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Original Research

The role of the neutrophil-to-lymphocyte ratio in predicting outcomes among patients with community-acquired pneumonia

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ABSTRACT

Objectives: The value of the neutrophil-to-lymphocyte ratio (NLR) in predicting outcomes in patients hospitalised with community-acquired pneumonia (CAP) remains debated. This study evaluated whether NLR independently predicts clinical outcomes and enhances the predictive performance of the CURB-65 score in patients with CAP.
Methods: Data from CAP admissions at two Australian hospitals from 2018 to 2023 were analysed. NLR was calculated using admission neutrophil and lymphocyte counts. Patients were categorised into NLR >12 and NLR ≤12. Multilevel-multivariable regression models, adjusting for age, sex, Charlson index, CURB-65 score, Hospital Frailty Risk Score (HFRS) and C-reactive protein (CRP), assessed outcomes including length of stay (LOS), intensive care unit (ICU) admission and in-hospital mortality.
Results: Over 6 years, 7,862 patients with CAP were hospitalised (mean age 75.1 years, 54.6% male). Mean NLR was 12.6, with 2,877 (36.6%) patients having an NLR >12. Those with NLR >12 were older males with higher disease severity and Charlson index ($p<0.05$). Adjusted analyses showed that NLR >12 was independently associated with prolonged LOS (IRR=1.11, 95% CI 1.08–1.13, $p<0.001$), increased risk of ICU admission (adjusted odds ratio (aOR) =1.41, 95% confidence interval (CI) 1.06–1.88, $p=0.019$), and higher in-hospital mortality (aOR=1.27, 95% CI 1.06–1.53, $p=0.009$). The predictive ability of the CURB-65 score for in-hospital mortality was good (area under the curve (AUC) 0.68, 95% CI 0.66–0.70), while it was modest for the NLR (AUC 0.58, 95% CI 0.56–0.60). Incorporation of NLR to the CURB-65 score did not enhance its predictive ability (AUC 0.69, $p>0.05$).
Conclusions: NLR independently predicts adverse outcomes in patients hospitalised with CAP but does not improve the predictive performance of the CURB-65 score.

Introduction

Community-acquired pneumonia (CAP) is a leading cause of hospitalisation worldwide, responsible for over 1.5 million hospitalisations annually in the USA and over 100,000 deaths each year.[1] In Australia, CAP accounts for 2% of emergency hospitalisations, with an inpatient mortality of 8%, which rises to 17.7% among patients requiring intensive care unit (ICU) admission.[2] Risk stratification and prognostication in patients hospitalised with CAP are essential for defining disease trajectory and guiding management.[3] Several prognostic tools, such as the pneumonia severity index (PSI),[4] SMART-COP,[5] CURB-65[6] and the ATS/IDSA guidelines,[7] have been validated and are commonly used with satisfactory outcomes. However, the use of individual biomarkers like N-terminal pro-brain natriuretic peptide (NT-proBNP), C-reactive protein (CRP) and procalcitonin has been found to be less satisfactory.[8,9]

The neutrophil-to-lymphocyte ratio (NLR), which is the ratio between the absolute neutrophil count and the absolute lymphocyte count, is an easily measurable index that has gained interest as a useful prognostic marker in various conditions, including infections.[10] Previous studies on the use of NLR as a prognostic marker among patients hospitalised with CAP have shown conflicting results.[8,11,12,13] For example, the addition of the NLR to the PSI and the CURB-65 did not improve

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the mortality prediction ability of these tools in one study.[14] A recent study indicated that a high NLR ratio (>12) can be used to predict ICU admission (adjusted odds ratio (aOR) 1.40, 95% confidence interval (CI) 1.21–1.62, p<0.001) but not mortality.[13] A recent systematic review[15] demonstrated that the prognostic value of NLR is comparable to that of CRP, procalcitonin, white cell count, neutrophil count, lymphocyte count, PSI and CURB-65 score in predicting mortality. However, the studies included in the meta-analysis were limited by small sample sizes, single-centre designs and a lack of adjustment for important confounding factors, such as pneumonia severity and frailty, which can impact mortality in CAP.[16,17] Furthermore, these studies[13,14] have focused primarily on mortality as an outcome, with minimal evaluation of other important clinical outcomes such as the need for non-invasive and invasive mechanical ventilation, vasopressor support, length of hospital stay (LOS) and 30-day readmissions. Additionally, all of these studies have been conducted outside Australia.

