RESEARCH PAPER

Comparison of Prognostic Nutritional Index, SOFA Score, and APACHE II in Predicting Outcomes of Non-COVID-19 Acute Respiratory Distress Syndrome Patients in the ICU

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ABSTRACT

Acute Respiratory Distress Syndrome (ARDS) represents a critical illness with a strong association to high mortality in the intensive care unit. As a marker of both nutritional and inflammatory status, the Prognostic Nutritional Index (PNI) might predict outcomes for critically ill patients. This study aimed to compare how well PNI, the SOFA score, and the APACHE-II score predict outcomes for non-Covid-19 ARDS patients in the ICU. This retrospective cross-sectional analytic observational study was conducted using medical records of non-Covid-19 ARDS patients admitted to the ICU of RSPAL Dr. Ramelan Surabaya from January 2022 to December 2024. A total of 564 patients met the inclusion criteria. Variables analyzed included PNI, SOFA score, APACHE-II score, mortality, duration of mechanical ventilation, and ICU length of stay. Statistical analyses included Spearman correlation, logistic regression, Receiver Operating Characteristic (ROC) curve analysis, and DeLong test with a significance level of $p<0.05$. The mortality rate among ARDS patients was 87.4%. SOFA, APACHE-II, and PNI were significantly associated with mortality in ARDS patients ($p<0.001$). The highest Area Under Curve (AUC) value was observed in APACHE-II (0.686), followed by SOFA (0.667) and PNI (0.652). DeLong test demonstrated no significant difference among the three predictors ($p>0.05$). The optimal cut-off values for SOFA, APACHE-II, and PNI were 7.5, 27.5, and 31.303, respectively. PNI demonstrated the highest sensitivity (70.8%), whereas APACHE-II showed the highest specificity (77.5%). Multivariate logistic regression showed that SOFA, APACHE-II, and PNI all independently and significantly predicted mortality in ARDS patients. All three measures demonstrated moderate ability to distinguish between survivors and non-survivors among non-Covid-19 ARDS patients in the ICU, with no statistically significant differences between them. Given its high sensitivity, PNI could serve as an early screening tool, whereas APACHE-II may be better suited for confirming mortality risk.

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INTRODUCTION

Malnutrition is an established risk factor for higher illness and death rates in many diseases.[1] Acute Respiratory Distress Syndrome (ARDS) is one such condition affected by nutrition.[2] As an acute and diffuse inflammatory condition of the lungs, ARDS results in increased vascular permeability in the lungs, an increase in overall lung mass, and a loss of tissue that normally contains air.[3] ARDS is characterized by a proinflammatory response associated with hypercatabolism, which can result in significant nutritional deficits. Poor nutritional status can further worsen the outcomes of ARDS patients.[2] ARDS has high morbidity and mortality rates; however, specific prognostic scores for ARDS have not been widely studied. Prognostic Nutritional Index (PNI) is a score or index first introduced by Buzby in 1980, used to evaluate the prognosis of patients undergoing gastrointestinal surgery.[4] PNI uses the formula: 10 x albumin (g/dl) + 0.005 x total lymphocyte count (mm^3).[5] PNI is frequently used as a predictor of outcomes in malignancies, such as gastrointestinal cancer,[6–10] oropharyngeal cancer,[11] ovarian cancer,[12] renal cancer,[13] lung cancer,[14] and brain cancer.[15]

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However, PNI has now additionally been connected to the prognosis of non-malignant conditions, including coronary artery disease and pneumonia.[5,16,17] According to a 2023 study by Manman Xu, patients with aneurysmal subarachnoid hemorrhage and a low PNI value faced higher rates of postoperative pneumonia.[17]

The intensive care unit (ICU) patient outcome scoring systems most commonly used today are Acute Physiology and Chronic Health Evaluation (APACHE)-II and Sequential Organ Failure Assessment (SOFA) score.[18] In the statistics of several studies, PNI has been reported to show no significant difference compared to APACHE-II score,[19] whereas PNI has never been compared with SOFA score. PNI appears to be usable as a prognostic score for ARDS,[20] but research on this matter remains limited.

Prognostic Nutritional Index has an advantage over both APACHE-II score and SOFA score in that it uses fewer variables. With its simplicity, PNI is expected to be capable of predicting ICU patient outcomes with fewer resources. Therefore, the researchers sought to compare PNI with APACHE-II score and SOFA score in predicting the outcomes of ICU patients with ARDS. The main research problems posed by this study concern how PNI, SOFA score, and APACHE-II score relate to outcomes for non-Covid-19 ARDS patients in the intensive care unit. In addition, this study also highlights the comparison of the predictive ability of these three indicators in predicting the outcomes of non-Covid-19 ARDS patients in the ICU. The broad goal of this study is a comparison of PNI, SOFA, and APACHE-II in forecasting non-Covid-19 ARDS patient outcomes after ICU admission. More narrowly, it examines each indicator's association with outcomes and assesses the three tools' prognostic accuracy.

RESEARCH METHODS

Study Type and Design

This study used an analytic observational research design with a retrospective cross-sectional approach. Data from non-Covid-19 ARDS patients were analyzed to compare the effectiveness of Prognostic Nutritional Index (PNI) with Sequential Organ Failure Assessment (SOFA) score and Acute Physiology and Chronic Health Evaluation (APACHE)-II score in predicting patient outcomes.

Population and Sample

The study population consisted of all non-Covid-19 ARDS patients admitted to the ICU (Intensive Care Unit) of RSPAL Dr. Ramelan (Dr. Ramelan Navy Central Hospital) Surabaya from 2022 to 2024. Patient data were extracted from electronic medical records.

Patient medical record data formed the research sample, drawn from a population meeting defined inclusion and exclusion criteria. Inclusion criteria specified ARDS patients on ventilation, age 18 or older, and ICU admission at RSPAL Dr. Ramelan Surabaya. Exclusion criteria included incomplete medical records, ARDS patients caused by Covid-19, and patients with a history of parenteral nutrition use.

The sample size in this study was determined using total sampling, meaning all medical records of inpatients in the ICU of RSPAL Dr. Ramelan Surabaya that met the criteria during a 3-year period from January 2022 to December 2024. The sampling technique used was also total sampling, so that the entire population meeting the study criteria was used as the research sample.

Research Variables

The variables in this research were separated into independent variables and dependent variables. Among the independent variables were the Prognostic Nutritional Index (PNI), the Sequential Organ Failure Assessment (SOFA) score, and the Acute Physiology and Chronic Health Evaluation (APACHE)-II score. Meanwhile, the dependent variables in this study were the outcomes of Acute Respiratory Distress Syndrome (ARDS) patients in the ICU, which included patient mortality, duration of mechanical ventilation use, and length of ICU stay.

The operational definitions of variables in this study encompass various clinical characteristics and assessment indicators of non-Covid-19 ARDS patients in the ICU of RSPAL Dr. Ramelan Surabaya. ARDS patients were defined as patients with acute respiratory distress within 1 week or less from symptom onset, with radiological findings of bilateral pulmonary opacities not caused by effusion, lung collapse, or nodules, and not due to cardiac failure or fluid overload, with mild severity (PaO2/FiO2 201-300), moderate severity (101-200), and severe severity (100 or below). Other variables such as age, sex, and body weight were used as baseline demographic data.

SOFA score was calculated within the first 24 hours of ICU care based on parameters of respiration, platelets, bilirubin, blood pressure, GCS, and creatinine, with score classifications of 5 or below and above 5. APACHE-II score was also calculated within the first 24 hours of care based on various physiological parameters, age, and chronic health conditions, with classifications of below 13 and 13 or above. As for PNI, its value came from a combination of serum albumin and lymphocyte count. This produced a result that was either below the threshold of 41.975 or at that threshold and higher.

Clinical patient outcomes included mortality (alive or deceased), ICU stay length (less than 7 days, 7–14 days, more than 14 days), and duration of mechanical ventilation (same categories). Non-COVID-19 status was determined by negative antigen and/or RT-PCR test results. A history of parenteral nutrition (yes or no) was recorded as an exclusion factor.

