SYSTEMATIC REVIEW AND META-ANALYSIS

Prognostic performance of GNRI versus PNI for predicting mortality in elderly critically ill patients: A systematic review and meta-analysis

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Abstract

Background: Malnutrition significantly impacts outcomes in elderly critically ill patients. The Geriatric Nutritional Risk Index (GNRI) and Prognostic Nutritional Index (PNI) are two established tools to assess nutritional status and predict mortality. However, their comparative prognostic performance in this population remains unclear.

Objective: This study aimed to compare the predictive ability of GNRI and PNI for mortality among elderly ICU patients.

Methods: We conducted a systematic search in PubMed, Scopus, and Web of Science for studies assessing GNRI and/or PNI in relation to mortality in ICU patients aged ≥60 years. We extracted mean and standard deviation values for survivors and non-survivors. Meta-analyses were conducted to calculate pooled mean differences (MD) with 95% confidence intervals (CI), and heterogeneity was evaluated using the I^2 statistic.

Results: Eight studies involving 6,217 ICU patients were included. Both GNRI and PNI scores were significantly lower in non-survivors. The pooled MD for GNRI was −8.99 [95% CI −9.71 to −8.27] (I^2 = 86%), and for PNI was −4.45 [95% CI −4.94 to −3.96] (I^2 = 47%). GNRI showed a larger effect size but greater heterogeneity, while PNI results were more consistent. Most studies had low to moderate risk of bias based on the ROBINS-E tool.

Conclusion: GNRI and PNI are valid prognostic tools for predicting mortality in elderly ICU patients. GNRI may provide stronger predictive value, whereas PNI offers more consistent prognostic performance.

Keywords: GNRI, PNI, elderly, ICU, mortality, nutritional assessment

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Introduction

Malnutrition is highly prevalent among elderly individuals admitted to the intensive care unit (ICU), with estimates ranging from 30% to 60% depending on the population and diagnostic criteria used[1]. This condition is associated with impaired immune responses, prolonged hospital stays, increased complication rates, and higher mortality. Elderly patients are especially vulnerable due to multiple comorbidities, reduced physiological reserves, and altered metabolic responses to critical illness.[1]

To assess nutritional risk and predict adverse outcomes in this population, various screening tools have been developed. Among them, the Geriatric Nutritional Risk Index (GNRI) and the Prognostic Nutritional Index (PNI) are widely used due to their simplicity, reliance on routinely available laboratory parameters, and reported prognostic value. GNRI incorporates serum albumin and the ratio of actual to ideal body weight, whereas PNI is calculated from serum albumin and total lymphocyte count, reflecting both nutritional and immunological status.[3]

Previous studies have demonstrated the association between low GNRI or PNI values and increased mortality in various populations, including patients with sepsis, trauma, cardiovascular disease, and elderly ICU patients. However, comparative evidence on the predictive strength of GNRI versus PNI in critically ill elderly patients remains inconsistent. For instance, Kim et al. found GNRI had better predictive accuracy than PNI for in-hospital mortality after acute myocardial infarction, while Shao et al.[2] reported similar prognostic abilities of both indices in a large ICU cohort. Furthermore, studies by Soylu et al. and Taskın et al.[9] in older ICU patients supported the prognostic value of both indices, but with varying cutoff sensitivities and specificities.

Given these variations and the lack of a definitive comparison, this study aimed to systematically review and quantitatively synthesize the current evidence on the prognostic performance of GNRI and PNI in predicting mortality among elderly critically ill patients. Clarifying which index provides superior prognostic performance is clinically important, as it may guide ICU clinicians in selecting a more reliable, simple, and cost-effective tool for early risk stratification and timely nutritional interventions, thereby potentially improving survival outcomes in elderly critically ill patients.