Therefore, the aim of the current research was to determine the prognostic impact of NLR in predicting various clinical outcomes in Australian patients hospitalised with CAP after accounting for pneumonia severity, comorbidities and frailty.

Materials and methods

Study design and setting

This study was conducted at the two major metropolitan hospitals in South Australia: Flinders Medical Centre (FMC) and Royal Adelaide Hospital (RAH). We identified all adult patients ≥18 years with CAP using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10AM) codes (J13–J18) from electronic medical records (EMR) for admissions between 1 January 2018 and 31 December 2023. CAP was defined as an acute infection of the pulmonary parenchyma, characterised by clinical symptoms (cough, fever, pleuritic chest pain and dyspnoea) and a new radiographic infiltrate not acquired in a hospital or healthcare setting. We included patients with CAP identified based on ICD-10-AM codes. Exclusion criteria included patients who tested positive for coronavirus disease 2019 (COVID-19) detected on viral polymerase chain reaction (PCR) and those with hospital-acquired pneumonia (HAP), where symptoms developed more than 48 h after hospitalisation. Ethical approval for this study was granted by both the Southern Adelaide Human Clinical Research (SAH REC) and the Central Adelaide Human Clinical Research Ethics Committees.

Variable definitions

All data for this study were extracted from EMR, including information on demographic variables and comorbidities. Comorbidities influencing outcomes among patients with CAP[18,19] were identified, including chronic lung disease (eg chronic obstructive pulmonary disease (COPD), bronchial asthma, bronchiectasis and interstitial lung disease (ILD)), coronary artery disease (CAD), chronic kidney disease (CKD) and a history of cancer. Pneumonia severity was evaluated using the CURB-65 score[4] on admission, computed from parameters including confusion, urea concentrations >7 mmol/L, respiratory rate >30/min, blood pressure (systolic <90 mmHg and/or diastolic ≤65 mmHg) and age >65 years. Comorbidity burden was quantified using the Charlson Comorbidity Index (CCI).[20] The frailty status of patients was determined using the Hospital Frailty Risk Score (HFRS),[21] with patients scoring ≥5 classified as frail. Nutritional status was assessed using the Malnutrition Universal Screening Tool (MUST),[22] with patients scoring >1 classified as malnourished.

The white blood cell count (WBC), which measures total leukocytes, is recorded as 10^9/L in our hospitals, with the normal count ranging between 4.0 and 11.0×10^9/L. For the differential components, the normal ranges for neutrophil and lymphocyte counts are 1.80–7.50×10^9/L and 1.10–3.50×10^9/L, respectively. The neutrophil and lymphocyte counts tested during the first 24 h of hospital admission (first reading available if more than one result was found during hospitalisation) were recorded and used to calculate the NLR. Based on literature,[13] a NLR cut-off of 12 was used to compare characteristics and outcomes of patients (NLR ≤12 vs NLR >12). Other laboratory parameters measured on admission included haemoglobin (measured in g/L; normal range: males 135–175 g/L and females 115–165 g/L), CRP (measured in mg/L; normal range: <8 mg/L), albumin (measured in g/L; normal range: 34–48 g/L), creatinine (measured in μmol/L; normal range: males 60–110 μmol/L and females 45–90 μmol/L), and international normalised ratio (INR). We also recorded data on medical emergency response team (MET) calls, ICU admissions, high-flow oxygen therapy (HFOT) (defined as the need for 100% humidified oxygen at a flow rate of up to 60 L/min), non-invasive ventilation (NIV), invasive mechanical ventilation, and vasopressor support during hospitalisation.

