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Association and Discriminatory Performance of Nutritional Risk and Illness Severity Scores for Low Vitamin D Status in Critically Ill Adults

Clara Alverina^{1*}, A. Yasmin Syauki¹, Nurpudji Astuti Daud¹,
Suryani As'ad¹, Haerani Rasyid^{1,2}, Nur Ashari¹

¹Department of Clinical Nutrition, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

²Department of Internal Medicine, Faculty of Medicine, Hasanuddin University, Indonesia

ABSTRACT: Low vitamin D status is common in critically ill patients, but whether routinely available nutritional-risk and illness-severity scores can identify patients with low serum 25-hydroxyvitamin D [25(OH)D] remains uncertain. This analytical cross-sectional study included 73 adult patients admitted to the intensive care unit of Dr. Wahidin Sudirohusodo General Hospital, Makassar, Indonesia. Nutritional risk was assessed using Nutritional Risk Screening 2002 (NRS-2002) and modified Nutrition Risk in the Critically Ill (mNUTRIC), while illness severity was assessed using Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA). Serum 25(OH)D was measured using a chemiluminescent microparticle immunoassay. Associations between clinical scores and serum 25(OH)D were evaluated using Spearman correlation, and discriminatory performance for low vitamin D status (<30 ng/mL) was assessed using receiver operating characteristic analysis. Low vitamin D status was present in 66 of 73 participants (90.4%). Serum 25(OH)D was not significantly correlated with NRS-2002 ($\rho=0.171$, $p=0.148$), modified NUTRIC ($\rho=0.223$, $p=0.058$), or SOFA ($\rho=-0.048$, $p=0.689$). APACHE II showed a weak positive correlation with 25(OH)D ($\rho=0.242$, $p=0.039$). None of the four scores demonstrated significant discrimination for low vitamin D status: AUCs were 0.576 for NRS-2002, 0.422 for modified NUTRIC, 0.345 for APACHE II, and 0.450 for SOFA. Routine nutritional-risk and illness-severity scores showed limited ability to identify low vitamin D status and should not be considered substitutes for direct serum 25(OH)D measurement.

1. INTRODUCTION

Low circulating 25-hydroxyvitamin D [25(OH)D] is common in critically ill adults [1]. Concentrations may reflect pre-existing vitamin D stores as well as reduced intake or absorption, altered metabolism, and acute fluid shifts during critical illness [2]. In a multicenter cohort of 662 ICU patients, 59% had 25(OH)D <20 ng/mL and only 10% had concentrations >30 ng/mL [2]. Another cohort of 1,091 critically ill adults found 25(OH)D <30 ng/mL in 72.4%, although deficiency was not independently associated with hospital mortality [3]. Vitamin D inadequacy is also common across Asia [4] and can persist in sunshine-abundant settings such as Thailand [5].

Nutritional risk and illness severity are routinely assessed in the ICU. ESPEN guidance recognizes NRS-2002 and NUTRIC-based approaches while noting limitations of available ICU screening tools [6]. In a prospective cohort, NRS-2002 and modified NUTRIC were associated with longer length of stay, prolonged mechanical ventilation, and 28-day mortality [7]. A meta-analysis of 31 studies involving 13,271 patients reported a summary AUC of 0.80 for modified NUTRIC in mortality prediction, with

substantial heterogeneity [8]. NRS-2002 and modified NUTRIC also showed prognostic discrimination for mortality in another ICU cohort [9].

A multicenter study further showed higher APACHE II, SOFA, and modified NUTRIC scores among patients with vitamin D deficiency [10]. However, such associations do not establish whether these routine scores can identify individual patients with low vitamin D status. This study therefore examined the associations of NRS-2002, modified NUTRIC, APACHE II, and SOFA with serum 25(OH)D and evaluated their ability to discriminate low vitamin D status (<30 ng/mL) among critically ill adults in tropical Indonesia.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This analytical cross-sectional study was conducted in the intensive care unit (ICU) of Dr. Wahidin Sudirohusodo General Hospital, Makassar, Indonesia, from April 1 to June 1, 2026. Each participant underwent a single study assessment to evaluate the relationships between routinely available nutritional-risk and illness-severity scores and serum 25-hydroxyvitamin D [25(OH)D] concentration.

2.2 Participants and Sampling

Adult patients admitted to the ICU during the study period were screened for eligibility using a total-sampling approach. Patients were eligible if they were older than 18 years, were beyond the initial ebb phase of critical illness, had complete information required to calculate the Nutritional Risk Screening 2002 (NRS-2002), modified Nutrition Risk in the Critically Ill (mNUTRIC) score, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, and Sequential Organ Failure Assessment (SOFA) score, and were undergoing their first ICU admission.