Research Location and Time

This study was conducted using electronic medical record data of non-Covid-19 ARDS patients in the ICU of RSPAL Dr. Ramelan Surabaya. The study was conducted immediately after the researchers obtained ethical clearance.

Data Collection and Acquisition Procedures

Data were collected from electronic medical records, including laboratory results, PNI values, SOFA scores, APACHE-II scores, and patient outcomes. Relevant data such as demographics, medical history, and patient characteristics were also retrieved.

Data Analysis

Comparative statistical analysis was performed to compare the effectiveness of PNI, SOFA score, and APACHE-II score in predicting ARDS patient outcomes. Logistic regression tests or other statistical methods were used to identify the relationship between independent variables (PNI, SOFA score, and APACHE-II score) and the dependent variable (ARDS patient outcomes). The statistical methods used in this study comprised Chi-Square, independent t-test, and logistic regression, among others. Which test was applied varied according to the type of data gathered and the research questions under investigation. Statistical significance was defined as $p < 0.05$, and the analysis of collected data was carried out using SPSS software.

RESEARCH RESULTS

Results of Descriptive Analysis of Research Subjects

This study enrolled non-Covid-19 Acute Respiratory Distress Syndrome (ARDS) patients who received intensive care at RSPAL Dr. Ramelan Surabaya from January 1, 2022 through December 31, 2024. An overview of their demographic data and clinical status is provided in the following tables.

Table 1. Description of research subjects (numerical data)

Variable	Mean	Median	SD	IQR	Min	Max	Shapiro-Wilk	
							W	p
Age	61.77	64	15.35	19.25	18	93	0.964	<0.001
ICU Length of Stay	10.08	7	9.61	9	1	101	0.745	<0.001
Ventilator Duration	9.05	6	9.31	9	1	101	0.731	<0.001
SOFA	8.49	8	3.28	5	2	19	0.981	<0.001
APACHE	27.22	27	7.53	11	4	51	0.997	0.307
PNI	28.74	28.36	6.94	8.75	10.8	53.9	0.992	0.004

Table 2. Description of research subjects (categorical data)

Variable	Category	Count	Percentage
Gender	Male	335	59.40%
	Female	229	40.60%
ARDS Severity	Mild	168	29.80%
	Moderate	132	23.40%
	Severe	264	46.80%
Surgery	Surgery	122	21.60%
	Non Surgery	442	78.40%
Origin	Emergency Department	330	58.50%
	Ward	230	40.80%
	Other	4	0.70%
Mortality	Deceased	493	87.40%
	Alive	71	12.60%
ICU Length of Stay	< 7 days	262	46.50%
	7-14 days	173	30.70%
	> 14 days	129	22.90%
Ventilator Duration	< 7 days	295	52.30%
	7-14 days	159	28.20%
	> 14 days	110	19.50%

A total of 564 patients with non-Covid-19 Acute Respiratory Distress Syndrome (ARDS) were included in the analysis for this study. All of them had been admitted to the ICU at RSPAL Dr. Ramelan Surabaya from January 1, 2022 through December 31, 2024. The numerical characteristics of the subjects showed that patient age had a median of 64 years with an interquartile range (IQR) of 19.25 years and an age range from 18 to 93 years. ICU length of stay was recorded with a median of 7 days (IQR 9, range 1-101

days), while the median duration of mechanical ventilator use was 6 days (IQR 8, range 1-101 days). Disease severity was reflected in the Sequential Organ Failure Assessment (SOFA) score with a median of 8 (IQR 5, range 2-19) and Acute Physiology and Chronic Health Evaluation (APACHE)-II score mean of 27.22 (SD 7.53, range 4-51). Patient nutritional status assessed using Prognostic Nutritional Index (PNI) showed a median of 28.36 (IQR 8.75, range 10.8-53.9). According to Shapiro-Wilk normality tests performed on all numerical variables, the data for age, ICU length of stay, ventilator duration, SOFA score, and PNI did not follow a normal distribution, as indicated by p values below 0.05. In contrast, only the APACHE-II score data were normally distributed, with a p value exceeding 0.05.

Categorical characteristics showed that the majority of patients were male, totaling 335 patients (59.4%), while female patients numbered 229 (40.6%). Based on ARDS severity, the largest group was severe ARDS with 264 patients (46.8%), followed by mild ARDS with 168 patients (29.8%) and moderate ARDS with 132 patients (23.4%). The majority of patients were in the non-surgery group, totaling 442 patients (78.4%), while patients who underwent surgery numbered 122 (21.6%). A total of 330 patients (58.5%) originated from the emergency department, 230 patients (40.8%) came from wards, while 4 other patients (0.7%) came from the High Care Unit, central ICU, operating room, and external hospitals.

Clinical outcomes showed a high mortality rate, with 493 patients (87.4%) deceased, while 71 patients (12.6%) were recorded as alive. Based on ICU length of stay, the majority of patients were hospitalized for less than 7 days totaling 262 patients (46.5%), while those hospitalized for 7-14 days numbered 173 patients (30.7%) and those hospitalized for more than 14 days numbered 129 patients (22.9%). A similar pattern was also observed in the duration of mechanical ventilator use, where the majority of patients used ventilators for less than 7 days totaling 295 patients (52.3%), followed by use for 7-14 days in 159 patients (28.2%) and more than 14 days in 110 patients (19.5%).

Results of Correlation Analysis (Bivariate) Between SOFA Score, APACHE-II Score, and PNI with ARDS Patient Outcomes

This subsection presents the results of the analysis of the strength of association between SOFA score, APACHE-II score, and PNI with ARDS patient outcomes. The ARDS patient outcomes in this study include 3 variables, namely duration of ventilator use (ventilator duration) and ICU length of stay, and patient mortality. The absence of normal distribution in the data led to the use of the Spearman correlation test. Key results from this analysis are summarized in the table that follows.

Table 3. Results of Spearman correlation test between SOFA score, APACHE score, and PNI with ARDS patient outcomes

Variable 1	Variable 2	Spearman rho	df	p
SOFA	ICU Length of Stay	-0.090	562	0.034
	Ventilator Duration	0.003	562	0.934
	Mortality	0.192	562	<0.001
APACHE	ICU Length of Stay	-0.106	562	0.012
	Ventilator Duration	0.013	562	0.764
	Mortality	0.213	562	<0.001
PNI	ICU Length of Stay	0.008	562	0.852
	Ventilator Duration	0.023	562	0.589
	Mortality	-0.174	562	<0.001

Based on the Spearman correlation test results, it can be seen that ARDS patient mortality has a statistically significant relationship with SOFA score, APACHE score, and PNI ($p < 0.001$), indicating that the degree of organ severity, physiological condition, and nutritional status play an important role in patient clinical outcomes. ICU length of stay had a significant relationship with SOFA score and APACHE-II score ($p < 0.05$ significance level), but was not closely related to PNI. Meanwhile, duration of mechanical ventilator use showed no significant relationship with SOFA score, APACHE score, and PNI (p greater than the 0.05 significance level).

Based on these correlation results, subsequent analysis was focused on the mortality outcome of ARDS patients, given that all three predictive variables, namely SOFA score, APACHE-II score, and PNI, all showed statistically significant relationships with mortality. Meanwhile, although ICU length of stay was significantly related to SOFA and APACHE-II scores, the PNI variable did not show a significant relationship, so not all predictors met the criteria for further analysis on that outcome. The duration of mechanical ventilator use was not continued in the predictive analysis because all three predictive variables did not show statistically significant relationships. Therefore, the

following subsection will focus on evaluating the predictive ability of SOFA score, APACHE score, and PNI on ARDS patient mortality through a more comprehensive multivariate analysis.

