsis[22,26]. As a prognostic marker for sepsis-related mortality, PNI has shown a sensitivity of 70% and specificity of 80%, with an area under the curve (AUC) ranging from 0.64 to 0.73.[22,26]

To date, there is no study in Indonesia about the predictive value of different nutritional assessment tools for sepsis-related mortality. This study was designed to evaluate PNI, SGA, and NRS 2002 as predictors of sepsis mortality, and to evaluate the extent to which malnutrition contributes to mortality alongside other risk factors.

METHODS

This was a prospective cohort study. Subjects were selected using consecutive sampling. Inclusion criteria were patients aged ≥18 years and diagnosed with sepsis within the last 48

hours, based on an increase in the Sequential Organ Failure Assessment (SOFA) score of ≥2 points accompanied by confirmed or suspected infection. Exclusion criteria were pregnant patients, patients or their family members who were unable to participate in nutritional assessment interviews, and patients who had planned to be discharged against medical advice since the beginning of subject screening for recruitment. During hospitalization, subjects who requested discharge against medical advice were classified as dropouts.

Patient data were collected through interviews, physical examinations, and medical records during hospitalization. Nutritional status assessment was performed within the first 48 hours after sepsis diagnosis. The following are dependent variables that were being assessed:

- SGA: categorized as normal (Category A) or malnourished (Category B or C);
- NRS 2002: scores <3 categorized as normal, and ≥3 as malnourished;
- PNI: calculated using albumin and total lymphocyte count with the formula: *(10 × albumin [g/dL]) + (0.005 × total lymphocyte count [cells/mm³])*

Confounding variables that were being assessed include comorbidities using the Charlson Comorbidity Index (CCI), the degree of organ dysfunction using the SOFA score, pathogen classification as multidrug-resistant based on the WHO 2017 list of priority pathogens, and the highest serum lactate level measured within 24 hours before and 24 hours after the sepsis diagnosis. The primary outcome variable was in-hospital mortality, classified as survival or death, and recorded from hospital medical records.

Data analysis was performed using SPSS and STATA. Cut-off points for numerical variables (PNI, CCI, SOFA, and serum lactate) were determined using Receiver Operating Characteristic (ROC) analysis to identify the optimal sensitivity, specificity, and AUC in predicting mortality outcomes. Bivariate analysis was performed using the Chi-square test or Fisher's exact test, while multivariate analysis was conducted using binary logistic regression to identify independent predictors of mortality.

This study was reviewed and approved by the Ethics Committee of the Faculty of Medicine Universitas Indonesia/Cipto Mangunkusumo National General Hospital (FKUI/RSCM) with ethical clearance number KET-1263/UN2.F1/ETIK/ PPM.00.02/2024. All subjects agreed to participate and signed an informed consent form before their involvement in this study.

RESULTS

Recruitment and Characteristics

The subject recruitment process was conducted in the period between October 2024 and May 2025. Subject recruitment took place in the emergency room, intensive care unit, and non-intensive ward. The stages of subject recruitment are presented in **Figure 1**.

