**Electronic Journal of General Medicine**
2025, 22(4), em656
e-ISSN: 2516-3507
https://www.ejgm.co.uk/

MODESTUM

**Original Article**

**OPEN ACCESS**

# The predictors of prognostic nutritional index and its association with in-hospital mortality among critically ill geriatric patients

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**Citation:** Elsorady KE, Abotaha AAM, Shaheen MAE, Abdelaziz HAHM, Aggour EYA, Mahmoud MEM. The predictors of prognostic nutritional index and its association with in-hospital mortality among critically ill geriatric patients. Electron J Gen Med. 2025;22(4):em656. https://doi.org/10.29333/ejgm/16303

**ARTICLE INFO**

Received: 14 Dec. 2024

Accepted: 10 Mar. 2025

**ABSTRACT**

**Purpose:** The study aimed to determine the predictors of prognostic nutritional index (PNI) and its association with in-hospital mortality among critically ill geriatric patients

**Materials and methods:** Prospective cohort study included 113 critically ill older patients at a geriatrics hospital in Egypt. Clinical history, laboratory analyses, Charlson comorbidity index, and simplified acute physiology score II were conducted on admission. Immuno-nutritional biomarkers included PNI, neutrophil/lymphocyte ratio (NLR), systemic immune inflammation index (SII), and platelet/lymphocyte ratio (PLR). The hospital outcome was in-hospital mortality.

**Results:** Median PNI was 33.45. Predictors of PNI were albumin and hematocrit. PNI showed a negative correlation with NLR ($r = -0.475$, $p < 0.001$), PLR ($r = -0.263$, $p = 0.005$), and SII ($r = -0.287$, $p = 0.002$). PNI < 35.475 and NLR > 6.5 defined in-hospital mortality with an area under the curve of 0.633, $p = 0.011$ and $p = 0.612$, $p = 0.036$, respectively.

**Conclusion:** PNI < 35.475 and NLR > 6.5 are associated with in-hospital mortality. PNI had an inverse correlation with NLR, SII, and PLR.

**Keywords:** geriatric patients, prognostic nutritional index, immuno-nutrition, mortality

## INTRODUCTION

Malnutrition is a highly prevalent syndrome in acutely ill geriatric patients, worsening immune function and hospital outcomes [1]. Immuno-nutritional (IN) status is the changes of nutrients in diet that are capable of modifying the immunological system. It depends on the availability of immuno-active nutrients as arginine, omega 3 fatty acids, and antioxidants such as L-ascorbic acid. Deficiency of these nutrients could negatively influence immune functions including both humoral and cell-mediated immunological activity [1].

Several recent studies found that IN status could influence morbidity among patients undergoing surgery. However, its impact on clinical outcomes such as infections, length of hospital confinement, and mortality, remains deficient in acute geriatric care settings [1]. Critically ill patients are at a higher risk of worsening due to rapidly progressive disorders. Therefore, having simple objective IN indicators can aid clinicians to rapidly stratify patients and improve their clinical outcomes [2].

There are several simple laboratory markers of prognostic utility such as serum albumin, transthyretin, and inflammatory markers such as C-reactive protein (CRP) and white blood cells counts. Currently, combinations of these markers could form more efficient prognostic indicators such as the prognostic nutritional index (PNI), neutrophil/lymphocyte ratio (NLR), and the platelet/lymphocyte ratio (PLR) [3]. However, PNI is a simple and objective indicator of IN status and has a high predictive utility among patients [4]. Accordingly, assessing the effectiveness and prognostic value of these IN prognostic scores in critically ill geriatric patients is crucial. In the current study we selected PNI as a representative for IN status. This study aimed to determine the predictors of PNI and its association with in-hospital mortality among critically ill geriatric patients.

## MATERIALS AND METHODS

### Ethical Approvals

The study's protocol underwent two steps of ethical approvals. First, it was checked and accepted by the ethical committee of the geriatrics hospital, Ain Shams University

hospitals where the study was accomplished. Second, the study's protocol was revised and accepted by the research ethics committee at the faculty of Medicine, Ain Shams University. Approval number: FMASU R 197/2024. Informed consents were obtained from participants or their proxies.

### Representative Sample Calculation

Using PASS 15 program and based on data of previous related research [5], setting statistical power at 80% and alpha level of error at 0.05, it was estimated that a minimum 75 patients were needed to detect an expected area under the ROC curve of 0.79 for PNI for prediction of in-hospital mortality of 12%.