Results of Univariate Logistic Regression Analysis to Determine the Ability of SOFA Score, APACHE-II Score, and PNI in Predicting ARDS Patient Mortality

The analysis began with a univariate logistic regression approach, in which each predictor variable was analyzed separately against the mortality outcome. This approach aimed to evaluate the individual relationship between each score and the risk of death, while also assessing the strength of association and the direction of influence of each predictor before multivariate analysis was performed. The results of this univariate analysis served as the basis for assessing the potential of each variable as a predictor of ARDS patient mortality as well as a consideration in developing a more comprehensive predictive model. For every predictor variable, the results of univariate logistic regression analysis have been compiled and are presented in the following tables.

Table 4. Results of logistic regression analysis for predicting ARDS patient mortality based on SOFA score

Variables in the Equation							
		B	S.E.	Wald	df	p	Exp(B)
Step 1[a]	SOFA	0.197	0.045	19.358	1	0.000	1.218
	Constant	0.409	0.343	1.419	1	0.234	1.505
Model Summary							
Step	**-2 Log likelihood**	**Cox & Snell R Square**		**Nagelkerke R Square**			
1	405.179	0.038		0.071			
Hosmer and Lemeshow Test							
Step	**Chi-square**	**df**	**p**				
1	5.785	8	0.671				

Table 5. Results of logistic regression analysis for predicting ARDS patient mortality based on APACHE-II score

Variables in the Equation							
		B	S.E.	Wald	df	P	Exp(B)
Step 1[a]	APACHE	0.092	0.018	25.119	1	0.000	1.096
	Constant	-0.397	0.454	0.767	1	0.381	0.672
Model Summary							
Step	**-2 Log likelihood**	**Cox & Snell R Square**		**Nagelkerke R Square**			
1	399.487	0.048		0.089			
Hosmer and Lemeshow Test							
Step	**Chi-square**	**df**	**p**				
1	10.918	8	0.206				

Table 6. Results of logistic regression analysis for predicting ARDS patient mortality based on PNI

Variables in the Equation							
		B	S.E.	Wald	df	P	Exp(B)
Step 1[a]	PNI	-0.078	0.018	18.390	1	0.000	0.925
	Constant	4.293	0.588	53.369	1	0.000	73.158
Model Summary							
Step	**-2 Log likelihood**	**Cox & Snell R Square**		**Nagelkerke R Square**			
1	408.138	0.033		0.062			
Hosmer and Lemeshow Test							
Step	**Chi-square**	**df**	**p**				
1	2.791	8	0.947				

The findings from univariate logistic regression revealed that mortality in ARDS patients was significantly related to the SOFA score, the APACHE-II score, and the PNI. In the SOFA score analysis, a regression coefficient (B) of 0.197 was obtained with an odds ratio [Exp(B)] of 1.218 ($p < 0.001$), indicating that every one-point increase in SOFA score increases the probability of mortality by 21.8%. The -2 Log

Likelihood value of 405.179 and the Nagelkerke R Square value of 0.071 showed that SOFA score in the univariate analysis was capable of explaining approximately 7.1% of the variation in mortality events. In addition, the non-significant Hosmer and Lemeshow test result ($p = 0.671$) indicated that the model had a good fit between predicted probabilities and actual events.

Univariate logistic regression analysis of APACHE-II score also showed a significant relationship with ARDS patient mortality, with coefficient B of 0.092 and an odds ratio of 1.096 ($p < 0.001$). This means that every one-point increase in APACHE-II score increases the probability of death by 9.6%. This model had a -2 Log Likelihood value of 399.487 and a Nagelkerke R Square value of 0.089, indicating that APACHE-II score was capable of explaining approximately 8.9% of the variation in mortality, slightly higher than SOFA score. The Hosmer and Lemeshow test also showed a non-significant result ($p = 0.206$), indicating a reasonably good model fit.

Meanwhile, the analysis for PNI produced a negative regression coefficient ($B = -0.078$) and an odds ratio of 0.925 ($p < 0.001$). This finding means that higher PNI values correspond to lower mortality risk in ARDS patients. From a clinical perspective, each one-unit rise in PNI reduces the likelihood of death by roughly 7.5%. However, the relatively higher -2 Log Likelihood value (408.138) and the low Nagelkerke R Square value (0.062) showed that the ability of PNI to explain the variation in mortality in the univariate analysis was relatively limited compared to SOFA score and APACHE-II score. Nevertheless, the non-significant Hosmer and Lemeshow test ($p = 0.947$) still indicated that the model had adequate fit.

Overall, the results of univariate logistic regression analysis showed that SOFA score, APACHE-II score, and PNI individually had reasonably good and comparably balanced predictive ability in predicting ARDS patient mortality.

Based on the results of the univariate logistic regression analysis showing that SOFA score, APACHE-II, and PNI had different levels of association with ARDS patient mortality, further analysis was required to evaluate and compare the discriminatory ability of each score in distinguishing patients who died from those who survived. Therefore, in the following subsection, Receiver Operating Characteristic (ROC) curve analysis was used in order to determine the predictive accuracy of every predictor included in the study.

Results of ROC Curve Analysis to Assess the Predictive Accuracy of SOFA Score, APACHE-II Score, and PNI in Predicting ARDS Patient Mortality

ROC analysis was performed to evaluate the ability of each score to distinguish patients who died from those who survived, represented through the Area Under the Curve (AUC) value. This approach complemented the results of the univariate logistic regression analysis by providing a comprehensive picture of the discriminative performance of each predictor individually, and served as the basis for determining which score had the best predictive ability before multivariate predictive model development was undertaken.

The goal of ROC curve analysis was to assess the ability of SOFA score, APACHE-II score, and PNI to separate patients at elevated risk of death from those who lived. By identifying the best cut-off value, this model helps clinicians recognize patients with a high mortality risk and enables earlier medical intervention. Additional results from the evaluation included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the curve (AUC) for determining the accuracy of the predictive model.

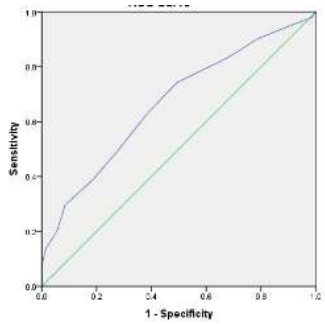

Figure 1. ROC curve of ARDS patient mortality based on SOFA score

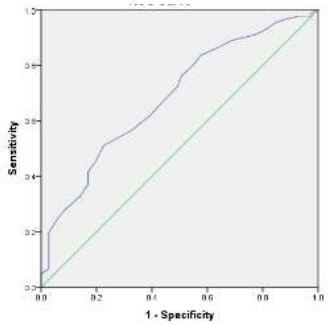

Figure 2. ROC curve of ARDS patient mortality based on APACHE-II score

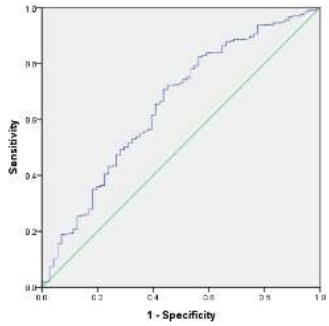

Figure 3. ROC curve of ARDS patient mortality based on PNI

From the ROC curve analysis results, one can observe that the ROC curves for SOFA score and APACHE-II score clearly exceeded the diagonal reference line. These curves also took on a sharper shape, with their location close enough to the upper left corner of the ROC area. This pattern showed that both scores had reasonably good discriminatory ability in distinguishing ARDS patients who died from those who survived, with a relatively optimal balance of sensitivity and specificity at various cut-off points. In contrast, the ROC curve for PNI showed a flatter curve and its position was closer to the diagonal line, indicating lower discriminatory ability compared to SOFA score and APACHE-II score. Overall, the shape and position of these ROC curves indicate that PNI has a predictive accuracy that is sufficiently comparable to mortality of ARDS patients when compared to disease severity-based predictors such as SOFA and APACHE-II, when each predictor is evaluated individually.