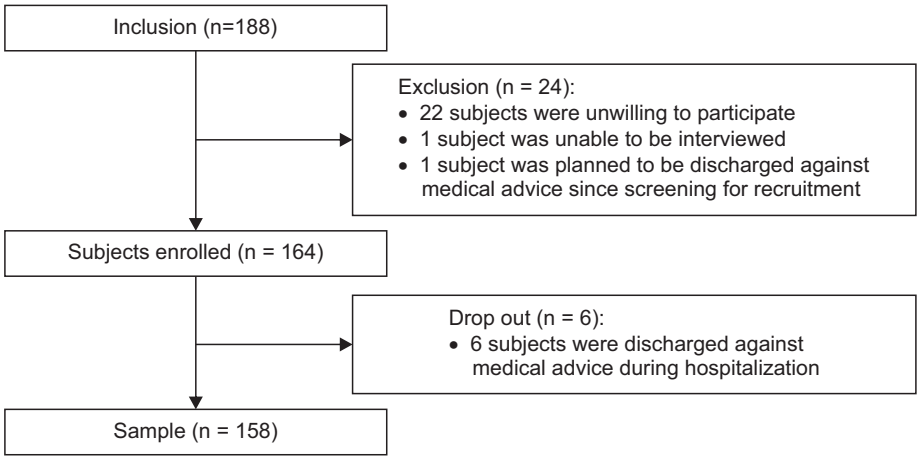

Figure 1. Subject recruitment process

The characteristics of the study subjects are presented in **Table 1**. Of the 158 study subjects, 68.4% were classified as malnourished based on SGA, and 62.7% experienced in-hospital mortality.

Determination of Cut-off Points for Numerical Variables

Cut-off points for numerical variables (PNI, CCI, SOFA score, and serum lactate level) were determined using ROC analysis. Figure 2 presents the ROC curves for these four variables.

Table 1. Characteristics of study subjects

Characteristics	Nutritional Status	
	Malnutrition (n = 108)	Normal (n = 50)
Study outcomes, *n (%)*		
- Mortality	76 (70.4)	23 (46.0)
- Survival	32 (29.6)	27 (54.0)
Sex, n (%)		
- Male	51 (47.2)	24 (48.0)
- Female	57 (52.8)	26 (52.0)
Age (year), median (min-max)	54 (18-87)	55 (18-83)
CCI score, mean ± *SD*	6.2 ± 3.3	4.6 ± 2.9
SOFA score, mean ± *SD*	8.6 ± 3.9	8.6 ± 3.4
Type of pathogen, *n (%)*		
- Multi-resistant	33 (30.6)	20 (40.0)
- Non-multi-resistant	23 (21.3)	13 (26.0)
- Sterile cultures or commensal bacteria	52 (48.1)	17 (34.0)
Serum lactate level (mmol/L), median (min-max)	2.8 (0.4-17.0)	2.0 (0.5-14.1)
Absolute lymphocyte count (cells/mm^3), mean ± *SD*	1073 ± 946	1293 ± 759
Neutrophil-lymphocyte ratio, median (min-max)	15 (0.2-218)	10 (0.3-44)
Serum albumin level (g/dL), mean ± *SD*	2.3 ± 0.6	2.6 ± 0.6
PNI, mean ± *SD*	28.5 ± 7.9	32.4 ± 7.3
NRS 2002, n (%)		
- Normal (score < 3)	1 (0.9)	7 (14.0)
- Malnutrition (score ≥ 3)	107 (99.1)	43 (86.0)