Positive sputum culture results were defined according to the criteria proposed by the Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) guidelines.[23] A positive sputum culture result was required to exhibit <9 epithelial cells/high power field with moderate to many white blood cells to indicate infection. Sputum samples that exhibited many epithelial cells were deemed to represent an inadequate sample collection. Similarly, if no or fewer than 25 white blood cells/low power field were present, this was deemed to represent colonisation.[23,24] However, if the same bacterial species was also isolated from sterile sites (such as blood or pleural fluid), then sputum cultures were classified as representative of a true infection. In addition, we captured the results of all nasal or throat swab multiplex PCR tests performed during admission to discern viral aetiology associated with CAP.

Outcomes

Primary outcomes included in-hospital mortality and LOS. Secondary outcome measures included the need for non-invasive and invasive mechanical ventilation, vasopressor support, ICU admission, number of MET calls, mortality within 30 days of hospital admission, and 30-day readmission rate from the day of discharge.

Statistical analyses

Variables were assessed for normality by visual inspection of histograms and use of the Shapiro–Wilk test. Continuous variables are reported as means with standard deviations (SD) or medians with interquartile ranges (IQR), as appropriate, and categorical variables as numbers and frequencies. Continuous variables were assessed using *t*-tests or Mann–Whitney U tests, while the chi-square statistic was used for categorical variables. A NLR ≤12 was used as the reference for comparisons as reported in previous literature,[13,15] Multilevel multivariable logistic and Poisson regression models were used to report odds ratios (OR) and risk ratios (RR) with corresponding 95% confidence intervals (CI), adjusting for age, sex, CCI, CURB-65, HFRS and CRP.

Sensitivity analyses

The association between NLR and outcomes was verified using the sensitivity analyses:

- Using NLR as a continuous variable
- Classifying patients into five NLR quintiles ((1) NLR <4.1, (2) NLR ≥4.1 and <6.9, (3) NLR ≥6.9 and <10.7, (4) NLR ≥10.7 and <17.8, and (5) >17.8 with (1) as the reference group))

C-statistics were used to examine the predictive abilities of the NLR, and the CURB-65 score for mortality and ICU admission. Receiver operating characteristic (ROC) curves were plotted to determine the area under the curve (AUC) with 95% CI. We also determined the additional potential contribution of the NLR to the CURB-65 score in predicting

Table 1
Demographic and clinical characteristics of patients.