### Research Strategy and Place

A prospective cohort study included 113 geriatric patients aged ≥ 60 years old. These patients were admitted at high dependency units (HDUs) in a specialized geriatrics hospital, Ain Shams university hospitals, Egypt between August and October 2024. Each participant was initially subjected to clinical history taking. Socio-demoghaphic data included age and sex. Charlson comorbidity index (CCI) was calculated to assess the burden of multi-morbidity. It is one of the most widely utilized scoring tools to assess comorbidity and survival [6]. Comorbidities and geriatric syndromes included cardiovascular disease (CVD), diabetes, chronic live disease, chronic renal disease/end stage renal disease, cognitive impairment, falls/accidents and urinary/fecal incontinence.

### Selection Criteria and Inclusion in the Study

The inclusion criteria were, as follows: critically ill patients admitted in HDUs, aged ≥ 60 years; the laboratory analysis within the first 48 hours of admission. Patients with recurrent admissions were excluded, except for the data on the first admission. Patients who had on-demand discharge and those transferred to other hospital before completion of treatment regime were excluded.

### Acute Illness Severity Evaluation

$PaO_2/FiO_2$ ratio (PFR) was utilized to assess oxygenation status and calculated based on arterial blood gases and oxygen saturation on admission [7, 8]. Simplified acute physiology score II (SAPS II) was used to determine acute illness severity [9]. SAPS II score depends on patients admission criteria including vitals, conscious level, urine output over 24 hours, chronic diseases, type of admission, base-line laboratory results, and PFR value [9].

### Laboratory Analysis

Blood sampling was conducted by qualified nursing personnel at the hospital. Samples were analyzed at the laboratories of Ain Shams University. Hematological testing included complete blood count (CBC) with differential count analysis. It was measured with CELL-DYN RUBY hematology operator (Abbott, USA), XN 1000 (Sysmex, Germany), and ADVIA 560 (Siemens, Mumbai). CBC reports included hemoglobin, hematocrit, red cell distribution width (RDW), platelets, total leucocytes count, and differential counts of white blood cells. Biochemical analyses included the serum levels of albumin, total proteins, electrolytes, creatinine, blood urea nitrogen, alanine aminotransferase, aspartate aminotransferase, total bilirubin, and CRP. These analyses were processed through these devices: AU680, AU480 analyzers (Beckman Coulter, USA) and COBAS C311 analyzer–Roche.

### Immuno-Nutritional Status Evaluation

Several blood-derived IN biomarkers have prognostic and predictive utility in practical settings due to the interplay between malnutrition and chronic inflammatory reaction [10]. We utilized different combinations of prognostic indices including

- PNI is an objective IN biomarker. It was calculated by using serum albumin level and peripheral lymphocyte count, as follows, PNI = serum albumin (g/l) + 5 × lymphocyte count ($10^3/mm^3$) [4, 10].
- NLR is a simple inflammatory index and has a prognostic value in clinical polices. It was evaluated by dividing the absolute neutrophils by peripheral absolute lymphocytes count as reported in differential CBC analyses, as follows: NLR = neutrophil count ($10^3/mm^3$)/lymphocyte count ($10^3/mm^3$) [10, 11].
- PLR is the proportion of platelets count to peripheral lymphocytes count. It is an integral inflammatory biomarker in different diseases and cancer. PLR can be calculated easily utilizing parameters from CBC reports. PLR = platelet count ($10^3$/uL)/lymphocyte count ($10^3/mm^3$) [10, 12].
- Systemic immune inflammation index (SII) is a novel systemic inflammatory indicator. It can be considered as a predictor of survival and calculated easily from CBC reports, as follows: SII = neutrophil count ($10^3/mm^3$)/lymphocyte count ($10^3/mm^3$) × platelet count ($10^3$/uL) [10, 13].

### Hospital Outcome

The target observed outcome was in-hospital mortality. The follow up process started when the patient was initially admitted to the HDUs and ended on either discharge alive or death at the hospital.

### Statistical Testing

The statistical package for the social sciences version 28 (IBM Corp., Armonk, NY, USA) was utilized for data analysis. Data was organized and presented as mean and standard deviation for normally distributed quantitative parameters s or median and interquartile range for non-normally distributed quantitative parameters and frequencies (numbers) and relative frequencies (percentages) for categorical elements. Comparisons between groups were done using unpaired t- test in normally distributed quantitative parameters while non-parametric Mann-Whitney test was used for non-normally distributed quantitative parameters. For categorical elements, Chi square ($\chi^2$) test was performed for comparisons. Exact (Fisher-Irwin) test was used instead when the expected frequency is less than 5. Correlations between quantitative parameters were done using Spearman correlation coefficient ($r$). The ROC curve was used with an area under curve (AUC) analysis to detect optimal cutoffs of the studied biomarkers for detection of in-hospital mortality. Logistic regression testing was performed to detect the independent predictors of low PNI with the odds ratio (OR). p-values < 0.05 were considered as statistically significant.