Methods

Search strategy

This systematic review and meta-analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[5] The review protocol was registered in PROSPERO under the registration number CRD420251086421. A systematic search was conducted in PubMed, Scopus, and Web of Science databases from inception to July 2025. The search strategy used Boolean operators and MeSH terms, combining the following keywords: "Geriatric Nutritional Risk Index", "GNRI", "Prognostic Nutritional Index", "PNI", "elderly", "intensive care", "ICU", and "mortality". The complete search strings for each database are presented in Supplementary Table S1 to ensure reproducibility. For example, the PubMed search strategy was: ("Geriatric Nutritional Risk Index" OR GNRI) AND ("Prognostic Nutritional Index" OR PNI) AND (elderly OR aged OR "older adults") AND ("intensive

care unit" OR ICU) AND (mortality OR survival). Equivalent search terms and syntax were adapted for Scopus and Web of Science. In addition to database searches, we also screened grey literature sources including ClinicalTrials.gov, medRxiv, and relevant conference abstracts to minimize potential publication bias. However, no additional eligible studies were identified from these sources. The full search strategy is available upon request. References of relevant articles were also manually screened to identify additional eligible studies.

Eligibility criteria

We included original observational studies (cohort or cross-sectional) that evaluated the prognostic utility of the Geriatric Nutritional Risk Index (GNRI) and/or Prognostic Nutritional Index (PNI) in predicting mortality among elderly critically ill patients aged ≥60 years admitted to the intensive care unit (ICU). Studies were eligible if they reported GNRI and/or PNI values (mean ± standard deviation) for survivors and non-survivors. Only studies published in English were included. Studies involving pediatric populations, non-ICU settings, or lacking outcome data were excluded.

Study selection

All reviewers independently screened titles and abstracts. Full texts of potentially relevant articles were assessed against the eligibility criteria. Discrepancies were resolved by consensus or consultation with a third reviewer. The selection process is depicted in the PRISMA 2020 flow diagram. In line with PRISMA 2020 recommendations, the flow diagram provides a transparent overview of the number of records identified, screened, excluded, and finally included.

Data extraction

Data were extracted using a standardized form and included: author name, publication year, country, patient population, sample size, mean ± SD of GNRI and/or PNI for both survivors and non-survivors, and mortality outcomes. Data extraction was independently performed by two reviewers (DP and AH) to ensure accuracy.

Quality of assessment

The ROBINS-E (Risk of bias in non-randomized studies of exposures) tool was applied to evaluate the methodological quality across seven domains, including confounding, selection of participants, classification of exposures, and outcome measurement. The risk of bias in each study was classified as low, some concern, high, or very high according to the ROBINS-E criteria.

Data synthesis and statistical analysis

Meta-analyses were performed using Review Manager (RevMan) version 5.4.1. Continuous outcomes (GNRI and PNI scores) were summarized using pooled mean differences (MDs) with 95% confidence intervals (CIs). Heterogeneity was assessed using the I^2 statistic, with values >50% considered substantial. Both fixed-effect and

random-effects models were applied for sensitivity analysis. Forest plots were generated to visualize pooled effects. Funnel plots were used to explore potential publication bias.