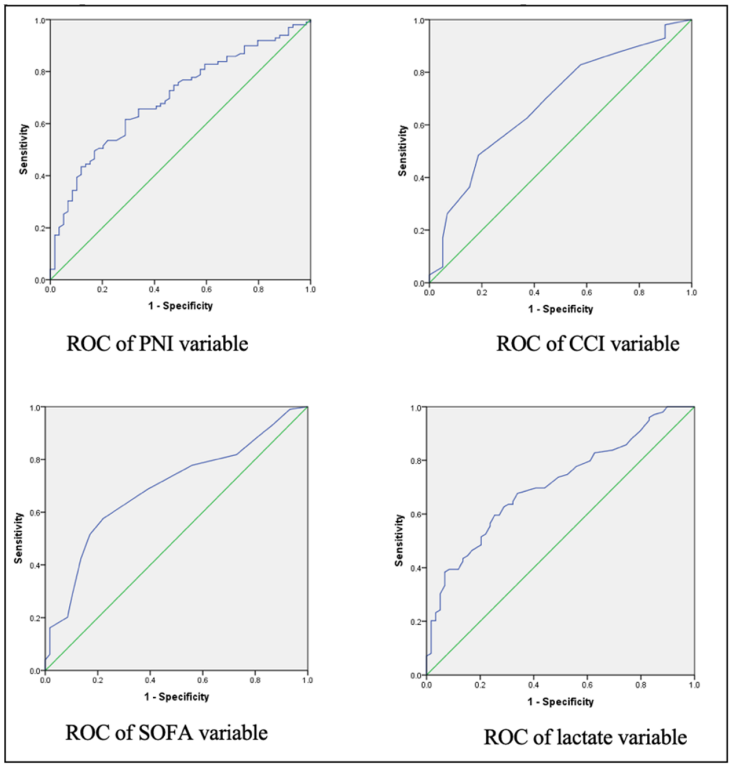

Figure 2. The ROC of numerical variables, i.e., PNI, CCI, SOFA, and lactatea

Table 2 presents the AUC and optimal cut-off points for each numerical variable.

Accuracy of PNI, SGA, and NRS 2002 as Predictors of Inpatient Mortality in Patients with Sepsis

Table 3 presents the cross-tabulation of PNI, SGA, and NRS 2002 variables with inpatient outcomes. The accuracy of PNI, SGA, and NRS 2002 as predictors of inpatient mortality in patients with sepsis is shown in **Table 4**.

Figure 3 shows the ROC curves of the three nutritional parameters as predictors of inpatient mortality in sepsis, with the significance between parameters presented in **Table 5**.

Table 2. AUC values and optimal cut-off points for PNI, CCI, SOFA, and lactate variables

Variable	AUC	Optimal cut-off point
PNI	0.697	30.550
CCI	0.683	4.5
SOFA	0.690	6.5
Lactate (mmol/L)	0.709	1.85

Table 3. Cross-tabulation of PNI, SGA, and NRS 2002 with inpatient outcomes

Variable, n (%)	Outcomes		Total
	Mortality	Survival	
PNI			
- Score ≤ 30.55	72 (72.7)	27 (27.3)	99 (100)
- Score > 30.55	27 (45.8)	32 (54.2)	59 (100)
Total	99 (62.7)	59 (37.3)	158 (100)
SGA			
- Malnutrition	76 (70.4)	32 (29.6)	108 (100)
- Normal	23 (46.0)	27 (54.0)	50 (100)
Total	99 (62.7)	59 (37.3)	158 (100)
NRS 2002			
- Malnutrition	97 (64.7)	53 (35.3)	150 (100)
- Normal	2 (25.0)	6 (75.0)	8 (100)
Total	99 (62.7)	59 (37.3)	158 (100)

Table 4. Accuracy of PNI, SGA, and NRS 2002 as predictors of inpatient mortality of sepsis

Prognostic value	PNI	SGA	NRS 2002
Positive predictive value (%)	72.7	70.4	64.7
Negative predictive value (%)	54.2	54.0	75.0
Sensitivity (%)	72.7	76.8	97.9
Specificity (%)	54.2	45.8	10.2