**Table 1.** Comparison between patients based on PNI

| Variable | PNI | | | | p-value |
|---|---|---|---|---|---|
| | ≤ 33.45 | | > 33.45 | | |
| | C | P (%) | C | P (%) | |
| Sex (male/female) | 21/36 | 36.8/63.2 | 20/36 | 35.7/64.3 | 0.901 |
| CVD | 46 | 80.7 | 49 | 87.5 | 0.323 |
| Diabetes mellitus | 25 | 43.9 | 28 | 50.0 | 0.513 |
| Old CVA/TIA | 23 | 40.4 | 16 | 28.6 | 0.188 |
| CKD/ESRD | 17 | 29.8 | 17 | 30.4 | 0.951 |
| Chronic liver disease | 10 | 17.5 | 9 | 16.1 | 0.834 |
| Incontinence | 5 | 8.8 | 9 | 16.1 | 0.239 |
| Malignancy | 11 | 19.3 | 6 | 10.7 | 0.202 |
| Cognitive impairment | 19 | 33.3 | 17 | 30.4 | 0.734 |
| Falls/accidents | 12 | 21.1 | 18 | 32.1 | 0.182 |
| Chronic pulmonary disease | 5 | 8.8 | 10 | 17.9 | 0.155 |
| Thyroid dysfunction | 3 | 5.3 | 1 | 1.8 | 0.618 |
| In-hospital mortality | 36 | 63.2 | 26 | 46.4 | 0.074 |

Note. C: Count; P: Percentage; CVA/TIA: Cerebro-vascular accidents/transient ischemic attacks; & CKD/ESRD: Chronic kidney disease/end stage renal disease

**Table 2.** Association between PNI and quantitative variables

| Quantitative variables | PNI | | | | p-value |
|---|---|---|---|---|---|
| | ≤ 33.45 | | > 33.45 | | |
| | M | SD | M | SD | |
| Age | 73.49 | 8.62 | 73.98 | 9.64 | 0.776 |
| GCS | 12.11 | 3.07 | 12.42 | 3.35 | 0.611 |
| Respiratory rate | 23.70 | 5.86 | 25.59 | 6.61 | 0.114 |
| Heart rate | 91.30 | 22.48 | 88.83 | 18.83 | 0.534 |
| MBP | 82.79 | 16.56 | 89.20 | 14.39 | 0.032 |
| Temperature | 37.37 | 0.36 | 37.30 | 0.32 | 0.334 |
| Sodium | 134.46 | 9.27 | 136.47 | 8.20 | 0.230 |
| Potassium | 3.78 | 0.84 | 4.19 | 0.85 | 0.013 |
| Calcium | 9.07 | 0.95 | 9.12 | 1.47 | 0.827 |
| Magnesium | 1.82 | 0.45 | 2.09 | 0.50 | 0.006 |
| Total proteins | 5.44 | 0.93 | 6.70 | 0.69 | < 0.001 |
| Hemoglobin | 9.87 | 2.15 | 11.74 | 2.16 | < 0.001 |
| Hematocrit | 29.97 | 6.69 | 35.82 | 7.60 | < 0.001 |
| RDW | 16.48 | 3.30 | 14.76 | 2.14 | 0.003 |
| Albumin | 2.26 | 0.38 | 3.18 | 0.48 | < 0.001 |
| CCI | 8.02 | 2.66 | 7.59 | 2.41 | 0.383 |
| SAPS II Score | 41.42 | 10.66 | 34.73 | 10.86 | 0.004 |

Note. M: Mean; SD: Standard deviation; GCS: Glasgow coma scale; MBP: Mean blood pressure; & Normal range of sodium (136-145 mmol/l), potassium (3.5-5.1 mmol/l), calcium (8.6-10.3 mg/dl), magnesium (1.8-2.6 mg/dl), total proteins (6-8.3 g/dl), hemoglobin (12-15g/dl), hematocrit (40.0-50.0%), RDW (11.5-14.0%), & albumin (3.5-5.4 g/dl)