Characteristics	Total n = 7,862	NLR ≤12 n= 4,985	NLR >12 n= 2,877	*P*-value
Age, mean (SD)	75.1 (17.6)	74.3 (18.0)	76.6 (16.7)	<0.001
Age group, n (%)				
<40	435 (5.5)	317 (6.4)	118 (4.1)	<0.001
40–59	973 (12.4)	660 (13.2)	313 (10.9)	
60–79	2,641 (33.6)	1,665 (33.4)	976 (33.9)	
>80	3,813 (48.5)	2,343 (47.0)	1,470 (51.1)	
Sex, male n (%)	4,290 (54.6)	2,659 (53.3)	1,631 (56.7)	0.004
Race, n (%)				
Caucasian	7,176 (91.3)	4,540 (91.1)	2,636 (91.6)	0.007
Asian	510 (6.5)	343 (6.9)	167 (5.8)	
Black	40 (0.5)	30 (0.6)	10 (0.5)	
Indigenous	136 (1.7)	42 (1.4)	64 (2.2)	
BMI, mean (SD)	27.1 (7.3)	27.6 (7.3)	26.3 (7.2)	<0.001
CURB-65, mean (SD)	1.8 (1.0)	1.7 (1.0)	2.0 (1.0)	<0.001
CCI, mean (SD)	2.7 (2.9)	2.6 (2.9)	2.8 (2.9)	0.027
HFRS, mean (SD)	5.3 (4.7)	5.0 (4.7)	5.7 (4.8)	<0.001
Asthma, n (%)	259 (3.3)	181 (3.6)	78 (2.7)	0.028
COPD, n (%)	2,088 (26.6)	1,248 (25.0)	840 (29.2)	<0.001
ILD, n (%)	281 (3.6)	182 (3.7)	99 (3.4)	0.627
Bronchiectasis, n (%)	199 (2.5)	123 (2.5)	76 (2.6)	0.637
CAD, n (%)	741 (9.4)	460 (9.2)	281 (9.8)	0.433
CKD, n (%)	1,379 (17.5)	827 (16.6)	552 (19.2)	0.004
Smokers, n (%)	310 (3.9)	199 (4.0)	111 (3.9)	0.767
Cancer, n (%)	1,315 (16.7)	836 (16.8)	479 (16.6)	0.885
WBC count, n (%)	12.5 (10.3)	11.0 (10.8)	15.3 (8.6)	<0.001
Neutrophil count, mean (SD)	10.2 (6.4)	8.0 (4.1)	14.2 (7.7)	<0.001
Lymphocyte count, mean (SD)	1.6 (7.3)	2.0 (9.0)	0.7 (0.4)	<0.001
NLR, mean (SD)	12.6 (14.3)	5.9 (2.9)	24.9 (18.3)	<0.001
CRP, mean (SD)	102.4 (100.5)	88.1 (89.0)	128.1 (114.1)	<0.001
Creatinine, mean (SD)	123.1 (131.0)	118.1 (123.4)	132.2 (143.6)	<0.001
Albumin, mean (SD)	29.7 (5.5)	30.1 (5.4)	28.9 (5.8)	<0.001
INR, mean (SD)	1.4 (0.8)	1.4 (0.7)	1.4 (0.8)	0.163
Causative aetiology, n (%)	983 (12.5)	596 (11.9)	387 (13.5)	0.054

NLR, neutrophil/lymphocyte ration; SD, standard deviation; CURB-65, CURB65, (pneumonia severity score calculated from following parameters: confusion, urea levels >7 mmol/L, respiratory rate ≥30/min, blood pressure systolic <90 mmHg or diastolic ≤60 mmHg, and age ≥65 years); CCI, Charlson comorbidity index; HFRS, hospital frailty risk score; COPD, chronic obstructive pulmonary disease; ILD, interstitial lung disease; CAD, coronary artery disease; CKD, chronic kidney disease; WBC, white cell count; CRP, C-reactive protein; INR, international normalised ratio.

mortality. The ROC curves were compared using DeLong's test.[25] In addition, we compared the predictive abilities of the NLR for mortality and ICU admission against the absolute neutrophil and lymphocyte counts. A significance threshold of p<0.05 was applied for all tests, and Stata software version 18.0 was used for all statistical analyses (StataCorp LLC, College Station, TX, USA).

Results

Over the 6-year period, 7,862 patients with CAP were admitted across the two hospitals (Supplementary Figure 1). The mean (SD) age was 75.1 (17.6) years (range 18–107), and 54.6% were males. The mean (SD) CURB-65 score was 1.8 (1.0), and the CCI was 2.7 (2.9). Frailty, as defined by a HFRS ≥5, was present in 3,243 (41.2%) patients. The median (IQR) LOS was 3.9 (2.0, 7.2) days, and in-hospital mortality occurred in 618 (7.9%) patients. The baseline characteristics of patients according to the admitting hospital are presented in Supplementary Table A**.** Patients admitted to RAH were significantly frailer, with higher creatinine and albumin levels, whereas those admitted to FMC were more likely to be smokers and had a higher prevalence of COPD ($p<0.05$).