Patients were excluded if they had hyperparathyroidism, rickets, liver cirrhosis, chronic kidney disease, hematologic disease, malabsorption, chronic hepatitis, fatty liver disease, autoimmune disease, tuberculosis, or HIV/AIDS; had received vitamin D supplementation $>3,000$ IU/day during the preceding month; had a history of gastrointestinal surgery; had chronic pre-admission use of anticonvulsants, corticosteroids, diuretics, or immunosuppressants; were receiving cholestyramine, orlistat, or hormonal therapy; or were pregnant or breastfeeding. Anticonvulsants, corticosteroids, diuretics, or immunosuppressants initiated acutely during the index ICU admission were not considered exclusionary. Seventy-three eligible participants were included in the final analysis.

2.3 Nutritional Risk and Illness Severity Assessment

Nutritional risk was assessed using the NRS-2002 and modified NUTRIC scores. The NRS-2002 incorporates nutritional-status impairment, disease severity, and an age adjustment. The modified NUTRIC score was calculated without interleukin-6 and included age, APACHE II score, SOFA score, number of comorbidities, and duration of hospitalization before ICU admission.

Illness severity was assessed using APACHE II and SOFA scores. Information required for NRS-2002, including recent weight loss and dietary intake, was obtained directly from participants whenever possible or from family members when direct interviewing was not feasible. Clinical examination and medical-record data were used to obtain the physiological, laboratory, comorbidity, and ventilatory parameters required for the modified NUTRIC, APACHE II, and SOFA scores. All four clinical scores were determined during the same study assessment in which serum 25(OH)D was measured, after participants had progressed beyond the initial ebb phase of critical illness.

2.4 Laboratory Assessment and Vitamin D Classification

Venous blood was collected once at study enrollment, after participants had met the eligibility criteria and were beyond the initial ebb phase of critical illness. Serum 25(OH)D concentration was measured using a chemiluminescent microparticle immunoassay (CMIA). Vitamin D status was classified as deficiency at serum 25(OH)D <20 ng/mL, insufficiency at 20 to <30 ng/mL, and sufficient at ≥ 30 ng/mL. For the discrimination analysis, the <30 ng/mL threshold was prespecified to combine vitamin D deficiency and insufficiency into a single low-vitamin-D category, with concentrations ≥ 30 ng/mL serving as the sufficient reference category.

2.5 Study Outcomes

The primary outcome was serum 25(OH)D concentration analyzed as a continuous variable. Associations between serum 25(OH)D and NRS-2002, modified NUTRIC, APACHE II, and SOFA scores were evaluated individually. A secondary discrimination analysis evaluated the ability of each clinical score to distinguish participants with low vitamin D status (<30 ng/mL) from those with sufficient vitamin D status (≥ 30 ng/mL).

2.6 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Macintosh, Version 30.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean $\pm$ standard deviation (SD) when approximately normally distributed and as median with the first and third quartiles [median (Q1–Q3)] when non-normally distributed. Categorical variables were summarized as frequencies and percentages.

Because serum 25(OH)D was not normally distributed, associations with the clinical scores were evaluated using a nonparametric approach. Associations between serum 25(OH)D concentration and NRS-2002, modified NUTRIC, APACHE II, and SOFA scores were evaluated using Spearman rank correlation coefficients (ρ). Receiver operating characteristic (ROC) curve analysis was used to evaluate the discriminatory ability of each score for low vitamin D status. Low vitamin D status (<30 ng/mL) was specified as the positive state, with larger score values indicating greater evidence for the positive state. Areas under the ROC curve (AUCs) were estimated nonparametrically and reported with standard errors and 95% confidence intervals. Each AUC was tested against the null value of 0.50. Because only seven participants had sufficient vitamin D status, optimal cutoff values and their corresponding sensitivity and specificity estimates were not derived. All statistical tests were two-sided, with $p < 0.05$ considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Participant Characteristics

A total of 73 critically ill adults were included in the analysis. The mean age was 48.33 ± 16.66 years, and the sex distribution was nearly balanced between men and women. Most participants were postoperative patients (79.5%), and 65 patients (89.0%) required mechanical ventilation.

The median NRS-2002 score was 3.00 (Q1–Q3, 3.00–4.00), while the median modified NUTRIC score was 2.00 (1.00–3.00). Mean APACHE II and SOFA scores were 9.92 ± 4.62 and 6.10 ± 3.25 , respectively. The median serum 25-hydroxyvitamin D [25(OH)D] concentration was 21.00 ng/mL (17.05–25.45). Overall, 33 patients (45.2%) were vitamin D deficient, 33 (45.2%) were insufficient, and only 7 (9.6%) had sufficient vitamin D status. Thus, 66 of 73 participants (90.4%) had low vitamin D status (<30 ng/mL).