Results

Study selection

A total of 148 records were identified through database searching. After removing 36 duplicates, 112 titles and abstracts were screened. Of these, 21 full-text articles were assessed for eligibility. Thirteen studies were excluded due to insufficient data or ineligible outcomes, resulting in 8 studies included in the final meta-analysis. The selection process is illustrated in the PRISMA flow diagram (**Figure 1**).
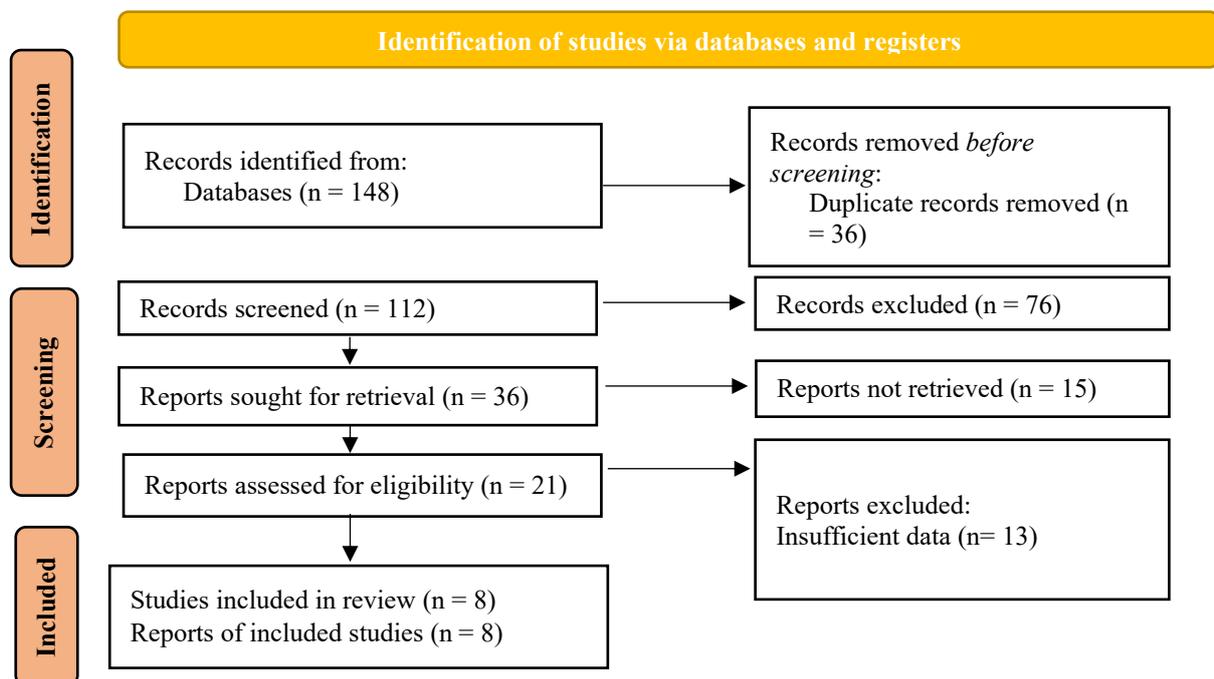
Figure 1. Prisma flowchart, stages of study selection flowchart for systematic review and meta-analysis

Study characteristics

The 8 included studies involved a total of 6,217 elderly ICU patients. Sample sizes ranged from 91 to 2,060 participants, with populations including trauma patients, sepsis cases, very elderly ($\geq$85 years), and patients on mechanical ventilation. GNRI and PNI scores were reported as mean $\pm$ standard deviation (SD) for both survivors and non-survivors. **Table 1** summarizes the study characteristics and findings.

Table 1. Study characteristics and findings

Author, Year	Country	Population	Number of Samples		GNRI Score (Mean ± SD)		PNI Score (Mean ± SD)		Outcome
			Death	Survivor	Death	Survival	Death	Survival	
Rau et al., 2023 [6]	Taiwan	ICU trauma patients (n=1126)	138	988	94.4 ± 14.7	99.8±12.5	41.6 ± 11.4	44.8±9.4	GNRI significantly predicted mortality, PNI was not significant
Hiramatsu et al., 2019[7]	Japan	Elderly undernourished patients (n=230)	90	140	61.0 ± 73.4	64.3 ± 78.2	23.3 ± 32.5	25.8 ± 34.5	GNRI slightly better but not statistically significant
Kim et al., 2021[8]	Republic of Korea	Acute myocardial infarction patients (n=1147)	86	1061	97.8 ± 4.30	108.30 ± 0.89	49.03 ± 3.33	54.30 ± 0.81	GNRI had significantly higher predictive accuracy (AUC) compared to PNI
Kollu et al., 2024[1]	Turkey	Elderly ICU patients (≥65 years, n=153)	66	87	82.9 ± 9.6	87.8 ± 10.2	33.6 ± 7.5	37.5 ± 7.5	Both GNRI and PNI significantly predicted ICU mortality; similar predictive performance (AUC)
Soylu et al., 2022 [3]	Turkey	Very elderly ICU patients (≥85 years, n=189)	123	66	90.36± 11.44	94.77±10.42	32.04 ±6.54	34.32±6.40	GNRI slightly better with higher sensitivity & specificity
Kyo et al., 2023[4]	Japan	Patients with sepsis (n=32,159)	67	178	83.13 ± 12.59	89.37 ± 9.7	32.77 ± 5.93	36.57 ± 6.07	Both GNRI and PNI significantly predicted mortality, sharp increase risk GNRI<100, PNI<40
Shao et al., 2021[2]	USA	ICU patients (n=2060)	108	151	86.37 ± 11.26	98.27 ± 9.63	34.67 ± 4.59	38.63 ± 4.59	Both GNRI and PNI significantly predicted ICU mortality, similar predictive ability
Taşkın et al., 2023 [9]	Turkey	ICU patients on mechanical ventilation (n=91)	46	44	87.93 ± 6.22	92.33 ± 7.19	31.87 ± 4.74	36.27 ± 3.78	Both GNRI and PNI significantly predicted mortality