**Table 3.** Association between PNI and quantitative variables

| QV | PNI | | | | | | p-value |
|---|---|---|---|---|---|---|---|
| | ≤ 33.45 | | | > 33.45 | | | |
| | MD | 1st Q | 3rd Q | MD | 1st Q | 3rd Q | |
| TLC | 12.00 | 7.50 | 16.70 | 10.40 | 7.75 | 13.65 | 0.484 |
| PL | 200.00 | 131.00 | 305.00 | 245.50 | 186.00 | 301.50 | 0.137 |
| BUN | 43.00 | 23.00 | 69.00 | 28.00 | 17.50 | 66.50 | 0.267 |
| Cr | 1.40 | 1.00 | 3.10 | 1.30 | 0.80 | 2.70 | 0.240 |
| PH | 3.30 | 2.60 | 4.30 | 3.40 | 2.70 | 4.30 | 0.787 |
| TB | 0.80 | 0.45 | 1.00 | 0.60 | 0.40 | 0.90 | 0.268 |
| ALT | 16.00 | 10.00 | 26.00 | 14.50 | 10.00 | 21.00 | 0.587 |
| AST | 26.00 | 19.00 | 44.00 | 28.00 | 19.00 | 36.00 | 0.545 |
| PFR | 347.62 | 262.00 | 447.62 | 300.00 | 242.86 | 368.10 | 0.060 |
| CRP | 94.20 | 41.00 | 172.00 | 45.00 | 18.60 | 122.70 | 0.016 |
| PLR | 210.68 | 127.89 | 347.30 | 156.88 | 121.17 | 249.05 | 0.053 |
| SII | 1,708.6 | 880.0 | 4,321.7 | 1,364.6 | 673.3 | 1,987.2 | 0.058 |
| NLR | 11.00 | 5.00 | 19.00 | 6.00 | 3.00 | 8.00 | < 0.001 |

Note. QV: Quantitative variables; MD: Median; Q: Quartile; TLC: Total leucocyte count; BUN: Blood urea nitrogen; PL: Platelets; Cr: Creatinine; PH: Phosphorus; TB: Total bilirubin; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; & Normal range of total leukocyte count (4-10×$10^3$/µL), platelets (150-410×$10^3$/µL), BUN (8-20 mg/dl), creatinine (0.6-1.2 mg/dl), phosphorus (2.5-5.0 mg/dl), total bilirubin (0.3-1mg/dl), ALT (7-52 IU/l), AST (13-39 IU/l), & CRP (< 6 mg/l)

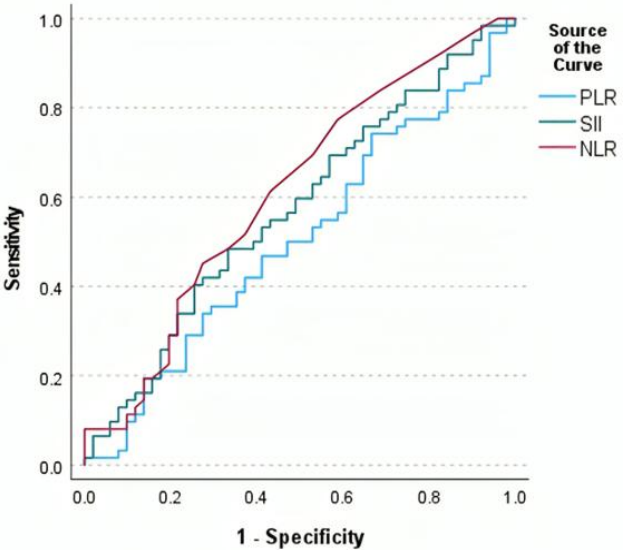


**Figure 1.** ROC for prediction of mortality using PLR, SII, & NLR (Source: Authors' own elaboration)

## RESULTS

The mean age of participants was 73.73 ± 9.10 years. Median values of PNI was 33.45, accordingly, patients were classified into 2 groups: low PNI (≤ 33.45) and high PNI (> 33.45). Those with low PNI had a significantly higher SAPS II score 41.42 ± 10.66 vs. 34.73 ± 10.86, p = 0.004. Among the laboratory variables studied, RDW was significantly higher 16.48 ± 3.30 vs 14.76 ± 2.14, p = 0.003. They had significantly lower serum albumin and total proteins.