Body fluid cultures (sputum, blood or pleural fluid) were obtained in 81% of patients with CAP. A causative agent was identified in 983 (12.5%) of patients. In terms of aetiology, a bacterial agent was identified in 736 (9.4%) patients. *Mycoplasma pneumoniae* (20.4%) and *Streptococcus pneumoniae* (19.6%) were the most commonly identified bacteria. In terms of any viral aetiology, rhinovirus (64.9%) and parainfluenza virus (10.2%) were the most commonly identifiable viruses. Seventy patients with CAP (0.9%) were identified to have both viral and bacterial infections. The mean (SD) WBC count was 12.5 (10.3), with mean (SD) neutrophil and lymphocyte counts of 10.2 (6.3) and 1.6 (7.3), respectively. The mean (SD) NLR was 12.6 (14.3), with 2,877 (36.6%) patients having a NLR >12. Patients with a NLR >12 were more likely to be older males, Caucasians with a lower body mass index (BMI) and higher CAP severity and CCI ($p<0.05$) compared to those with a NLR ≤12. This group also had higher rates of frailty, COPD and CKD, but a lower prevalence of asthma ($p<0.05$). In terms of investigations, patients with a NLR >12 had higher mean WBC count, neutrophil count, CRP and creatinine levels, while lymphocyte count and albumin levels were significantly lower than those with a NLR ≤12 ($p<0.05$) (Table 1). A causative agent was more likely identifiable among patients with a NLR >12 compared to those with a NLR ≤12, although this difference was not statistically significant (13.5% vs. 11.9%, $p=0.054$).

Clinical outcomes

Unadjusted analysis: Patients with a NLR >12 had a significantly longer median LOS (4.3 (2.3, 8.1) vs. 3.8 (1.9, 6.8) days, $p<0.05$), a higher ICU admission rate (3.7% vs. 2.6%, $p=0.005$), and increased in-hospital (10.3% vs. 6.4%, $p<0.05$) and 30-day (17.2% vs. 12.6%, $p<0.05$) mortality. The need for vasopressor support was higher in the NLR >12 group, while readmission risk was lower ($p<0.05$) (Table 2).

Adjusted analysis: Multilevel Poisson regression showed that patients with an NLR >12 had an 11% increased risk of longer LOS (adjusted incident rate ratio (aIRR) 1.11, 95% CI 1.08–1.13, $p<0.001$). They also had higher odds of ICU admission (adjusted odds ratio (aOR) 1.41, 95% CI 1.06–1.88, $p=0.019$), in-hospital mortality (aOR 1.27, 95% CI 1.06–1.53, p=0.009), and vasopressor support (aOR 1.88, 95% CI 1.37–2.58, $p<0.001$). Other outcomes were similar between the two groups, except

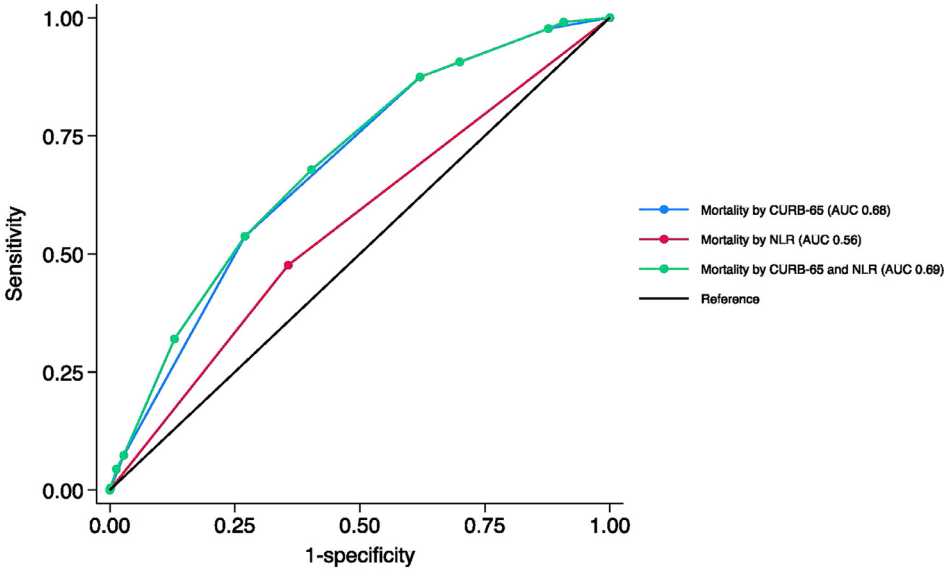

Fig. 1. Receiver operating characteristic (ROC) curves displaying predictive abilities of CURB-65, NLR, and combined CURB-65 and NLR for in-hospital mortality in CAP.