GNRI and PNI performance on mortality prediction

Across all studies, both GNRI and PNI scores were consistently lower in non-survivors compared to survivors. Pooled analysis demonstrated that non-survivors had significantly lower GNRI scores, with a mean difference (MD) of −8.99 [95% CI: −9.71 to −8.27], indicating a strong association between poor nutritional status and higher mortality. The forest plot illustrating this result under the fixed-effect model is shown in **Figure 2**. However, due to considerable statistical heterogeneity (I² = 86%), we performed a sensitivity analysis using a random-effects model, which yielded comparable results, confirming the robustness of the finding (**Figure 2**).
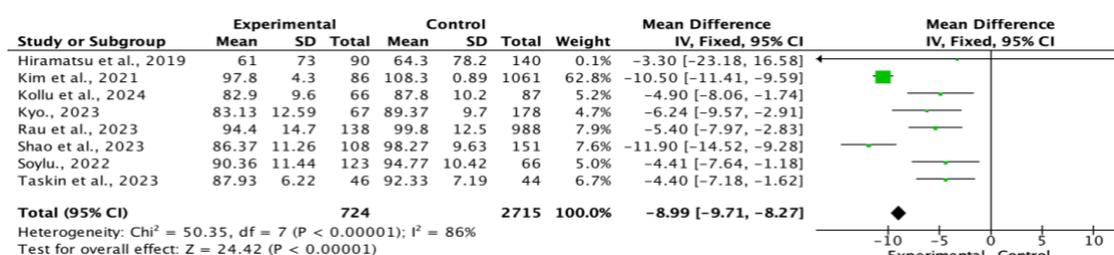

Figure 2. Forest plot showing the association between GNRI and mortality under the fixed-effect model.

Similarly, analysis of PNI showed that lower PNI scores were significantly associated with mortality, with a pooled mean difference of −4.45 [95% CI: −4.94 to −3.96]. The heterogeneity for PNI was moderate (I² = 47%), and the consistency of the outcome across studies was better than that for GNRI. Forest plots of PNI under both fixed-effect and random-effects models are shown in **Figures 3**, respectively.

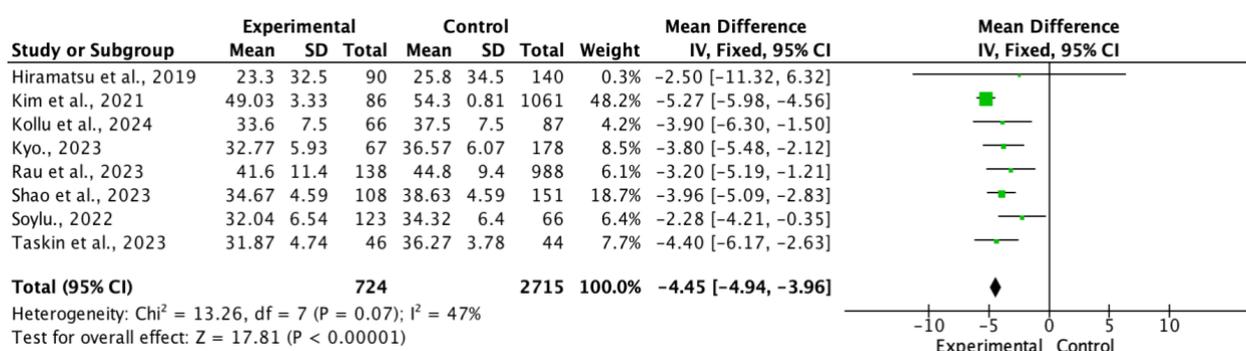**Figure 3**. Forest plot showing the association between PNI and mortality under the fixed-effect model.