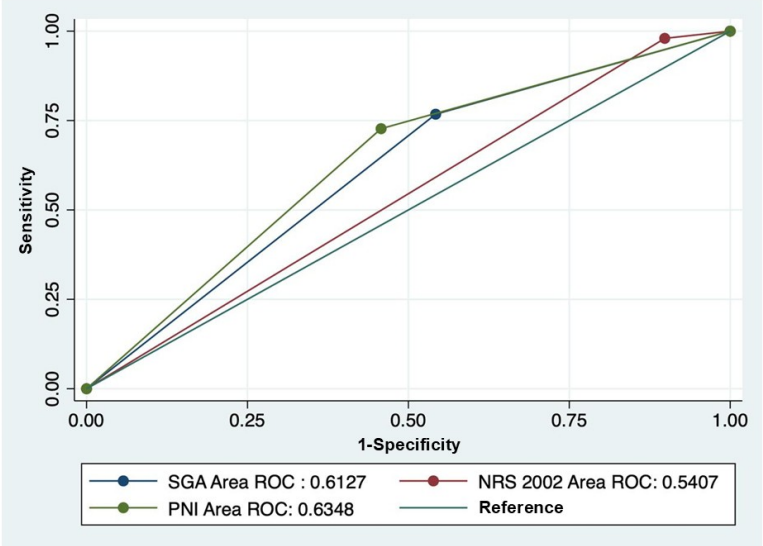

Figure 3. The ROC curve of PNI, SGA, and NRS 2002 parameters

Table 5. p-values between PNI, SGA, and NRS 2002 parameters

	PNI	SGA	NRS 2002
PNI	-	0.649	0.033
SGA	0.649	-	0.060
NRS 2002	0.033	0.060	-

Bivariate Analysis of Independent and Confounding Variables on Inpatient Outcomes

Table 6 presents the results of the bivariate analysis of independent variables (PNI, SGA, NRS 2002) and confounding variables (CCI, SOFA, pathogen type, and lactate) in relation to inpatient mortality in sepsis.

Multivariate Analysis of Independent and Confounding Variables on Inpatient Outcomes

The bivariate analysis results showed that all variables had a p-value < 0.2, making them eligible for multivariate analysis. Collinearity tests for all confounding variables yielded VIF values < 5, indicating that all confounders could be included in the multivariate analysis. **Tables 7–9** present the results of binary logistic regression using the enter method for the multivariate analysis of independent and confounding variables on inpatient outcomes in patients with sepsis.

Table 6. Bivariate analysis of independent and confounding variables on inpatient outcomes

Variable, *n (%)*	Outcomes		Total	p-value	RR (IC 95%)
	Mortality	Survival			
PNI					
- Score ≤ 30.55	72 (72.7)	27 (27.3)	99 (100)	0.001[c]	1.589 (1.174-2.151)
- Score > 30.55	27 (45.8)	32 (54.2)	59 (100)		
SGA					
- Malnutrition	76 (70.4)	32 (29.6)	108 (100)	0.003[c]	1.530 (1.106-2.116)
- Normal	23 (46.0)	27 (54.0)	50 (100)		
NRS 2002					
- Malnutrition	97 (64.7)	53 (35.3)	150 (100)	0.053[f]	2.587 (0.774-8.640)
- Normal	2 (25.0)	6 (75.0)	8 (100)		
CCI score					
- Score > 4.5	69 (72.6)	26 (27.4)	95 (100)	0.001[c]	1.525 (1.145-2.032)
- Score ≤ 4.5	30 (47.6)	33 (52.4)	63 (100)		
SOFA score					
- Score > 6.5	77 (70.0)	33 (30.0)	110 (100)	0.004[c]	1.527 (1.097-2.126)
- Score ≤ 6.5	22 (45.8)	26 (54.2)	48 (100)		
Type of pathogen					
- Multi-resistant	31 (58.5)	22 (41.5)	53 (100)	0.149[c]	0.824 (0.627-1.081)
- Non-multi-resistant	19 (52.8)	17 (47.2)	36 (100)	0.063[c]	0.743 (0.527-1.048)
- Sterile/commensal	49 (71.0)	20 (29.0)	69 (100)		reference
Serum lactate level					
- Lactate > 1.85	73 (71.6)	29 (28.4)	102 (100)	0.002[c]	1.541 (1.134-2.095)
- Lactate ≤ 1.85	26 (46.4)	30 (53.6)	56 (100)		

c: Chi-square; f: Fisher

Table 7. Multivariate analysis of PNI and confounding variables on inpatient outcomes