Table 2
Clinical outcomes among non-COVID-19 CAP according to NLR cut-off ≤12 or >12.

Outcome	NLR ≤12	NLR >12	*P*-value
N	4,985	2,878	
LOS, median (IQR)	3.8 (1.9, 6.8)	4.3 (2.3, 8.1)	<0.001
ICU admission, n (%)	127 (2.6)	106 (3.7)	0.004
In-hospital mortality, n (%)	321 (6.4)	297 (10.3)	<0.001
30-day mortality, n (%)	628 (12.6)	494 (17.2)	<0.001
30-day readmission, n (%)	901 (18.1)	428 (14.5)	<0.001
HFOT, n (%)	53 (1.1)	44 (1.5)	0.071
NIV, n (%)	24 (0.48)	21 (0.73)	0.160
Invasive ventilation, n (%)	15 (0.3)	10 (0.4)	0.724
Vasopressor, n (%)	86 (1.7)	103 (3.6)	<0.001

NLR, neutrophil/lymphocyte ratio; LOS, length of hospital stay; IQR, interquartile range; ICU, intensive care unit; HFOT; high-flow oxygen therapy; NIV, non-invasive ventilation.

for a lower risk of 30-day readmission among patients with an NLR >12 (Table 3). The risk factors associated with above clinical outcomes are presented in Supplementary Fig. 2–7.

Sensitivity analyses with NLR as a continuous variable confirmed these findings (Supplementary Table B). Additionally, analysis with NLR quintiles revealed worse clinical outcomes for patients in the highest quintile compared to the first, although the lower readmission risk was not confirmed (Supplementary Table C).

Predictive ability

The predictive ability of the CURB-65 score for in-hospital mortality was good (AUC 0.68, 95% CI 0.66–0.70), while it was modest for the NLR (AUC 0.58, 95% CI 0.56–0.60). Adding the NLR to the CURB-65 score did not significantly enhance its predictive ability for in-hospital mortality (AUC 0.69) (Fig. 1). For predicting ICU admission, the CURB-65 score had poor predictive ability (AUC 0.53, 95% CI 0.49–0.56), whereas the NLR showed modest predictive ability (AUC 0.58, 95% CI 0.54–0.62). Incorporating the NLR into the CURB-65 score did not improve its predictive ability for ICU admissions (AUC 0.56, 95% CI 0.52–0.59) (Fig. 2).

When compared to the NLR, the predictive ability of the absolute neutrophil count for in-hospital mortality was lower (AUC 0.55, 95% CI 0.52–0.57), while lymphocyte count demonstrated poor predictive ability (AUC 0.42, 95% CI 0.39–0.44). Similarly, for ICU admission, the predictive ability of the absolute neutrophil count was lower (AUC 0.54, 95% CI 0.51–0.59), while it remained poor for lymphocyte count (AUC 0.42, 95% CI 0.38–0.46).

Discussion

In this large, multicentre, retrospective study of hospitalised patients with CAP, we found that CAP patients with a NLR >12 were significantly older, had higher number of comorbidities and more likely to be frail compared to those with an NLR ≤12. Additionally, these pa-

Table 3
Comparison of clinical outcomes of patients with NLR >12 with NLR ≤12 after unadjusted and adjusted multilevel regression models.