Risk of bias

Risk of bias for each study was assessed using the ROBINS-E (Risk of bias in non-randomized studies of exposures) tool. Most studies were judged to be of low risk to some concern, with no study excluded due to critical bias. A visual summary of the risk assessment across seven domains is presented in **Figures 4.**
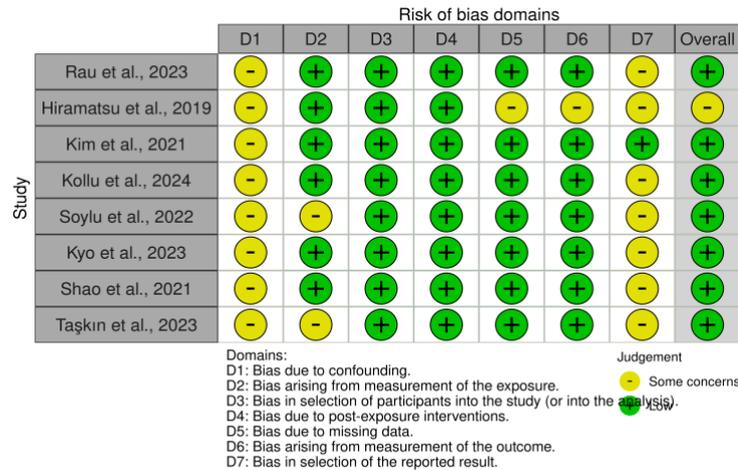
(A)
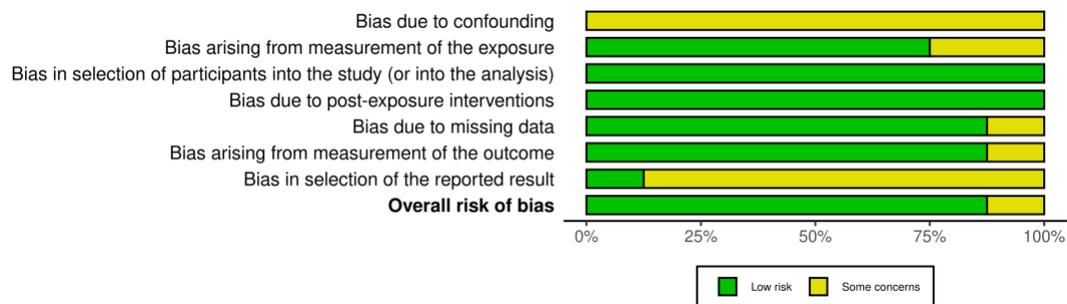
(B)

Figure 4. Risk of bias of the entire study (A) ROBINS-E Traffic-light plot; (B) ROBINS-E Summary plot.