A more quantitative and objective assessment of predictive performance was carried out by comparing the Area Under the Curve (AUC) values as the main measure of discriminatory ability, as well as other diagnostic accuracy parameters including accuracy, sensitivity, and specificity. In this analysis, the determination of the optimal cut-off value for each score was based on the point providing the best balance between sensitivity and specificity, so that ARDS patients could be appropriately classified into high and low mortality risk groups. A comprehensive evaluation of AUC values and accuracy parameters at the optimal cut-off enabled a more meaningful comparison between SOFA score, APACHE-II score, and PNI, while also serving as the basis for identifying the most reliable and relevant predictor for use as a clinical prediction tool in ARDS patients. The following is a comparison of AUC values from the three predictors in predicting ARDS patient mortality.

Table 7. Comparison of Area Under Curve (AUC) values of ROC curves among the three predictors

Predictor	AUC Value
SOFA Score	0.667
APACHE-II Score	0.686
PNI	0.652

The comparison of Area Under the Curve (AUC) values showed that APACHE-II score had the highest discriminatory ability in predicting ARDS patient mortality with an AUC value of 0.686, followed by SOFA score with an AUC value of 0.667 and PNI with an AUC value of 0.652. All three AUC values fell in the moderate discriminatory ability category, indicating that disease severity-based scores had adequate accuracy in distinguishing patients who died from those who survived. These preliminary findings

indicated that APACHE-II score and SOFA score had slightly better predictive performance compared to PNI when used individually, with APACHE-II score showing a relative advantage in terms of discriminatory ability.

To assess whether the difference in AUC values between SOFA score, APACHE-II score, and PNI had statistically significant meaning, a DeLong test was subsequently performed as a comparative method to compare correlated ROC curves. This test was used to determine whether the differences in discriminatory ability among the three predictors truly reflected real differences in predictive performance, or were merely caused by sample variation. The results of the DeLong test between ROC curves are presented in the following table.

Table 8. Results of DeLong test for comparison of Area Under Curve (AUC) values of ROC curves among the three predictors

AUC Comparison		χ^2	p
SOFA	APACHE	0.11	0.7403
SOFA	PNI	0.66	0.4165
APACHE	PNI	0.38	0.5395

The DeLong test revealed that the discriminatory power of SOFA score, APACHE-II score, and PNI for predicting death in ARDS patients did not differ in a statistically meaningful way. Each p value was greater than the established significance level of 0.05. These findings indicated that PNI had a relatively comparable discriminatory ability compared to disease severity-based scores, namely SOFA and APACHE-II, in predicting ARDS patient mortality.

In addition to assessing how well each predictor could discriminate outcomes via AUC values, the study used ROC curve analysis to determine the optimal cut-off value for each one. These cut-off values indicate the point of greatest balance between sensitivity and specificity for predicting ARDS patient mortality. The purpose of setting these cut-off values was to create an objective system for sorting patients into high risk and low risk of death, one that can be used in everyday clinical practice. Below is a summary showing the optimal cut-off values alongside the sensitivity, specificity, and accuracy values for each predictive model.

Table 9. Comparison of sensitivity, specificity, and accuracy levels among the three predictors

Parameter	SOFA Score	APACHE-II Score	PNI
Optimal Cut-Off Value	7.5	27.5	31.303
Sensitivity	62.5%	51.1%	70.8%
Specificity	62.0%	77.5%	56.3%
Accuracy	62.4%	54.4%	69.0%

For SOFA score, the optimal cut-off value was 7.5, with sensitivity of 62.5% and specificity of 62.0%, and accuracy of 62.4%. These results showed that SOFA score had a reasonably good and stable ability to identify ARDS patients at risk of mortality, both in terms of sensitivity and specificity. Predictive accuracy of 62.4% reflects a sufficiently adequate predictive validity for use as a clinical risk stratification tool.

APACHE-II score showed slightly lower predictive performance than SOFA score, with an optimal cut-off value of 27.5, sensitivity of 51.1%, specificity of 77.5%, and accuracy of 54.4%. The sensitivity of APACHE-II score being lower than SOFA score indicated that SOFA score had a superior ability over APACHE-II score in detecting patients with mortality risk. On the other hand, the relatively higher specificity of APACHE-II score compared to SOFA score demonstrated the reliability of APACHE-II score in identifying surviving patients better than SOFA score.

Meanwhile, PNI with a cut-off value of 31.303 showed reasonably good predictive performance with sensitivity of 70.8%, specificity of 56.3%, and accuracy of 69.0%. The sensitivity of PNI was the highest compared to both other predictors, namely SOFA score and APACHE-II score. This means that most patients who died could be better detected using this PNI threshold. Predictive accuracy of 69.0% reflects a sufficient predictive validity for use as a clinical risk stratification tool.

Overall, the results of this analysis showed that the three predictors had different abilities in predicting ARDS patient mortality. PNI had the highest sensitivity of 70.8%, indicating a better ability to identify patients at risk of death, although its specificity was relatively low at 56.3%, so there was still a fairly high possibility of false positives. In contrast, APACHE-II score showed the highest specificity of 77.5%, meaning it was more accurate in identifying patients who did not experience mortality, but its sensitivity was the lowest

at 51.1%, potentially missing some mortality cases. Meanwhile, SOFA score showed relatively balanced sensitivity and specificity values of 62.5% and 62% respectively, but did not show a prominent advantage compared to the other two scores. Thus, PNI has more potential to be used as an early screening tool due to its high sensitivity, whereas APACHE-II is more appropriate for risk confirmation due to its better specificity, and SOFA can be considered as an indicator with moderate, relatively balanced ability in detecting ARDS patient mortality.

In addition, based on positive likelihood ratio (LR+) values, all three predictors showed relatively low discriminatory ability in increasing the probability of mortality in ARDS patients. APACHE-II score had the highest LR+ value of 2.27, indicating that patients with a positive result on this score had approximately 2.27 times greater probability of experiencing mortality compared to those who did not, although its predictive strength was still considered weak. Meanwhile, SOFA score and PNI had nearly similar LR+ values of 1.64 and 1.62, respectively, indicating that both scores only slightly increased the probability of mortality occurring. Overall, the LR+ values of all three predictors being still below 5 showed that their ability to confirm mortality risk remained limited, so their use would be more appropriate if combined with other clinical parameters to improve predictive accuracy.

Results of Chi-Square Test to Examine the Relationship Between Categorized SOFA Score, APACHE-II Score, and PNI with ARDS Patient Mortality

After cut-off values had been determined for SOFA score, APACHE-II score, and PNI, a chi-square test was conducted to examine the relationship between each categorized predictor and mortality outcomes among non-Covid-19 ARDS patients in the ICU. The three predictors, now divided into categories according to these cut-offs, were displayed as contingency tables. The chi-square test then assessed whether a statistically significant relationship existed between each predictor and ARDS patient mortality. The following tables show these contingency tables and the chi-square test results for SOFA score, APACHE-II score, PNI, and mortality in ARDS patients.

Table 10. Cross-tabulation and Chi-Square test results of the relationship between categorized SOFA score and ARDS patient mortality

SOFA Score	Mortality		Total	χ^2	p
	Deceased	Alive			
High SOFA Score (≥ 7.5)	308	27	335	15.379	<0.001
Low SOFA Score (< 7.5)	185	44	229		
Total	493	71	564		

A significant relationship emerged from the chi-square test between the cut-off-based categorization of SOFA score and death in non-Covid-19 ARDS patients admitted to the ICU. The chi-square statistic was 15.379, and the p value was less than 0.001. These findings indicated that the proportion of patients who died differed significantly between the groups with high SOFA score and low SOFA score, so that SOFA score had a very strong relationship with mortality outcomes in ARDS patients.