Outcome	Unadjusted OR	95% CI	*P*-value	Adjusted OR[a]	95% CI	*P*-value
LOS	1.20[b]	1.17–1.22	<0.001	1.11[b]	1.08–1.13	<0.001
ICU admission	1.45	1.11–1.88	<0.006	1.41	1.06–1.88	0.019
In-hospital mortality	1.67	1.42–1.97	<0.001	1.27	1.06–1.53	0.009
30-day mortality	1.44	1.26–1.63	<0.001	1.12	0.97–1.29	0.116
30-day readmission	0.79	0.69–0.89	<0.001	0.79	0.69–0.91	0.001
HFOT	1.43	0.95–2.14	0.081	1.18	0.77–1.79	0.431
NIV	1.51	0.84–2.73	0.163	1.48	0.80–2.73	0.205
Invasive ventilation	1.15	0.51–2.17	0.734	1.04	0.43–2.49	0.917
Vasopressor	2.11	1.58–2.82	<0.001	1.88	1.37–2.58	<0.001

NLR, neutrophil/lymphocyte ratio; LOS, length of hospital stay; IQR, interquartile range; ICU, intensive care unit; HFOT; high-flow oxygen therapy; NIV, non-invasive ventilation.

[a] Model adjusted for age, sex, Charlson index, CURB-65, Hospital Frailty Risk Score (HFRS) and C-reactive protein (CRP)

[b] IRR, incident risk ratio.

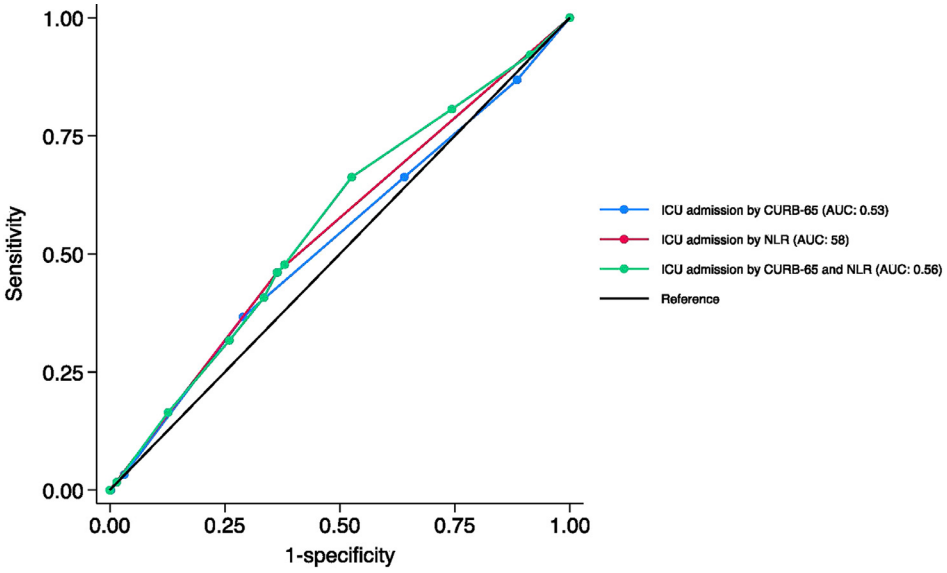

Fig. 2. Receiver operating characteristic (ROC) curves displaying predictive abilities of CURB-65, NLR, and combined CURB-65 and NLR for intensive care unit (ICU) admission in CAP.

tients displayed greater CAP severity as indicated by the higher CURB-65 score. An NLR >12 on admission was associated with a longer hospital LOS, a greater likelihood of ICU admission and vasopressor support, and higher in-hospital mortality after adjusted analysis. Although higher 30-day mortality and lower 30-day readmission rates were also observed among patients with a NLR >12 compared to those with a NLR ≤12, these findings were not confirmed in the sensitivity analyses. The addition of the NLR to the CURB-65 score did not increase its predictive ability for in-hospital mortality or ICU admission rates. The predictive abilities of NLR were found to be better than those of the absolute neutrophil and lymphocyte counts in predicting both in-hospital mortality and ICU admission rates.