Mean serum total proteins and albumin measured 5.44 ± 0.93 vs. 6.70 ± 0.69 and 2.26 ± 0.38 vs. 3.18 ± 0.48, respectively with p-value < 0.001 for both. Similarly, they had significantly lower hematocrit 29.97 ± 6.69 vs. 35.82 ± 7.60 and hemoglobin 9.87 ± 2.15 vs. 11.74 ± 2.16, p-value < 0.001 (**Table 1** and **Table 2**).

Compared to patients with higher PNI, patients with low PNI had significantly higher median values of NLR and CRP 11.00 vs. 6.00, p < 0.001, and 94.20 vs. 45.00, p = 0.016, respectively (**Table 3**).

The ROC curve determined the specified cut-off values of IN biomarkers associated with in-hospital mortality. PNI at a cut-off < 35.475 had the highest predictive utility with an AUC of 0.633, p = 0.011 (**Figure 1**, **Figure 2**, and **Table 4**).

Based on logistic regression testing, we determined the OR of factors significantly associated with low PNI. Both hematocrit and albumin were the independent predictors of low PNI with an OR of 0.795, p = 0.019 and and OR of 0.000013, p = 0.015, respectively (**Table 5**).

Spearman correlation analysis revealed a significant negative correlation between PNI and other IN biomarkers. PNI-PLR (r = -0.263, p = 0.005), PNI-NLR (r = -0.475, p < 0.001), PNI-SII (r = -0.287, p = 0.002) (**Table 6**).

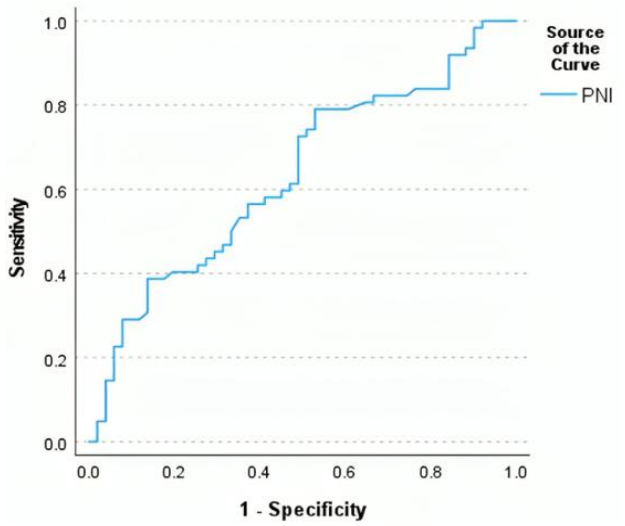


**Figure 2.** ROC for prediction of mortality using PNI (Source: Authors' own elaboration)

**Table 4.** ROC of different IN biomarkers for prediction of mortality

| IN-B | AUC | p-value | 95% CI | | Cut-off | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|---|---|
| | | | LB | UB | | | |
| PLR | 0.503 | 0.959 | 0.395 | 0.610 | - | - | - |
| SII | 0.571 | 0.187 | 0.465 | 0.678 | - | - | - |
| NLR | 0.612 | 0.036 | 0.507 | 0.718 | > 6.500 | 61.3 | 56.9 |
| PNI | 0.633 | 0.011 | 0.530 | 0.735 | < 35.475 | 72.6 | 51.0 |

Note. IN-B: IN biomarkers; LB: Lower bound; & UB: Upper bound

**Table 5.** Logistic regression analysis to identify predictors of PNI

| Predictive factors | Univariate logistic regression | | Multivariate logistic regression | |
|---|---|---|---|---|
| | p-value | OR (95% CI) | p-value | OR (95% CI) |
| MBP | 0.035 | 0.973 (0.949-0.998) | - | - |
| Potassium | 0.015 | 0.564 (0.355-0.896) | - | - |
| Magnesium | 0.009 | 0.287 (0.113-0.732) | - | - |
| Total protein | < 0.001 | 0.119 (0.045-0.310) | - | - |
| Hemoglobin | < 0.001 | 0.668 (0.547-0.815) | - | - |
| Hematocrit | < 0.001 | 0.892 (0.841-0.947) | 0.019 | 0.795 (0.656-0.963) |
| RDW | 0.006 | 1.310 (1.081-1.587) | - | - |
| Albumin | < 0.001 | 0.002 (0.000-0.024) | 0.015 | 0.000013 (0.000-0.112) |
| SAPS II | 0.007 | 1.062 (1.017-1.109) | - | - |
| CRP | 0.100 | 1.004 (0.999-1.008) | - | - |