Variable	p-value	aRR (IC 95%)
PNI		
- Score ≤ 30.55	0.006	3.022 (1.376-6.637)
- Score > 30.55		
CCI score		
- Score > 4.5	0.006	2.887 (1.358-6.134)
- Score ≤ 4.5		
SOFA score		
- Score > 6.5	0.003	3.387 (1.509-7.603)
- Score ≤ 6.5		
Type of pathogen		
- Multi-resistant	0.044	2.486 (1.027-6.019)
- Non-multi-resistant	0.046	2.728 (1.020-7.297)
- Sterile/commensal		reference
Serum lactate level		
- Lactate > 1.85	0.004	3.222 (1.455-7.131)
- Lactate ≤ 1.85		

Hosmer and Lemeshow Test: p = 0.063; Nagelkerke R^2 = 0.317; Classification accuracy = 70.9%

Table 8. Multivariate analysis of SGA and confounding variables on inpatient outcomes

Variable	p-value	aRR (IC 95%)
SGA		
- Malnutrition	0.029	2.415 (1.093-5.341)
- Normal		
CCI score		
- Score > 4.5	0.007	2.783 (1.319-5.873)
- Score ≤ 4.5		
SOFA score		
- Score > 6.5	0.002	3.608 (1.607-8.099)
- Score ≤ 6.5		
Type of pathogen		
- Multi-resistant	0.148	1.864 (0.802-4.335)
- Non-multi-resistant	0.070	2.495 (0.928-6.710)
- Sterile / commensal		reference
Serum lactate level		
- Lactate > 1.85	0.001	3.743 (1.696-8.260)
- Lactate ≤ 1.85		

Hosmer and Lemeshow Test: p = 0.785; Nagelkerke R^2 = 0.297; Classification accuracy = 71.5%

Table 9. Multivariate analysis of NRS 2002 and confounding variables on inpatient outcomes

Variable	p-value	aRR (IC 95%)
NRS 2002		
- Malnutrition	0.629	1.580 (0.248-10.089)
- Normal		
CCI score		
- Score > 4.5	0.004	2.996 (1.433-6.263)
- Score ≤ 4.5		
SOFA score		
- Score > 6.5	0.008	3.107 (1.346-7.174)
- Score ≤ 6.5		
Type of pathogen		
- Multi-resistant	0.096	2.041 (0.881-4.729)
- Non-multi-resistant	0.049	2.620 (1.002-6.849)
- Sterile / commensal		Reference
Serum lactate level		
- Lactate > 1.85	0.001	3.707 (1.705-8.062)
- Lactate ≤ 1.85		

Hosmer and Lemeshow Test: p = 0.798; Nagelkerke R^2 = 0.266; Classification accuracy = 72.2%

DISCUSSION

This study involved 158 patients with sepsis, with a malnutrition prevalence of 68.4% based on SGA, as the standard diagnosis of malnutrition.[18] Inpatient mortality rate was 62.7%. This rate is higher than a previous study conducted at RSCM (48.6%).[5] The high mortality rate is influenced by the severity of sepsis. In this study, impaired consciousness was observed in 62.7% of the subjects. The majority of subjects (59.5%) also developed shock, requiring vasopressor support and admission to the intensive care unit. Additionally, 12% of the subjects required invasive mechanical ventilation. The severity of sepsis in this study was also reflected by a higher mean SOFA score (8.6 ± 3.9) compared to those reported in prior studies, where the median SOFA score was only about six.[3] The malnutrition rate (68.4%) in this study is considerably higher than both the national and international prevalence of malnutrition.[27,28], which also contributed to the elevated mortality rate in this study. For comparison, a study conducted in the United States in 2020 reported a malnutrition prevalence of only 9.8%, with a sepsis mortality rate of 14.2%.[12] Subjects' recruitment at a national tertiary referral hospital may also have contributed to the high sepsis mortality rate

observed in this study. This selection pattern constitutes a form of referral bias, as the study population likely overrepresents patients with greater clinical severity, advanced organ dysfunction, and multiple comorbidities, thereby influencing the overall case severity distribution within the cohort. This condition might be considered a referral bias of this study.