Heterogeneity and sensitivity analysis

Substantial heterogeneity was observed among studies evaluating GNRI ($I^2 = 86\%$), while PNI showed moderate heterogeneity ($I^2 = 47\%$). To account for this, we applied random-effects models in the meta-analysis. Under the random-effects model, GNRI remained significantly lower in non-survivors, with a pooled mean difference of −8.99 [95% CI: −9.71 to −8.27] (**Figure 5**). Similarly, PNI also showed a significant pooled difference of −4.45 [95% CI: −4.94 to −3.96] (**Figure 6**). The direction and magnitude of the effect remained consistent across models, indicating that the findings were robust and not driven by any single study.
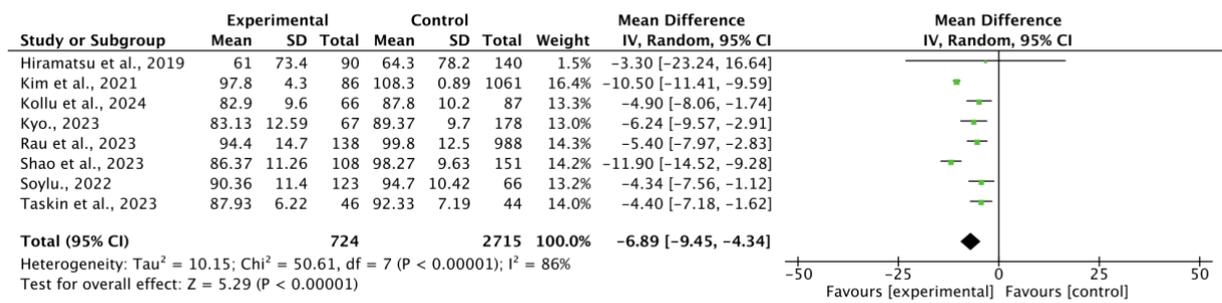
Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hiramatsu et al., 2019	61	73.4	90	64.3	78.2	140	1.5%	-3.30 [-23.24, 16.64]
Kim et al., 2021	97.8	4.3	86	108.3	0.89	1061	16.4%	-10.50 [-11.41, -9.59]
Kollu et al., 2024	82.9	9.6	66	87.8	10.2	87	13.3%	-4.90 [-8.06, -1.74]
Kyo., 2023	83.13	12.59	67	89.37	9.7	178	13.0%	-6.24 [-9.57, -2.91]
Rau et al., 2023	94.4	14.7	138	99.8	12.5	988	14.3%	-5.40 [-7.97, -2.83]
Shao et al., 2023	86.37	11.26	108	98.27	9.63	151	14.2%	-11.90 [-14.52, -9.28]
Soylu, 2022	90.36	11.4	123	94.7	10.42	66	13.2%	-4.34 [-7.56, -1.12]
Taskin et al., 2023	87.93	6.22	46	92.33	7.19	44	14.0%	-4.40 [-7.18, -1.62]
Total (95% CI)			**724**			**2715**	**100.0%**	**-6.89 [-9.45, -4.34]**

Heterogeneity: $Tau^2 = 10.15$; $Chi^2 = 50.61$, df = 7 (P < 0.00001); $I^2 = 86\%$
Test for overall effect: Z = 5.29 (P < 0.00001)

Figure 5. Forest plot showing the association between GNRI and mortality under the random-effects model.

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hiramatsu et al., 2019	23.3	32.5	90	25.8	34.5	140	0.8%	-2.50 [-11.32, 6.32]
Kim et al., 2021	49.03	3.33	86	54.3	0.81	1061	24.8%	-5.27 [-5.98, -4.56]
Kollu et al., 2024	33.6	7.5	66	37.5	7.5	87	8.2%	-3.90 [-6.30, -1.50]
Kyo., 2023	32.77	5.93	67	36.57	6.07	178	13.1%	-3.80 [-5.48, -2.12]
Rau et al., 2023	41.6	11.4	138	44.8	9.4	988	10.6%	-3.20 [-5.19, -1.21]
Shao et al., 2023	34.67	4.59	108	38.63	4.59	151	19.0%	-3.96 [-5.09, -2.83]
Soylu., 2022	32.04	6.54	123	34.32	6.4	66	11.1%	-2.28 [-4.21, -0.35]
Taskin et al., 2023	31.87	4.74	46	36.27	3.78	44	12.3%	-4.40 [-6.17, -2.63]
Total (95% CI)			**724**			**2715**	**100.0%**	**-4.03 [-4.84, -3.23]**