Table 11. Cross-tabulation and Chi-Square test results of the relationship between categorized APACHE-II score and ARDS patient mortality

APACHE-II Score	Mortality		Total	χ^2	p
	Deceased	Alive			
High APACHE-II Score (≥ 27.5)	252	16	268	20.328	<0.001
Low APACHE-II Score (< 27.5)	241	55	296		
Total	493	71	564		

APACHE-II score categorized based on the cut-off value also showed a highly significant relationship with ARDS patient mortality, with a chi-square value of 20.328 and $p < 0.001$. The chi-square value being larger compared to SOFA score indicated that APACHE-II score had a very strong relationship with mortality outcomes, reflecting the important role of physiological conditions and disease severity in determining ARDS patient prognosis.

Table 12. Cross-tabulation and Chi-Square test results of the relationship between categorized PNI and ARDS patient mortality

PNI Score	Mortality		Total	χ^2	p
	Deceased	Alive			
Low PNI (≤ 31.303)	349	31	380	20.780	<0.001
High PNI (> 31.303)	144	40	184		
Total	493	71	564		

The chi-square test results on Prognostic Nutritional Index (PNI) also showed a significant relationship with the mortality of non-Covid-19 ARDS patients in the ICU, with a chi-square value of 20.780 and $p < 0.001$. These findings showed that nutritional and systemic inflammatory status, as reflected by PNI, was significantly related to ARDS patient mortality outcomes.

Overall, the results of this chi-square test reinforced previous findings that all three predictors, namely SOFA score, APACHE-II score, and PNI, had significant relationships with non-Covid-19 ARDS patient mortality.

Although the chi-square test results showed a significant relationship between each categorized predictor and non-Covid-19 ARDS patient mortality, this analysis was not yet able to explain the independent contribution of each variable when considered simultaneously. In addition, the chi-square test also could not assess the relative magnitude of the influence of each predictor or the potential improvement in the predictive ability of the model if several variables were combined. Therefore, subsequent analysis was continued with multivariate logistic regression to evaluate the joint influence of SOFA score, APACHE-II score, and Prognostic Nutritional Index (PNI), and to obtain the most optimal predictive model in predicting non-Covid-19 ARDS patient mortality in the ICU.

Results of Multivariate Logistic Regression Analysis to Obtain the Best Predictive Model for Predicting ARDS Patient Mortality

After performing univariate logistic regression analysis to evaluate the ability of each predictor variable, namely Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation (APACHE)-II, and Prognostic Nutritional Index (PNI), in predicting Acute Respiratory Distress Syndrome (ARDS) patient mortality separately, the next step was to perform multivariate regression analysis. The previous univariate analysis showed that all three predictor variables independently had a significant influence on ARDS patient mortality. Nevertheless, the level of predictive ability of each variable was not entirely the same, where SOFA score and APACHE-II score showed relatively better predictive performance, while PNI tended to have a lower accuracy level compared to both scores.

Based on these findings, multivariate regression analysis was conducted to assess the predictive model built from a combination of all three variables simultaneously. The multivariate approach allowed researchers to evaluate the relative contribution of each score when entered together in one model, while also examining the combined influence of aspects of organ failure, acute physiological condition, and patient nutritional status on mortality risk. Thus, the multivariate regression model was expected to provide a more comprehensive picture of mortality prediction and improve the accuracy of risk estimation in ARDS patients. The multivariate logistic regression analysis conducted on the mortality prediction model for ARDS patients using SOFA score, APACHE-II score, and PNI produced the results shown below.

Table 13. Results of multivariate logistic regression analysis for predicting ARDS patient mortality based on SOFA score, APACHE-II score, and PNI

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1	SOFA	0.105	0.050	4.485	1	0.034	1.111
	APACHE	0.069	0.021	10.695	1	0.001	1.071
	PNI	-0.070	0.019	13.988	1	0.000	0.933
	Constant	1.476	0.768	3.696	1	0.055	4.377

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	378.963	0.082	0.154

Hosmer and Lemeshow Test			
Step	Chi-square	df	Sig.
1	9.662	8	0.290

The multivariate logistic regression analysis, as displayed in the Variables in the Equation table, revealed that SOFA score, APACHE-II score, and PNI together served as significant predictors for mortality among ARDS patients. This was indicated by the significance value of each variable, all of which were smaller than the 5% significance level ($p < 0.05$), indicating that all three variables had a statistically significant influence on the probability of mortality in ARDS patients when analyzed together in one model.

SOFA score had a coefficient B of 0.105 with a p value of 0.034 ($p < 0.05$), meaning it had a significant influence on mortality. An Exp(B) value of 1.111 indicated that every 1-point increase in SOFA score would increase the mortality risk by 11.1%, assuming other variables were constant.

APACHE-II score also showed a significant influence with coefficient B of 0.069 and p value of 0.001 ($p < 0.05$). An Exp(B) value of 1.071 showed that every 1-point increase in APACHE-II score increased mortality risk by 7.1%.

Meanwhile, PNI had a negative coefficient B of -0.070 with p value of 0.000 ($p < 0.05$), showing that this variable served as a protective factor. An Exp(B) value of 0.933 meant that every 1-unit increase in PNI would decrease mortality risk by 6.7%. This finding was consistent with the clinical concept that better nutritional status and immunological condition (indicated by a higher PNI value) was associated with a better prognosis in ARDS patients.

In general, based on the analysis results above, it can be stated that SOFA score and APACHE-II score served as risk factors that increased the probability of mortality, while PNI served as a protective factor that decreased mortality risk in ARDS patients.

Based on the Model Summary table, the Nagelkerke R2 value of 0.154 showed that approximately 15.4% of the variation in ARDS patient mortality in this study could be explained by the combination of three predictor variables in the model, namely SOFA score, APACHE-II score, and PNI, while the remainder was influenced by other factors outside the model that were not analyzed in this study.

Furthermore, the Hosmer-Lemeshow test results showed a significance value of 0.290 ($p > 0.05$), indicating that the logistic regression model built had reasonably good goodness-of-fit. In other words, there was no significant difference between the model's predicted values and the observed data, so the model could be considered sufficiently fit for use in predicting ARDS patient mortality.

Logistic Regression Model Equation

From the analysis findings described earlier, the multivariate logistic regression model that was derived may be expressed as a probability prediction for mortality, as shown below.

$$P_{(mortality)} = \frac{1}{1 + e^{-(1.476 + 0.105\,SOFA + 0.069\,APACHE - 0.070\,PNI)}}$$

This model enables the estimation of the probability of ARDS patient mortality based on the combination of SOFA score, APACHE-II score, and PNI values, so that it can be used as the basis for performing clinical risk stratification in patients with ARDS.

Results of ROC Curve Analysis of the Mortality Prediction Model Based on the Combination of SOFA Score, APACHE Score, and PNI

In the previous subsection, ROC curve analysis was performed separately on each predictor variable, namely SOFA score, APACHE score, and PNI, to assess the discriminatory ability of each variable in predicting ARDS patient mortality. Although this analysis provided a picture of the predictive performance of each parameter individually, this approach did not fully represent the clinical complexity of ARDS patients, which is generally influenced by various factors simultaneously. Therefore, in this subsection, ROC curve analysis was performed on the combined predictive model derived from the multivariate logistic regression results that integrated SOFA score, APACHE score, and PNI simultaneously. This analysis used the predicted probability values generated from the multivariate logistic regression model as the test variable against patient mortality outcome as the state variable. This approach aimed to evaluate the overall discriminatory ability of the model in distinguishing patients who experienced mortality from those who survived, represented through the AUC value. Consequently, this analysis aimed to deliver a fuller understanding of the predictive model's performance and to establish the optimal probability cut-off value when predicting mortality among ARDS patients in the ICU.