To predict in-hospital sepsis mortality, the positive predictive value (PPV), negative predictive value (NPV), and sensitivity of PNI were not significantly different from those of SGA; however, the specificity of PNI was higher than that of SGA (**Table 4**). The NRS 2002 demonstrated superior performance in terms of NPV and sensitivity, but had limitations in PPV and specificity. This indicates that NRS 2002 is useful for early screening, even before organ dysfunction occurs, as in sepsis. Its low PPV and specificity indicate that NRS 2002 cannot distinguish non-nutritional factors as causes of sepsis mortality. This is consistent with the role of NRS 2002 as a rapid malnutrition screening tool, which requires high NPV and sensitivity[29]. The PNI and SGA are more accurate in predicting sepsis-related mortality in terms of patients' nutritional status. The assessment of PNI, which includes albumin and lymphocyte components, provides better prognostic accuracy once organ dysfunction has occurred, considering that both albumin and lymphocyte levels tend to decrease with prolonged inflammation and immune system anergy.

Figure 3 also shows that PNI stands out as the best predictor of malnutrition-related in-hospital mortality among patients with sepsis, with an AUC of 0.635 and a cut-off point of 30.55. This value is comparable to a previous study that evaluated PNI as a predictor of sepsis mortality in 2,669 subjects, which reported an AUC of 0.644 with a PNI cut-off point of 29.3.[22] Based on the comparative ROC analysis (**Table 5**) among the three nutritional parameters for predicting in-hospital mortality in sepsis, there was no significant difference between PNI and SGA, indicating that PNI may serve as an objective alternative to SGA, which is considered the standard for diagnosing malnutrition.[18] The limitations of SGA such as the need for interviews and physical examinations can be addressed by PNI, especially in situations where the patient or family cannot be interviewed or when physical examination is difficult to perform. Moreover, the objectivity of PNI helps to overcome the subjectivity inherent in SGA assessments.

Despite the ability of PNI, SGA, and NRS 2002 to predict in-hospital mortality in patients with sepsis, the AUC values of all three nutritional parameters remain low (AUC < 0.70), indicating that nutritional factors alone are not sufficient predictors of sepsis mortality. Other factors beyond nutritional status also contribute to sepsis-related mortality. Therefore, further analysis should be conducted in conjunction with other clinical factors that may influence the in-hospital mortality in patients with sepsis.

Across all multivariate models, SOFA score, CCI, and serum lactate levels consistently emerged as significant predictors of mortality in patients with sepsis. These findings align with existing literature, which supports the SOFA score as a valid indicator of organ dysfunction and a reliable predictor of mortality. Similarly, elevated lactate levels reflect impaired perfusion and tissue hypoxia, with a significantly increased risk of death at lactate levels≥2 mmol/L.[1,2,5]

In contrast, infection with multidrug-resistant (MDR) pathogens was not significantly associated with mortality. This reinforces the understanding that mortality in sepsis is more strongly influenced by the host's uncontrolled immune response rather than by pathogen virulence.[30] Additionally, the timeliness and appropriateness of early treatment play a crucial role. A study by Kumar et al. found that each hour of delay in antibiotic administration increased the risk of death by 7.6%.[31] Therefore, antibiotic resistance alone is not a primary determinant of mortality, as demonstrated in this study by the non-significant results for pathogen type in both bivariate and multivariate analyses.

CONCLUSION

Malnutrition was significantly associated with in-hospital sepsis mortality. These findings suggest that nutritional assessment should be performed in all patients admitted with sepsis. Both PNI and SGA are equally effective in

predicting sepsis mortality. The PNI is more objective than SGA in terms of operational use. The NRS 2002 is the least predictive compared to both PNI and SGA in predicting sepsis mortality. Nutritional factors alone are insufficient as predictors of sepsis mortality, as indicated by their low AUC values. Other factors that also have a significant association with in-hospital sepsis mortality are CCI score, SOFA score, and serum lactate level, while the type of pathogen resistance has no significant association with in-hospital sepsis mortality.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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