**Table 6.** Correlation between PNI with PLR, NLR, and SII

| | | PLR | SII | PNI |
|---|---|---|---|---|
| SII | Correlation coefficient | 0.789 | | |
| | p-value | < 0.001 | | |
| | N | 113 | | |
| PNI | Correlation coefficient | -0.263 | -0.287 | |
| | p-value | 0.005 | 0.002 | |
| | N | 113 | 113 | |
| NLR | Correlation coefficient | 0.504 | 0.798 | -0.475 |
| | p-value | < 0.001 | < 0.001 | < 0.001 |
| | N | 113 | 113 | 113 |

Note. *Yellow color indicates significance

## DISCUSSION

The study explored the impact of IN status on hospital outcomes among critically ill geriatric patients. The study provided these main findings: first, provision of specified cut-off of PNI and NLR for predicting in-hospital mortality. Second, it showed inverse correlations between PNI and other IN biomarkers. Third, the study revealed independent predictors of PNI values among critically ill older patients. It is the first study examining these issues among geriatric patients with critical illnesses.

In the current study low PNI represented poor IN status; it had the highest predictive utility in comparison to other IN biomarkers. PNI is an easily obtainable biomarker at hospital sittings. It demonstrated a good predictive utility in postoperative, cancer, and CVD patients while its role in critically ill geriatric patients is still deficient [14].

Both PNI and NLR were significantly associated with in-hospital mortality at specified cut-offs. PNI at cut-off < 35.475 was associated with in-hospital mortality (AUC = 0.633, 95% confidence interval [CI] = 0.530-0.735, p = 0.011) with a sensitivity of 72.6% and specificity of 51%. These results confirm the burden of malnutrition combined with inflammation among hospitalized older adults. This is consistent with a previous retrospective observational study including critically ill older adults aged 85 years and above. It revealed a significant association between low PNI and 28 days mortality where PNI at a cut-off 33.8 predicted mortality with a sensitivity of 56.1% and specificity of 56.9% (AUC = 0.600, 95% CI = 0.514-0.685) [14].

Similarly, NLR at cut-off at > 6.5 was associated with in-hospital mortality (AUC = 0.612, 95% CI = 0.507-0.718, p = 0.036) with a sensitivity of 61.3% and specificity of 56.9%. These results are similar to another prospective cohort study included older patients at emergency department where the NLR at cut-off > 8 had a good predictive value for mortality (AUC = 0.70, 95% CI 0.670-0.730, p < 0.001) [15]. These data supported the superiority of PNI as a prognostic biomarker over other IN biomarkers as evidenced in another retrospective observational study among breast cancer patients [16]. Both PLR and SII did not show a significant association with mortality in comparison to other studies demonstrating their potential predictive utility in cancer patients [10]. These discrepancies could be attributed to differences in populations and sittings of various studies.

The superiority of PNI could be attributed to its ability to provide comprehensive IN representation. Because of the inclusion of serum albumin and lymphocytes count in the same equation [4, 10]. Serum albumin reflects both immune and nutritional status. Lower albumin levels signify poor nutrition and/or active inflammatory condition. Also, peripheral lymphocytes count reflects immunological activity. Reduced lymphocytes count has been linked to worse clinical outcomes including mortality. Similarly, NLR reflects the balance between neutrophils driven innate immune response and lymphocytes mediated adaptive immunity. Higher NLR reflects immune dysregulation and pro-inflammatory status [10, 11]. Compared to PLR and SII, NLR shows a more rapid response to various stressors, further supporting its prognostic significance. Conversely, SII and PLR, through useful inflammatory indicators, may not comprehensively represent the complex interplay between immunity, nutrition and

inflammation. PLR mainly reflects platelet driven inflammatory reaction, which are important in vascular pathology and thrombus formation. Likewise, SII lacks direct nutritional parameters, limiting its prognostic role in cases where malnutrition is a major contributor to death [10, 13].

The study explored significant relationships between PNI and other IN biomarkers as demonstrated by the significant inverse relationship between PNI and NLR ($r = -0.475$, $p < 0.001$). That is consistent with another retrospective study among 83 hepatocellular carcinoma patients where inverse correlation was demonstrated between PNI and NLR ($r = -0.2600$, $p = 0.0176$) [17]. Similarly, PNI values showed significantly inverse correlation with the NLR values ($r = 0.4974$, $p < 0.0001$) in previous reports [16]. Accordingly, the study confirmed that high PNI and low NLR are associated with worse hospital outcomes including mortality as demonstrated in other studies [16, 17].