Table 1. Characteristics of the study participants (n=73)

Variable	Value
Age, years	48.33 $\pm$ 16.66
Sex, n (%)	
Male	37 (50.7)
Female	36 (49.3)
Primary diagnosis, n (%)	
Postoperative	58 (79.5)
Trauma	7 (9.6)
Ischemic stroke	4 (5.5)
Hemorrhagic stroke	2 (2.7)

Sepsis	2 (2.7)
Mechanical ventilation, n (%)	
Yes	65 (89.0)
No	8 (11.0)
NRS-2002 score	3.00 (3.00–4.00)
Modified NUTRIC score	2.00 (1.00–3.00)
APACHE II score	9.92 ± 4.62
SOFA score	6.10 ± 3.25
Serum 25(OH)D, ng/mL	21.00 (17.05–25.45)
Vitamin D status, n (%)	
Deficiency (<20 ng/mL)	33 (45.2)
Insufficiency (20–<30 ng/mL)	33 (45.2)
Sufficient (≥30 ng/mL)	7 (9.6)

Notes: Values are presented as mean ± SD, median (Q1–Q3), or n (%), as appropriate. NRS-2002, modified NUTRIC score, and serum 25(OH)D are presented as median (Q1–Q3). Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation II; NRS-2002, Nutritional Risk Screening 2002; NUTRIC, Nutrition Risk in the Critically Ill; SOFA, Sequential Organ Failure Assessment; 25(OH)D, 25-hydroxyvitamin D.

3.2 Associations between routine clinical scores and serum 25(OH)D

Spearman correlation analysis showed no significant association between serum 25(OH)D and NRS-2002 ($\rho=0.171$, $p=0.148$), modified NUTRIC score ($\rho=0.223$, $p=0.058$), or SOFA score ($\rho=-0.048$, $p=0.689$). APACHE II showed a weak positive correlation with serum 25(OH)D ($\rho=0.242$, $p=0.039$).

Table 2. Associations of nutritional risk and illness severity scores with serum 25(OH)D

Clinical score	n	Spearman ρ	p value
NRS-2002	73	0.171	0.148
Modified NUTRIC	73	0.223	0.058
APACHE II	73	0.242	0.039*
SOFA	73	−0.048	0.689

Notes: Associations with serum 25(OH)D were evaluated using Spearman rank correlation. All tests were two-sided. $p<0.05$ was considered statistically significant. Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation II; NRS-2002, Nutritional Risk Screening 2002; NUTRIC, Nutrition Risk in the Critically Ill; SOFA, Sequential Organ Failure Assessment; 25(OH)D, 25-hydroxyvitamin D. * $p<0.05$.

3.3 Discrimination of low vitamin D status

Receiver operating characteristic analysis was performed to assess whether the four routinely available clinical scores could discriminate participants with low vitamin D status (<30 ng/mL) from those with sufficient vitamin D status. The analysis included 66 participants with low vitamin D status and 7 with sufficient status.

None of the four scores demonstrated significant discriminatory ability. The AUC was 0.576 for NRS-2002, 0.422 for modified NUTRIC, 0.345 for APACHE II, and 0.450 for SOFA. All 95% confidence intervals included 0.50, and none of the AUCs differed significantly from chance discrimination.

Table 3. Discriminatory ability of routine clinical scores for identifying low vitamin D status

Clinical score	AUC	SE	95% CI	p value
NRS-2002	0.576	0.093	0.393–0.758	0.512
Modified NUTRIC	0.422	0.103	0.220–0.624	0.500
APACHE II	0.345	0.088	0.174–0.517	0.180
SOFA	0.450	0.098	0.259–0.641	0.667

Notes: Low vitamin D status was defined as serum 25(OH)D <30 ng/mL. ROC analyses were specified a priori so that higher clinical scores indicated greater evidence for low vitamin D status. AUCs and standard errors were estimated nonparametrically. All tests were two-sided. Abbreviations: AUC, area under the receiver operating characteristic curve; CI, confidence interval; SE, standard error; APACHE II, Acute Physiology and Chronic Health Evaluation II; NRS-2002, Nutritional Risk Screening 2002; NUTRIC, Nutrition Risk in the Critically Ill; SOFA, Sequential Organ Failure Assessment.