Heterogeneity: $Tau^2 = 0.55$; $Chi^2 = 13.26$, df = 7 (P = 0.07); $I^2 = 47\%$
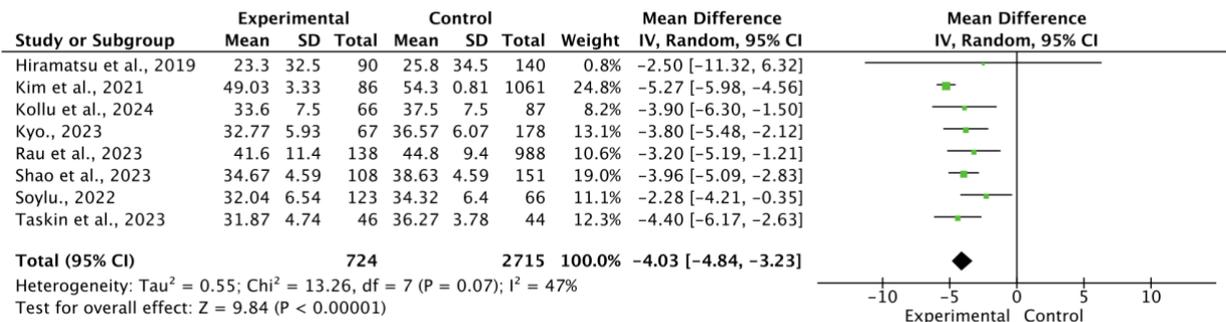Test for overall effect: Z = 9.84 (P < 0.00001)

Figure 6. Forest plot showing the association between PNI and mortality under the random-effects model.

Publication bias

Visual inspection of the funnel plots for both GNRI and PNI (**Figure 7**) revealed symmetrical distribution of effect sizes, suggesting the absence of significant publication bias among the included studies. The plots showed no evidence of small-study effects or asymmetry, supporting the reliability of the pooled estimates. Although primarily used to detect reporting bias, the funnel plots also contribute to sensitivity analysis by evaluating the influence of study size and consistency across the evidence base. The symmetry observed in both plots further reinforces the robustness of the meta-analysis results.
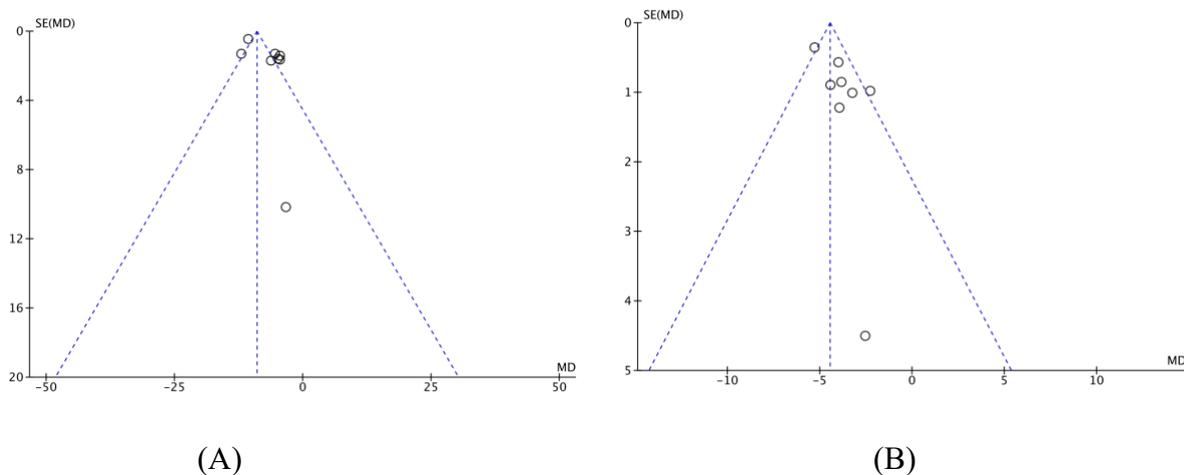

(A)   (B)

Figure 7. Funnel plot. (A) Funnel plot of GNRI. (B) Funnel plot of PNI

These results demonstrate that both GNRI and PNI are reliable indicators of mortality risk in elderly ICU patients, with GNRI showing a larger effect size but greater variability, and PNI showing more consistent performance across diverse populations and clinical contexts.