The study did not showed a significant relationship between PNI and specific diseases or geriatric syndromes. Also, CCI was not significantly related to PNI. It is against data from a previous study where higher CCI and malignancy were significantly associated with lower PNI [18].

The study assessed the association between PNI and vital signs at admission including respiratory rate, heart rate, mean blood pressure (MBP), body temperature and PFR. Our analysis showed that MBP was the only significant variable as demonstrated in another study [18]. Moreover higher SAPS II scores were associated with lower PNI as supported by another study where higher PNI quartiles had lower acute disease severity scores at admission [18].

Also, the study showed that both age and sex were not related to PNI. It contradicted another study included 1,673 heart failure patients showed patients in the higher PNI group were younger in age. However the same mentioned study showed that sex was not related to PNI similar to our results [19].

Regarding hematological parameters influencing PNI values Hemoglobin and hematocrit were significantly associated with PNI with an OR of 0.668 ($p < 0.001$) and 0.892 ($p < 0.001$), respectively. Also, RDW had an OR of 1.310 ($p = 0.006$) with PNI. These data is consistent with a previous study, which included 1,608 patients with pneumonia where patients with higher PNI had lower levels of hemoglobin, hematocrit and RDW at admission [18].

Regarding biochemical parameters; low PNI was associated with lower serum total proteins and albumin with an OR of 0.119 ($p < 0.001$) and 0.002 ($p < 0.001$), respectively

Also, lower serum potassium and magnesium levels were significantly related to low PNI. These data are supported by previous studies; however analyzing association between PNI and serum electrolytes is unique to our study [20].

Upon multivariate regression analysis, serum albumin and hematocrit were independent predictors of PNI among participants. These data are consistent with findings from a previous prospective study including ovarian cancer patients where PNI values post chemotherapy were independently related to body mass index, prealbumin, albumin, absolute lymphocyte count, and hemoglobin levels at admission [20].

Limitations in the study include its relatively small number of participants from a single geriatric acute care facility in Egypt. It impairs the general applicability of results. However, the study is the first to document specified cut-off values of both PNI and NLR for predicting in-hospital mortality among critically ill older population. Also, the study highlights the potential benefits of PNI as an easily obtainable IN biomarker and tries to fulfill its related gap of knowledge in acute geriatric care sittings.

## CONCLUSION

Poor IN status is highly prevalent among hospitalized geriatric populations. PNI is a pertinent biomarker of IN status. Predictors of PNI include serum albumin and hematocrit values. Both PNI and NLR are associated with in-hospital mortality at cut-offs < 35.475 and > 6.5, respectively. PNI has a significant inverse correlation with other IN biomarkers including NLR, SII, and PLR.

**Author contributions: KEE, AAMA, MAES, HAHMA, EYAA, & MEMM:** data analysis, writing – original draft, writing – review & editing; **KEE:** conceptualization, data curation. All authors have agreed with the results and conclusions.

**Funding:** No funding source is reported for this study.

**Acknowledgments:** The authors would like to thank all patients who participated in this study.

**Ethical statement:** The authors stated that the study was approved ny the Research Ethics Committee at Ain Shams University on 17 August 2024 with approval number FMASU R 197/2024. Written informed consents were obtained from the participants.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

1. Boccardi V, Cari L, Alhosseini MN, et al. Immunonutrition in acute geriatric care: Clinical outcomes, inflammatory profiles, and immune responses. Nutrients. 2024;16(23):4211. https://doi.org/10.3390/nu16234211 PMid:39683604 PMCid:PMC11644052
2. Lu Y, Ren C, Jiang J. The relationship between prognostic nutritional index and all-cause mortality in critically ill patients: A retrospective study. Int J Gen Med. 2021;14:3619-26. https://doi.org/10.2147/IJGM.S318896 PMid:34305408 PMCid:PMC8296707
3. Forget P, Echeverria G, Giglioli S, et al. Biomarkers in immunonutrition programme, is there still a need for new ones? A brief review. Ecancermedicalscience. 2015;9:546. https://doi.org/10.3332/ecancer.2015.546 PMid:26180545 PMCid:PMC4494817
4. Ekinci I, Uzun H, Utku IK, et al. Prognostic nutritional index as indicator of immune nutritional status of patients with COVID-19. Int J Vitam Nutr Res. 2022;92(1):4-12. https://doi.org/10.1024/0300-9831/a000730 PMid: 34538066
5. Capurso C, Buglio AL, Bellanti F, Vendemiale G. Prognostic nutritional index and instant nutritional assessement are associated with clinical outcomes in a geriatric cohort of acutely inpatients. Nutrients. 2024;16(9):1359. https://doi.org/10.3390/nu16091359 Mid:38732604 PMCid: PMC11085456

6. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis. 1987;40(5):373-83. https://doi.org/10.1016/0021-9681(87)90171-8 PMid:3558716
7. ARDS Definition Task Force, Ranieri VM, Rubenfeld GD, et al. Acute respiratory distress syndrome: The Berlin definition. JAMA. 2012;307(23):2526-33. https://doi.org/10.1001/jama.2012.5669
8. Sanz F, Dean N, Dickerson J, et al. Accuracy of $PaO_2/FiO_2$ calculated from $SpO_2$ for severity assessment in ED patients with pneumonia. Respirology. 2015;20(5):813-8. https://doi.org/10.1111/resp.12560 PMid:25998684
9. Allyn J, Ferdynus C, Bohrer M, Dalban C, Valance D, Allou N. Simplified acute physiology score II as predictor of mortality in intensive care units: A decision curve analysis. PLoS One. 2016;11(10):e0164828. https://doi.org/10.1371/journal.pone.0164828 PMid:27741304 PMCid:PMC5065161
10. Yildirim S, Dogan A, Akdag G, et al. The role of laboratory indices on treatment response and survival in breast cancer receiving neoadjuvant chemotherapy. Sci Rep. 2024;14(1):12123. https://doi.org/10.1038/s41598-024-63096-7 PMid:38802494 PMCid:PMC11130235
11. Faria SS, Fernandes Jr PC, Silva MJB, et al. The neutrophil-to-lymphocyte ratio: Narrative review. Ecancermedicalscience. 2016;10:702. https://doi.org/10.3332/ecancer.2016.702 PMid:28105073 PMCid:PMC5221645
12. Kim JK, Sun KH. Role of platelet-to-lymphocyte ratio at the time of arrival to the emergency room as a predictor of short-term mortality in trauma patients with severe trauma team activation. Acute Crit Care. 2024;39(1):146-54. https://doi.org/10.4266/acc.2023.01319 PMid:38476067 PMCid:PMC11002612
13. Ma J, Li K. Systemic immune-inflammation index is associated with coronary heart disease: A cross-sectional study of NHANES 2009-2018. Front Cardiovasc Med. 2023;10:1199433. https://doi.org/10.3389/fcvm.2023.1199433 PMid:37485261 PMCid:PMC10361751
14. 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. https://doi.org/10.33879/amh.142.2022.05045
15. Galardo G, Crisanti L, Gentile A, et al. Neutrophil to lymphocyte ratio (NLR) and short-term mortality risk in elderly acute medical patients admitted to a university hospital emergency department. Intern Emerg Med. 2024. https://doi.org/10.1007/s11739-024-03683-8 PMid:38918300
16. Oba T, Maeno K, Ono M, Ito T, Kanai T, Ito K-I. Prognostic nutritional index is superior to neutrophil-to-lymphocyte ratio as a prognostic marker in metastatic breast cancer patients treated with eribulin. Anticancer Res. 2021;41(1):445-52. https://doi.org/10.21873/anticanres.14794 PMid:33419842
17. Chen W, Zhang M, Chen C, Pang X. Prognostic nutritional index and neutrophil/Lymphocyte ratio can serve as independent predictors of the prognosis of hepatocellular carcinoma patients receiving targeted therapy. J Oncol. 2022;1389049. https://doi.org/10.1155/2022/1389049 PMid:35990994 PMCid:PMC9388296
18. Wang G, Wang N, Liu T, et al. Association between prognostic nutritional index and mortality risk in patients with community-acquired pneumonia: A retrospective study. BMC Pulm Med. 2024;24(1):555. https://doi.org/10.1186/s12890-024-03373-3 PMid:39501259 PMCid:PMC11536940
19. Cheng Y-L, Sung S-H, Cheng H-M, et al. Prognostic nutritional index and the risk of mortality in patients with acute heart failure. J Am Heart Assoc. 2017;6(6):e004876. https://doi.org/10.1161/JAHA.116.004876 PMid:28649089 PMCid:PMC5669149
20. Mengqin Z, Yalin H, Xing L, et al. Trends in nutritional status and factors affecting prognostic nutritional index in ovarian cancer patients during chemotherapy: A prospective longitudinal study based on generalized estimating equations. Support Care Cancer. 2024;32(3):191. https://doi.org/10.1007/s00520-024-08384-8 PMid:38400912 PMCid:PMC10894134