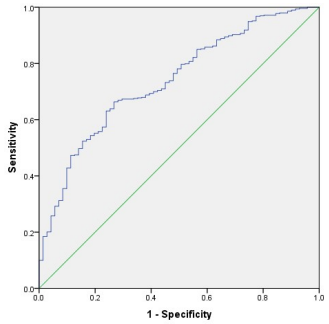

Figure 4. ROC curve of ARDS patient mortality based on combination of SOFA score, APACHE-II score, and PNI

Table 14. AUC value, optimal cut-off, sensitivity, and specificity of the mortality prediction model based on the combination of SOFA score, APACHE-II score, and PNI

Statistic	Value
AUC	0.738
Cut Off Optimal	0.744
Sensitivity	66.3%
Specificity	73.2%
Accuracy	67.2%

Based on the ROC curve formed, it can be seen that the curve was smoothly curved with a relatively symmetric peak curvature tending to approach the upper left corner of the graph. This pattern showed that the built prediction model had reasonably good discriminatory ability in distinguishing ARDS patients who experienced mortality from those who survived. The Area Under the Curve (AUC) value obtained of 0.738 showed that the predictive model had good discriminatory ability in predicting ARDS patient mortality. In addition, the AUC value of this combined model was also higher than the AUC values of each individual predictor variable (SOFA score, APACHE-II score, and PNI) analyzed separately in the previous subsection. This finding showed that the use of all three parameters simultaneously through the multivariate logistic regression model was capable of improving predictive ability in identifying mortality risk in ARDS patients compared to using each parameter individually.

The ROC curve generated from the prediction model combining SOFA score, APACHE-II score, and PNI showed a sufficiently smooth curve pattern with a relatively symmetric peak curvature approaching the upper left corner of the graph. This pattern indicated that the model had reasonably good discriminatory ability in distinguishing ARDS patients who experienced mortality from those who survived. Statistically, the AUC value obtained was 0.738, which fell in the good discrimination category.

An AUC value of 0.738 showed that the prediction model had approximately 73.8% probability of correctly distinguishing a random pair of patients between those who experienced mortality and those who did not. Notably, the AUC value of this combined model was higher than the AUC values of each predictor (SOFA score, APACHE-II score, and PNI) when analyzed separately in the previous subsection. This showed that the multivariate approach integrating several clinical indicators was capable of improving the accuracy of mortality prediction in ARDS patients.

Based on the ROC analysis, a probability cut-off value of 0.8797 was obtained, providing the optimal balance between model sensitivity and specificity. At this cut-off point, the model showed a sensitivity of 66.3% and a specificity of 73.2%. The sensitivity value indicated that approximately 66.3% of patients who experienced mortality could be correctly identified by the model, while the specificity value of 73.2% showed the model's ability to correctly classify patients who did not experience mortality.

Interpretively, the cut-off value of 0.8797 can be interpreted as meaning that patients with a predicted mortality probability of 0.8797 or above (87.97% or higher) based on the combined model of SOFA score, APACHE-II score, and PNI can be categorized as a high mortality risk group, while patients with a predicted probability below 0.8797 fall into the lower risk group. The establishment of this cut-off point provided practical value in the clinical context, as it could assist clinicians in performing more objective risk stratification of ARDS patients admitted. With this threshold, the prediction model also produced an accuracy value of 67.2%, showing that overall the model was capable of correctly classifying approximately two-thirds of cases.

Clinically, the improvement in the discriminatory ability of this model can be explained because the three variables used represent different but complementary physiological dimensions. The SOFA score indicates how much multiple organ dysfunction progresses during a patient's ICU stay. The APACHE-II score captures both illness severity and overall physiological status at the time of admission. The PNI, in contrast, reflects the patient's nutritional condition and immune function. The combination of these three parameters enabled the model to capture the spectrum of patient conditions more comprehensively, ranging from disease severity, organ failure, to immunonutritional status, all of which are known to play an important role in determining ARDS patient prognosis.

Overall, these findings showed that the use of predicted probabilities from the multivariate logistic regression model combining SOFA score, APACHE-II score, and PNI had the potential to be a sufficiently accurate clinical prediction tool in identifying ARDS patients with high mortality risk. This approach could provide a more objective basis for clinicians in performing early risk stratification, so that it was expected to support clinical decision-making and optimization of patient management strategies in the intensive care unit.

DISCUSSION

Characteristics of Research Subjects

This study involved 564 non-Covid-19 ARDS patients admitted to the ICU of RSPAL Dr. Ramelan Surabaya over a three-year period. Subject characteristics showed that the majority of patients were in the elderly age group with a median age of 64 years, indicating that this population belonged to the group with high vulnerability to poor ARDS outcomes. This was consistent with the literature stating that advanced age was associated with decreased physiological reserves and increased risk of multiple organ dysfunction, which overall contributed to increased mortality in critically ill patients, including ARDS.[21,22]

The distribution by gender revealed a predominance of male patients (59.4%), which aligns with multiple prior studies that have reported higher ARDS risk and worse prognosis for males. This was thought to be related to hormonal factors, inflammatory response, and the prevalence of risk factors such as smoking and comorbid diseases.[23]

The severity of ARDS in this study was dominated by severe ARDS (46.8%), reflecting that the patient population admitted to the ICU was a group with a high level of severity. This was consistent with the median SOFA score of 8 and APACHE-II score of 27, which indicated a significant level of organ dysfunction and disease severity. A cohort study by Lina Zhao found a median SOFA of 6 (4.0-9.0).[24] Research by Co Xuan Dao on mortality of ARDS patients in Vietnam found a median SOFA score of 10.0 (7.0-12.0), APACHE-II score of 18.0 (13.0-23.0), and mortality of 61.5%.[25] A high SOFA score was found by Wicaksono at Adam Malik Haji Hospital Medan with a median SOFA of 11.[26] The high proportion of severe ARDS was likely one of the main factors contributing to the high mortality rate in our study.

Patient nutritional status measured using PNI showed a median value of 28.36, indicating that the majority of patients were in a state of malnutrition or poor nutritional status. This condition was highly relevant in the context of ARDS, given that malnutrition and systemic inflammation could worsen organ dysfunction, interfere with the healing process, and increase the risk of complications and death. This confirmed that the initial nutritional status of patients before ICU admission was an important factor often overlooked in clinical practice.

The high mortality rate of 87.4% in this study showed that the study population was a group with very high risk. This high rate showed that ARDS remained a condition with poor prognosis, especially in a tertiary ICU setting. This figure was relatively higher than several international studies. Research by Dong-Hui Wang[22] in 2025 found an in-hospital mortality rate of 44.3% for ARDS patients, while a meta-analysis by Sadana[27] found an ARDS mortality rate of 41.8% for observational studies and 34.5% for randomized controlled trials. The high mortality rate in our study was likely influenced by several factors, such as the relatively high level of patient severity (median SOFA 8, APACHE 27), delayed referral, and limitations of ICU resources.

Relationship Between SOFA Score, APACHE-II Score, and Prognostic Nutritional Index (PNI) with ARDS Patient Outcomes

The correlation analysis results showed that SOFA, APACHE-II, and PNI had significant relationships with patient mortality ($p < 0.001$). This finding reinforced the concept that ARDS patient outcomes were not only determined by the degree of organ failure and disease severity, but also by nutritional status and inflammation.