ROC curves for the four clinical scores are shown in Figure 1. Consistent with the AUC estimates, the curves remained close to the reference line and did not demonstrate clinically useful discrimination between participants with low and sufficient vitamin D status.

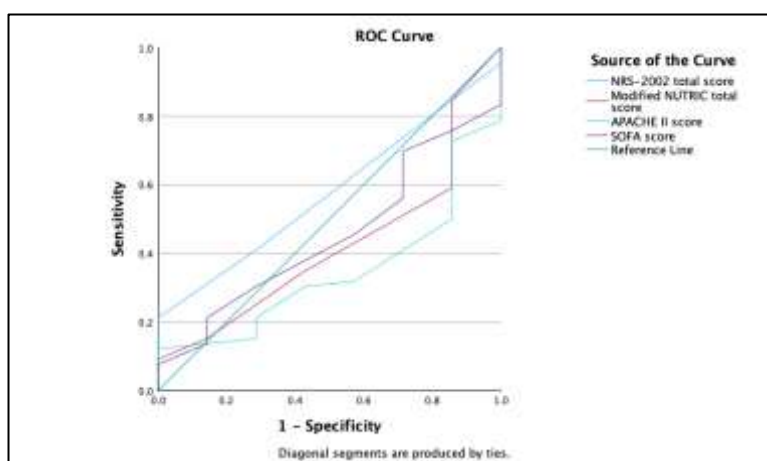


Figure 1. Receiver operating characteristic curves of NRS-2002, modified NUTRIC, APACHE II, and SOFA scores for identifying low vitamin D status (<30 ng/mL)

3.4 Discussion

The present study showed that low vitamin D status was highly prevalent among critically ill adults, with 90.4% having serum 25-hydroxyvitamin D [25(OH)D] <30 ng/mL. Despite this, routine nutritional-risk and illness-severity scores showed limited correspondence with vitamin D status. NRS-2002, modified NUTRIC, and SOFA were not significantly correlated with serum 25(OH)D, whereas APACHE II showed only a weak positive correlation. None of the four scores demonstrated significant discrimination for low vitamin D status on ROC analysis. Thus, prognostic or nutritional-risk information from these scores should not be assumed to reflect micronutrient-specific status.

The high prevalence is consistent with ICU literature, although comparisons require caution because thresholds differ. Chen et al. (2021) reported 25(OH)D <20 ng/mL in 59% of 662 critically ill patients [2], while Xie et al. (2022) found 25(OH)D <30 ng/mL in 72.4% of 1,091 critically ill adults [3]. Sistanian et al. (2024) reported deficiency <20 ng/mL in 69.1% of 236 ICU patients [10]. In Indonesia, Asdie et al. (2023) found that very low 25(OH)D (<8.1 ng/mL) was independently associated with higher 28-day mortality in sepsis [11]. Li and Ding (2020) similarly found severe deficiency (<10 ng/mL), but not milder deficiency or insufficiency, to be associated with mortality in sepsis [12]. Vitamin D inadequacy is also common across Asia [4] and can persist in sunshine-abundant settings [5].

The absence of significant associations for NRS-2002 and modified NUTRIC is clinically plausible because these instruments characterize nutritional risk and prognosis rather than micronutrient-specific deficiency. ESPEN recognizes NRS-2002 and NUTRIC-based approaches while emphasizing limitations of existing ICU screening tools [6]. Majari et al. (2021) found both scores associated with longer stay, prolonged mechanical ventilation, and 28-day mortality [7], whereas Guliyeva et al. (2024) demonstrated mortality discrimination [9]. A meta-analysis of 31 studies reported a summary AUC of 0.80 for modified NUTRIC in mortality prediction, although heterogeneity was substantial [8]. Their prognostic value therefore does not imply that they should track circulating 25(OH)D.

The APACHE II finding warrants attention. APACHE II was weakly and positively correlated with serum 25(OH)D ($\rho=0.242$; $p=0.039$), meaning that higher scores were associated with slightly higher rather than lower 25(OH)D concentrations. This differs from Sistanian et al. (2024), who observed higher APACHE II, SOFA, and modified NUTRIC scores among vitamin D-deficient patients [10]. Chen et al. (2021) also identified higher SOFA as independently associated with deficiency [2]. Conversely, Lim et al. (2021) found no significant differences in APACHE II or SOFA between trauma ICU patients with 25(OH)D <20 and ≥ 20 ng/mL [13], indicating that these relationships are not uniform across ICU populations.