The utility of the NLR in predicting clinical outcomes of CAP patients have been reported in previous studies with conflicting results. Many of these studies were limited by small sample sizes and did not used adjusted analyses for pneumonia severity, comorbidities, and frailty status. A recent systematic review[15]which included nine studies and 3,340 patients with CAP, confirmed an association between high NLR and mortality. This study found that an NLR cut-off >10 predicts mortality compared to the PSI, CURB-65, and other biomarkers including total WBC count, neutrophil and lymphocyte count, and CRP concentration. Higher sensitivity and specificity for mortality prediction were observed with NLR cut-off levels between 11.2 and 13.4. In contrast, another study[13] found a non-significant association between NLR and CAP mortality (aOR 1.12, 95% CI 0.77–1.61, p=0.559). This study only adjusted for pneumonia severity as determined using PSI and did not account for the frailty status of the patients or use the more robust CCI for comorbidity adjustment. Apart from other comorbidities, the CCI accounts for a history of diabetes, CAD and COPD, which are not included in the PSI calculation. These conditions are significant determinants of mortality in CAP.[26-28]

Our study indicates that the NLR taken singly is inferior to the CURB-65 score in predicting in-hospital mortality and does not add significant additive value to this score. Our findings are similar to a previous study by Postma *et al*,[14] which included 1,594 patients and found no improvement in CURB-65 and PSI models, despite a significant association with mortality on bivariate analysis. Similar findings were observed in studies conducted by Kaya *et al*[29] and Tekin *et al*,[13] which also found the NLR inferior to CURB-65 and the PSI models. The findings of this study are also consistent with those of De Jager *et al*,[11] which included 395 patients with CAP and found that NLR was superior in predicting mortality compared to both neutrophil count and lymphocyte count (NLR AUC 0.70 vs neutrophil AUC 0.68 vs lymphocyte AUC 0.56). This suggests that while NLR has better predictive value than individual neutrophil or lymphocyte counts, it still does not significantly enhance the prognostic accuracy of established severity scoring systems like CURB-65.

However, this study also reported a significant association between the NLR and ICU admission. This finding is consistent with a study by Tekin *et al*,[13] which noted that an NLR >12 was associated with a higher likelihood of ICU admission (aOR 1.41, 95% CI 1.22–1.62, p<0.001). Additionally, our study suggests that an association between an NLR >12 and hospital LOS in patients with CAP, an outcome rarely assessed previously. Only one study, by Postma *et al*,[14] explored the association between NLR and LOS and found no significant relationship. That study, however, excluded patients with CAP who required ICU admission, thus not accounting for patients with severe CAP who are likely to have longer hospital stays.

The strengths of our study include a large sample size, a multicentre approach, and the use of robust statistical analyses that adjust for pneumonia severity, comorbidities and frailty status of patients. However, there are several limitations. The observational design introduces potential for residual confounding, and we did not adjust for antimicrobial therapy used in the treatment of CAP. It is possible that missing data or coding inaccuracies may have affected the calculation of the CURB-65 score in some cases. Additionally, since this study was limited to hospitalised patients with CAP, the results may not be applicable to those treated in outpatient settings.

This study found that while NLR was associated with outcomes such as longer LOS, increased risk of ICU admission, and higher mortality in patients with CAP, its predictive ability was inferior to the CURB-65 score. Furthermore, adding NLR to the CURB-65 score did not improve its predictive power for in-hospital mortality.

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Ethical approval and consent to participate

This study was approved by the Southern Adelaide Human Clinical Research and the Central Adelaide Human Clinical Research Ethics Committees. This retrospective observational study did not require patient consent. The study has been approved by the Southern Adelaide

Human Clinical Research Ethics Committee, which determined that the research poses minimal risk to participants and that obtaining individual consent is not feasible. All patient information used in this study has been anonymised to protect privacy and confidentiality. The study complies with relevant regulations and guidelines for the ethical conduct of research.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declaration of competing interest

The authors declare no conflict of interest with any financial organisation regarding the material discussed in this manuscript.

CRediT authorship contribution statement

Yogesh Sharma: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Campbell Thompson:** Writing – review & editing, Supervision. **Angelo Zinellu:** Validation, Investigation. **Rashmi Shahi:** Validation, Methodology, Investigation. **Chris Horwood:** Resources, Investigation, Data curation. **Arduino A. Mangoni:** Writing – review & editing, Visualization, Supervision, Investigation, Conceptualization.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.clinme.2024.100278.

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