SOFA score in our study showed a significant relationship with ARDS patient outcomes. This was consistent with the basic concept of SOFA as a tool to assess the degree of multiple organ dysfunction. In ARDS, organ failure did not only occur in the respiratory system, but could also involve the cardiovascular system (septic shock), renal system (acute kidney failure), and neurological system. An increase in SOFA score reflected the accumulation of organ dysfunction that directly contributed to mortality. Research by Lina Zhao stated a similar finding, namely that a high SOFA score was associated with higher survival.[24] Research by Son Ngoc Do stated that SOFA

score had poor in-hospital mortality prediction, but had better ICU mortality predictor ability than APACHE-II.[28] Research by Yu Xu showed that the trend of SOFA score changes (delta SOFA) was more meaningful than the initial value.[29] The study reported that shifts in SOFA score during the first 72 hours in the ICU led to better 28-day mortality forecasting. This improvement was most evident when the score changes were used together with age and the first-day baseline SOFA score. This showed that the early dynamics of disease progression were more important than a single measurement at ICU admission.[29]

APACHE-II score showed a positive relationship with mortality. This score represented the patient's acute physiological condition as well as chronic factors, so that an increase in the score reflected an increasingly poor clinical condition. This was consistent with research by Cu Xuan Dao where the median APACHE-II was higher in the deceased group (20.0) compared to the survivor group (15.0).[25]

PNI was negatively correlated with mortality, so that higher PNI scores were linked to reduced death risk. This finding underscored how important both nutritional status and the immune system are when determining the prognosis of ARDS patients. A low PNI reflected a combination of hypoalbuminemia and lymphocytopenia, which were indicators of severe inflammation and immune dysfunction. Research by Burcu Baran showed that lower PNI scores were found in the group that died from Community-Acquired Pneumonia.[30]

This study did not find a significant relationship between the three predictors and the duration of ventilator use. This showed that ventilator duration was likely more influenced by other factors such as ventilation strategies, complications, and clinical policies, rather than the initial patient scores. A study by Villar applied machine learning to predict the length of mechanical ventilation in ARDS. Villar determined that making this prediction for ARDS patients is not straightforward, given the many clinical factors that affect ventilation duration.[31]

This study found that ICU length of stay was significantly related to SOFA score and APACHE-II score. SOFA and APACHE-II showed the degree of multiple organ dysfunction and acute physiological severity at ICU admission. High severity caused longer recovery duration, more complex therapy, and very high mortality effects. Research by Takekawa showed a similar finding in which higher APACHE-II, APACHE-III, and SAPS-II scores were associated with longer ICU length of stay.[32]

This study found that ICU length of stay was not significantly related to PNI. Research by Zhijuan Zheng showed that a low PNI value was a risk factor for prolonged ICU stay in severe pneumonia with respiratory failure without blood transfusion (OR: 1.378, 95% CI: 1.073-1.769, p = 0.012). According to Zhijuan Zheng, blood transfusion could overcome tissue hypoxia in ICU patients, but blood transfusion could cause various complications and affect patient prognosis.[33] The difference between the results of this study and our study may be because in our study, therapies during ICU care were not analyzed, including blood transfusion.

Univariate logistic regression analysis showed that all three variables, namely SOFA, APACHE-II, and PNI, were significant predictors of ARDS patient mortality. SOFA score had an odds ratio of 1.218, indicating that every one-point increase increased the risk of death by 21.8%. This showed that SOFA was a sensitive indicator of changes in patient clinical conditions. APACHE-II score had an odds ratio of 1.096, indicating a 9.6% increase in mortality risk for every one-point increase. Although lower than SOFA, this score had slightly better predictive ability based on pseudo R2 values. PNI showed a protective role with an odds ratio of 0.925, meaning that every increase in PNI value decreased the risk of death by 7.5%. This confirmed that nutritional status was an important factor in determining critically ill patient outcomes. However, the relatively low pseudo R2 values in all three models showed that each variable individually was only capable of explaining a small portion of the variation in mortality. This confirmed that ARDS was a complex multifactorial condition.

ROC analysis showed that all three predictors had discriminatory ability in the moderate category, with the highest AUC value in APACHE-II (0.686), followed by SOFA (0.667), and PNI (0.652). Although there were numerical differences, the DeLong test showed that these differences were not statistically significant. This indicated that PNI had a relatively equivalent predictive ability to clinical severity-based scores.

This finding was highly important because it showed that a simple parameter such as PNI, which only required albumin and lymphocyte count, could have a predictive value comparable to complex scores such as APACHE-II and SOFA. From a clinical perspective, PNI had the highest sensitivity, making it better suited as an early screening tool. In contrast, APACHE-II had the highest specificity, making it better suited for risk confirmation. SOFA was between the two with a more balanced performance.

Multivariate analysis showed that all three variables remained significant when analyzed simultaneously. This showed that each variable made an independent contribution to mortality. SOFA and APACHE-II served as risk factors, while PNI served as a protective factor. Their combination reflected three important aspects in ARDS, namely Organ dysfunction (SOFA),

Physiological severity (APACHE-II), and Nutritional and immune status (PNI)

The Nagelkerke R^2 value of 15.4% showed that the model was capable of explaining some of the variation in ARDS patient mortality, although there were still other factors that played a role.

The combined model showed improved discriminatory ability with an AUC value of 0.738, which fell in the good category and was higher than each individual predictor. This showed that the multivariate approach was more capable of representing the clinical complexity of ARDS patients. The integration of multiple clinical dimensions enabled more accurate prediction. From a clinical standpoint, this model had great potential as a risk stratification tool, particularly in early identification of high-risk patients, determination of therapy priorities, and optimization of ICU monitoring.

The results of this study had several important clinical implications, namely that Prognostic Nutritional Index (PNI) could be used as a simple yet meaningful predictor in assessing the condition of non-Covid-19 ARDS patients in the ICU. In addition, the combined use of SOFA score, APACHE-II score, and PNI simultaneously could provide more accurate prediction results compared to using each indicator separately. This showed that a multidimensional approach was very necessary in determining ARDS prognosis, because the patient's condition was not only determined by one aspect alone, but was the result of complex interactions between organ dysfunction, inflammatory response, and nutritional status.

Nevertheless, this study faced several limitations. Its retrospective nature could have introduced bias, and because it was conducted at a single center, the findings may not apply to a wider population. In addition, there was a possibility of selection bias because the patients studied tended to be cases with more severe conditions, so they did not fully represent all ARDS patients. This study also did not perform serial score assessments, and had not considered several confounding factors such as underlying diseases that could affect patient outcomes. Other limitations included the non-inclusion of additional inflammatory biomarkers such as C-Reactive Protein (CRP) or procalcitonin, which could actually enrich the analysis. The relatively low pseudo R2 values also showed that there were still many other factors that had not been analyzed in this study. In addition, the high patient mortality rate could affect the data distribution and interpretation of study results.

CONCLUSION

Based on the research results, it can be concluded that Prognostic Nutritional Index (PNI) had a statistically significant relationship with ARDS patient mortality, but did not show a significant relationship with ICU length of stay or duration of mechanical ventilator use. SOFA score also showed a statistically significant relationship with ARDS patient mortality and had a significant relationship with ICU length of stay, but was not significantly related to duration of mechanical ventilator use. Likewise, the APACHE-II score demonstrated a significant link to mortality among ARDS patients and to ICU length of stay. Nevertheless, it did not show a significant connection with the number of days a patient spent on mechanical ventilation.

Further, SOFA score, APACHE-II score, and PNI individually had relatively similar discriminatory ability in predicting ARDS patient mortality, with accuracy levels in the moderate category and no statistically significant differences. Among the three, PNI had a predictive ability comparable to SOFA score and APACHE-II score, and even tended to have higher sensitivity, so it had the potential to be used as an early screening tool in risk assessment of ARDS patients in the ICU.

Based on these findings, it is recommended that a combination of SOFA score, APACHE-II score, and PNI can be used as an assistive tool in mortality risk stratification of ARDS patients in the ICU. In addition, future studies are recommended to add other variables such as inflammatory biomarkers or additional clinical parameters to improve the accuracy of the predictive model. Multicenter studies are also needed to perform external validation so that the results of this study can be applied more broadly across various clinical settings.

REFERENCES

1. Fauzy SN, Rebecca R, Negara TRBJP, Ayuningtami D, Ernawati E. Community Diagnosis Report on Reducing New Cases of Toddler Malnutrition Through Primary Health Care Interventions. Pharmacol Med REPORTS, Orthop Illn DETAILS. 2025 Jul 26;4(3):144–58.
2. Umbrello M, Marini JJ, Formenti P. Metabolic support in acute respiratory distress syndrome : A narrative review. J Clin Med. 2023;12(3216).
3. Liufu R, Wang CY, Weng L, Du B. Newly proposed diagnostic criteria for acute respiratory distress syndrome: Does inclusion of high flow nasal cannula solve the problem? J Clin Med. 2023;12(3).
4. Zhang X, Zhang J, Liu F, Li W, Zhang T. Prognostic nutritional index (PNI) as a predictor in patients with metabolic syndrome and heart failure. Diabetes, Metab Syndr Obes. 2023;16:2503–14.
5. Huang Y, Zhang Q, Li P, Chen M, Wang R, Hu J, et al. The prognostic nutritional index predicts all-cause mortality in critically ill patients with acute myocardial infarction. BMC Cardiovasc Disord. 2023;23(1):1–11.