A plausible explanation lies partly in the structure of APACHE II. APACHE II incorporates age, acute physiological abnormalities, and chronic health status, whereas SOFA evaluates acute organ dysfunction without an age component [10]. Younger age was independently associated with vitamin D deficiency in critically ill Taiwanese patients [2], and with lower 25(OH)D in a national Thai survey [5]. The age component of APACHE II may therefore have contributed to the unexpected positive direction. The absence of a corresponding relationship for SOFA is compatible with this interpretation, although the cross-sectional design cannot establish age as the explanation.

The ROC findings reinforce this caution. AUCs ranged from 0.345 to 0.576 and none differed significantly from 0.50. The APACHE II AUC of 0.345 is directionally consistent with its positive correlation with 25(OH)D because low vitamin D was the positive state while higher APACHE II scores were prespecified to indicate greater evidence of low vitamin D. However, this does not mean that APACHE II identifies vitamin D sufficiency. Only seven participants had sufficient vitamin D status, making the reference group small and the estimates imprecise. The appropriate interpretation is limited discriminatory performance in this cohort.

Biological variability during critical illness may also weaken the correspondence between clinical scores and total 25(OH)D. Palmer et al. (2022) found lower total 25(OH)D in critically ill patients than controls while calculated free 25(OH)D was not lower, showing that total and unbound concentrations can diverge [14]. Jonsdottir et al. (2022) found multiple vitamin D metabolites to be low during critical illness and to rise substantially after recovery [15]. Cameron et al. (2024) showed lower 1,25(OH)₂D in critically ill patients with moderate-to-severe acute kidney injury despite no difference in 25(OH)D [16], indicating that metabolic disturbance may not be captured by total 25(OH)D alone. Subramanian et al. (2022) highlighted the influence of vitamin D-binding protein and albumin on total 25(OH)D interpretation in hospitalized COVID-19 [17], while Kahar et al. (2023) found lower vitamin D-binding protein and vitamin D concentrations associated with mortality in patients with sepsis [18].

A strength was evaluating two nutritional-risk and two illness-severity scores together and extending analysis from correlation to discrimination. Limitations include the single-center cross-sectional design, modest sample size, predominance of postoperative patients, only seven participants with sufficient vitamin D status, and a single 25(OH)D measurement not standardized to an exact ICU day. These factors limit causal interpretation and ROC precision. Residual confounding also cannot be excluded, particularly from age and other determinants of vitamin D status that were not comprehensively adjusted for in the primary analyses. The findings concern identification rather than treatment. Peng et al. (2020) found no mortality reduction with vitamin D supplementation [19], whereas Menger et al. (2022) reported a possible mortality benefit but emphasized heterogeneity and limited generalizability [20]. Accordingly, the present results should not be interpreted as evidence for or against supplementation. In this cohort, the four routine scores did not demonstrate sufficient discrimination to substitute for direct serum 25(OH)D measurement when vitamin D status itself was the clinical question.

4. CONCLUSION

Low vitamin D status was highly prevalent among critically ill adults, affecting 90.4% of participants. NRS-2002, modified NUTRIC, and SOFA scores were not significantly correlated with serum 25-hydroxyvitamin D [25(OH)D], while APACHE

II showed only a weak positive correlation. Importantly, none of the four routinely available scores demonstrated significant discriminatory ability for identifying low vitamin D status. The unexpected direction of the APACHE II association may partly reflect the age component incorporated within the score rather than an independent relationship between illness severity and vitamin D status. These findings indicate that nutritional-risk and illness-severity scores provide different clinical information from serum 25(OH)D and should not be considered surrogate markers of vitamin D status. Larger multicenter studies with more balanced vitamin D categories, standardized sampling times, and serial 25(OH)D measurements are warranted to clarify these relationships across diverse critically ill populations.

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AUTHOR CONTRIBUTIONS

Clara Alverina: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing – Original Draft, and Project Administration.

A. Yasmin Syauki: Conceptualization, Methodology, Supervision, Validation, Interpretation of Findings, and Writing – Review & Editing.

Nurpudji A. Daud: Conceptualization, Methodology, Supervision, Validation, Interpretation of Findings, and Writing – Review & Editing.

Suryani As'ad: Methodology, Validation, Interpretation of Findings, and Writing – Review & Editing.

Haerani Rasyid: Methodology, Validation, Interpretation of Findings, and Writing – Review & Editing.

Nur Ashari: Methodology, Validation, Interpretation of Findings, and Writing – Review & Editing.

All authors critically reviewed the manuscript, approved the final version, and agreed to be accountable for the accuracy and integrity of the work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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ETHICS STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia (Protocol No. UH26010149; Approval No. 249/UN4.6.4.5.31/PP36/2026). Written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional restrictions.

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