Discussion

This systematic review and meta-analysis demonstrated that both the Geriatric Nutritional Risk Index (GNRI) and Prognostic Nutritional Index (PNI) are valid predictors of mortality in elderly ICU patients. Pooled analyses revealed that non-survivors had significantly lower scores for both indices, with GNRI showing a larger effect size but greater heterogeneity, while PNI had a smaller effect size with more consistent results across studies.

Our findings are consistent with previous literature highlighting the prognostic utility of nutritional indices in critically ill populations. For instance, Kim et al.[8] reported that GNRI had a better predictive value for in-hospital mortality than PNI in elderly patients with acute myocardial infarction.[3] Similarly, Taskın et al.[9] showed that both GNRI and PNI were significantly associated with 28-day mortality in ICU patients on mechanical ventilation.[9]

Despite differences in populations and settings, several studies included in this review supported the predictive value of both indices. Shao et al.,[2] using a large cohort of 2,060 ICU patients, found no significant difference in prognostic ability between GNRI and PNI.[4] Meanwhile, Soylu et al.[16] suggested that GNRI may offer better sensitivity and specificity in very elderly ICU patients (≥85 years), aligning with our result that GNRI had a larger pooled effect size.[5]

In elderly critically ill patients, nutritional status is not only influenced by acute illness and age-related sarcopenia, but also by underlying metabolic factors such as obesity and genetic predisposition. Studies have suggested that gene polymorphisms, particularly those related to fat mass and obesity-associated (FTO) genes. In Asian populations, the AA genotype of the rs9939609 variant is associated with a greater risk of obesity compared to other genotypes.[10] This genotype may alter inflammatory responses and metabolic regulation during critical illness, thereby modifying prognostic indicators such as GNRI and PNI.

The greater heterogeneity observed in GNRI (I^2 = 86%) may reflect variability in patient conditions and weight-based calculations, which are often imprecise in ICU settings. In contrast, PNI showed more homogenous performance (I^2 = 47%), likely due to its reliance on stable laboratory parameters. Importantly, our funnel plot analyses showed no evidence of publication bias, and sensitivity analyses confirmed that findings were robust, with consistent results under random-effects modelling. These results strengthen the validity of both indices in predicting mortality, despite inter-study variability.

Some limitations should be acknowledged. First, the number of included studies is relatively limited (n = 8), and most were observational, introducing possible residual confounding. Second, GNRI and PNI cutoff values were inconsistent, and adjustments for disease severity were variably reported. Finally, our study did not explore the temporal change of nutritional indices during ICU stay, which may have additional prognostic value.

Nonetheless, the current evidence supports the incorporation of GNRI and PNI in routine ICU assessment for elderly patients. These indices offer simple, accessible, and cost-effective tools to support prognostication and guide early nutritional interventions.

Conclusion

Both GNRI and PNI are valuable tools for predicting mortality in elderly critically ill patients. Our pooled analysis indicates that GNRI demonstrates a stronger prognostic effect size, suggesting it may be more sensitive in detecting mortality risk. However, this comes with greater heterogeneity across studies, likely due to variability in weight-based parameters. In contrast, PNI showed more consistent predictive performance across diverse ICU populations, reflecting the stability of its laboratory-based components. Taken together, GNRI may be preferable when higher prognostic sensitivity is required, whereas PNI may be more reliable for routine clinical use due to its consistency and ease of application. These findings underscore the complementary roles of GNRI and PNI in supporting early risk stratification and guiding nutritional interventions in elderly ICU patients.

Conflict of interest

The authors declared no conflict of interest regarding this article.

Acknowledgement

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Author Contributions

DP: Conceptualization, data acquisition, formal analysis, interpretation of results, drafting the manuscript, and final approval of the version to be published; IWAH: Supervision, critical revision of the manuscript, interpretation of data, and final approval of the version to be published; MS: Conception and design of the study, critical revision of the manuscript for important intellectual content, and final approval of the version to be published.

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