6. Takahashi T, Kaneoka Y, Maeda A, Takayama Y, Fukami Y, Uji M. The preoperative prognostic nutrition index is a prognostic indicator for survival in elderly gastric cancer patients after gastrectomy: a propensity score-matched analysis. Updates Surg. 2020;72(2):483–91.
7. Okugawa Y, Toiyama Y, Oki S, Ide S, Yamamoto A, Ichikawa T, et al. Feasibility of assessing prognostic nutrition index in patients with rectal cancer who receive preoperative chemoradiotherapy. J Parenter Enter Nutr. 2018;42(6):998–1007.
8. Nakagawa S, Yamashita YI, Umezaki N, Yamao T, Okabe H, Imai K, et al. Serum marker score based on Prognostic Nutrition Index, Carcinoembryonic Antigen, and Carbohydrate Antigen 19-9 is associated with recurrence for patients undergoing surgery for pancreatic ductal adenocarcinoma. Pancreas. 2018;47(9):1130–4.
9. Kouzu K, Tsujimoto H, Sugasawa H, Ishibashi Y, Hase K, Kishi Y, et al. Modified geriatric nutrition risk index as a prognostic predictor of esophageal cancer. Esophagus. 2021;18(2):278–87.
10. Goh BKP, Kam JH, Lee SY, Chan CY, Allen JC, Jeyaraj P, et al. Significance of neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio and prognostic nutrition index as preoperative predictors of early mortality after liver resection for huge (≥10 cm) hepatocellular carcinoma. J Surg Oncol. 2016;113(6):621–7.
11. Oka T, Sato F, Ono T, Kawaguchi T, Murotani K, Sueyoshi S, et al. Prognostic values of systemic inflammation and nutrition-based prognostic indices in oropharyngeal carcinoma. Laryngoscope Investig Otolaryngol. 2023;8(3):675–85.
12. Pandey G, Patel B, Dave PS, Patel S, Arora R, Parekh C. Prognostic nutrition index and its significance in advanced ovarian cancer. Indian J Gynecol Oncol. 2020;18(3):1–5.
13. Ren W, Zhang H, Cheng L, Zhang Y, Yang C, Nie L, et al. Clinical significance of prognostic nutritional index (PNI)-monocyte-to-lymphocyte ratio (MLR)-platelet (PLT) score on postoperative outcomes in non-metastatic clear cell renal cell carcinoma. BMC Surg. 2023;23(1):1–13.
14. Matsubara K, Otani S, Yamamoto H, Tomioka Y, Shiotani T, Miyoshi K, et al. The impact of prognostic nutrition index on the waitlist mortality of lung transplantation. Gen Thorac Cardiovasc Surg. 2023;71(5):306–12.
15. Xu WZ, Li F, Xu ZK, Chen X, Sun B, Cao JW, et al. Preoperative albumin-to-globulin ratio and prognostic nutrition index predict prognosis for glioblastoma. Onco Targets Ther. 2017;10:725–33.
16. Ma M, Liu Y, Liu F, Li Z, Cheng Q, Liu Z, et al. Relationship between Prognostic Nutrition Index and New York Heart Association classification in patients with coronary heart disease: A RCSCD-TCM study. J Inflamm Res. 2022;15:4303–14.
17. Xu M, Zhang L, Wang J, Cheng L, Chen C, Li S, et al. Pre-operative prognostic nutrition index and post-operative pneumonia in aneurysmal subarachnoid hemorrhage patients. Front Neurol. 2023;14:1045929.
18. Godinjak A, Iglica A, Rama A, Tančica I, Jusufović S, Ajanović A, et al. Predictive value of SAPS II and APACHE II scoring systems for patient outcome in a medical intensive care unit. Acta Med Acad. 2016;45(2):97–103.
19. Soylu VG, İnan FÇ, Yılmaz A, Taşkın Ö, Demir U. Association between Prognostic Nutrition Index, Geriatric Nutrition Risk Index and 28-day mortality in critically very elderly patients (≥85 Years). Aging Med Healthc. 2023;14(2):85–91.
20. Li Y, Liu C, Luo X, He Q, Cheng Y, Shen W, et al. Controlling nutritional status score and prognostic nutrition index predict the outcome after severe traumatic brain injury. Nutr Neurosci. 2022;25(4):690–7.
21. Papamichalis P, Oikonomou KG, Xanthoudaki M, Papathanasiou SK, Skoura AL, Valsamaki A, et al. Length of stay, duration of mechanical ventilation, mortality, and acute kidney injury in acute respiratory failure requiring endotracheal intubation. WJCCM. 2025;14(4):1–14.
22. Wang D hui, Jia H miao, Zheng X, Xi X ming, Zheng Y, Li W xiong. Attributable mortality of ARDS among critically ill patients with sepsis : a multicenter , retrospective cohort study. BMC Pulm Med. 2024;24(110):1–11.
23. Bonanomi E, Cabrini L, Carlesso E, Castelli G, Cattaneo S, Cereda D, et al. Risk factors associated with mortality among patients with Covid-19 in Intensive Care Units in Lombardy, Italy. JAMA Intern Med. 2020;(3539):1–11.
24. Zhao L, Su F, Zhang N, Wu H, Shen Y, Liu H, et al. The impact of the new acute respiratory distress syndrome (ARDS) criteria on Berlin criteria ARDS patients : a multicenter cohort study. BMC Med. 2023;21(456):1–10.
25. Dao CX, Dang TQ, Luong CQ, Manabe T. Predictive validity of the sequential organ failure assessment score for mortality in patients with acute respiratory distress syndrome in Vietnam. Nature. 2025;15(7406):1–15.
26. Wicaksono DH. Correlation between total lymphocyte count and SOFA score in adult sepsis patients: A cross-sectional study in an ICU setting. Indones J Anesthesiol Reanim.

2026;8(1):42–7.
27. Sadana D, Kaur S, Sankaramangalam K, Saini I, Banerjee K, Siuba M, et al. Mortality associated with acute respiratory distress syndrome , 2009 – 2019 : a systematic review and meta-analysis. Crit Care Resusc. 2022;24(4):341–51.
28. Do SN, Dao CX, Nguyen TA, Nguyen MH. Sequential Organ Failure Assessment (SOFA) Score for predicting mortality in patients with sepsis in Vietnamese intensive care units : a multicentre, cross- -sectional study. BMJ Open. 2023;13(064870):1–14.
29. Chen M. Integrating dynamic SOFA changes and age to predict 28-day mortality in ICU patients : a nomogram and machine learning validation study. Front Med. 2026;12(1707548):1–11.
30. Baran B. Assessment of mortality risk in patients with acquired pneumonia : Role of novel inflammatory biomarkers. J Clin Lab Anal. 2025;39(70081):1–13.
31. Gonz M, Fern C, Soler JA, Ambr A, Pita-garc L, Fern L, et al. Predicting the length of mechanical ventilation in acute respiratory disease syndrome using machine learning : The PIONEER study. J Clin Med. 2024;13(13061811):1–13.
32. Takekawa D. Predict models for prolonged ICU stay using APACHE II , APACHE III and SAPS II scores : A Japanese multicenter retrospective cohort study. PLoS One. 2022;17(6):1–16.
33. Zheng Z, Yu M, Peng G, Xiao Y. Systemic Immune Inflammation Index (SII) and Prognostic Nutritional Index (PNI) associated with prolonged Intensive Care Unit (ICU) stay in patients with pneumonia complicated with respiratory failure. Int J Gen Med. 2025;18:1765–76.