



COMPARATIVE PROGNOSTIC VALUE OF THE PNEUMONIA SEVERITY INDEX, CURB-65 AND HAEMATOLOGICAL RATIOS (NLR, MLR, PLR) FOR PREDICTING IN-HOSPITAL MORTALITY IN COMMUNITY-ACQUIRED PNEUMONIA

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ABSTRACT

Background: Rapid, reliable risk stratification is central to the management of community-acquired pneumonia (CAP). The pneumonia severity index (PSI) and the CURB-65 score are well validated, but they are time-consuming or require laboratory data that may not be immediately available. Inexpensive haematological ratios derived from a routine complete blood count, the neutrophil-to-lymphocyte ratio (NLR), monocyte-to-lymphocyte ratio (MLR) and platelet-to-lymphocyte ratio (PLR), have been proposed as surrogate prognostic markers. We compared their performance against PSI and CURB-65 for predicting in-hospital mortality.

Methods: We conducted a retrospective observational cohort study of adults admitted with CAP to POF Hospital, Wah Cantt, between 1 April and 15 July 2024. Demographic, clinical and admission complete-blood-count data were retrieved from electronic records. PSI, CURB-65 and the three ratios were calculated for each patient. Survivors and non-survivors were compared with the Mann–Whitney U test; discrimination for in-hospital mortality was assessed with the area under the receiver-operating-characteristic curve (AUC), AUCs were compared with the DeLong test, and optimal thresholds were derived using the Youden index.

Results: Of 150 admission records, 143 unique patients were analysed (median age 68 years; 62% ≥ 65 years), of whom 121 had a complete admission blood count permitting ratio calculation. In-hospital mortality was 7.0% (10/143). PSI (AUC 0.88, 95% CI 0.75–0.96) and CURB-65 (AUC 0.84, 95% CI 0.72–0.94) discriminated mortality well, and both scores together with the National Early Warning Score were markedly higher in non-survivors (all $p \leq 0.001$). In contrast, NLR (AUC 0.44), MLR (AUC 0.52) and PLR (AUC 0.39) showed no discriminatory ability; both clinical scores outperformed every ratio on DeLong testing (all $p \leq 0.005$), and the ratios correlated only weakly and non-significantly with PSI and CURB-65 (all $|\rho| < 0.08$).

Conclusions: In this single-centre cohort, PSI and CURB-65 substantially outperformed the haematological ratios, which carried no independent prognostic value for in-hospital mortality. NLR, MLR and PLR should not replace established severity scores, although their low cost may warrant evaluation as adjuncts in adequately powered, multicentre studies.

Keywords: community-acquired pneumonia; pneumonia severity index; CURB-65; neutrophil-to-lymphocyte ratio; in-hospital mortality; prognosis

INTRODUCTION

Community-acquired pneumonia (CAP) remains one of the most consequential infectious diseases worldwide, both for the individual patient and for stretched health systems. The most recent Global Burden of Disease analysis attributed roughly 2.5 million deaths to lower respiratory infections in 2023, an increase of almost a fifth over the 2.1 million estimated for 2021, with older adults and young children carrying the heaviest burden.¹

CAP is among the leading infectious causes of hospitalisation and death, and its impact falls disproportionately on low- and middle-income countries where access to vaccination, diagnostics and intensive care is uneven.^{1,2} In this setting, the speed and accuracy with which a clinician sorts patients into appropriate levels of care directly shapes outcome. Severity-of-illness scores were developed for this purpose. The pneumonia severity index (PSI) stratifies patients into five risk classes using twenty demographic, comorbidity, examination and laboratory variables,³ while the CURB-65 score offers a simpler bedside alternative based on confusion, urea, respiratory rate, blood pressure and age.⁴ Both tools are recommended in international guidelines⁵ and have been repeatedly validated, including in South Asian and African populations,⁶ with meta-analyses showing strong, broadly comparable performance for the two scores.^{7,8}

Calculating the PSI is cumbersome and CURB-65 omits several physiological derangements, so interest has grown in inexpensive markers read directly from the admission differential white-cell count. Three ratios have attracted particular attention: the neutrophil-to-lymphocyte ratio (NLR), the monocyte-to-lymphocyte ratio (MLR) and the platelet-to-lymphocyte ratio (PLR). Each is thought to capture the balance between the innate inflammatory response and the relative lymphopenia that accompanies severe infection, and each can be derived at essentially no additional cost.⁹ The evidence for their prognostic value, however, is inconsistent. Some studies and meta-analyses report that a high NLR is associated with mortality and intensive-care admission,^{10,11,12} and a high MLR with mortality in acute respiratory distress syndrome,¹³ whereas others find that the ratios add little once pneumonia severity is accounted for and do not outperform PSI or CURB-65.^{14,15}

Given this uncertainty, and the relative scarcity of data from Pakistani hospitals^{16,17} This study sets out to compare the prognostic performance of PSI and CURB-65 with that of NLR, MLR and PLR for predicting in-hospital mortality among patients admitted with CAP at a tertiary-care hospital in Wah Cantt. This study hypothesised that the haematological ratios would, at best, parallel the established scores and would not provide independent discriminatory value.

MATERIALS AND METHODS

This was a retrospective observational cohort study carried out at POF Hospital, Wah Cantt, a tertiary-care teaching hospital. All adults admitted with a diagnosis of pneumonia between 1 April 2024 and 15 July 2024 were eligible.

The study used routinely collected data and did not alter patient management; it is reported in line with the STROBE recommendations for observational studies.

Consecutive sampling was used. Patients of either sex admitted with CAP during the study window were included. Patients with chronic pulmonary disease or with incomplete records were excluded. An a priori sample size of 169 was estimated with the Raosoft calculator (95% confidence, 5% margin of error, anticipated population of 300 admissions over the period). During the defined window 150 admission records were retrieved; 7 represented duplicate re-admission entries for the same patient and were removed, leaving 143 unique patients for the primary analysis. A complete admission blood count permitting calculation of all three ratios was available for 121 patients, who formed the cohort for the biomarker comparisons (Figure 1).

Demographic details, ward placement, length of stay, the National Early Warning Score (NEWS), oxygen saturation, requirement for assisted ventilation and the in-hospital outcome (survival or death) were extracted from the electronic record. The complete blood count taken at admission was traced, and absolute neutrophil, lymphocyte, monocyte and platelet counts were recorded. Two records contained physiologically implausible white-cell values consistent with transcription error and were excluded from the ratio analyses. CURB-65 was scored from one point each for confusion, blood urea nitrogen above 20 mg/dL, respiratory rate of 30/min or more, systolic blood pressure below 90 mmHg (or diastolic below 60 mmHg), and age of 65 years or older (Table 1); a score of 2 or more was taken to indicate high mortality risk.⁴ The PSI was calculated from demographic, comorbidity, examination and laboratory variables and patients were assigned to classes I–V.³ The ratios were derived from the admission count as $NLR = \text{neutrophils} \div \text{lymphocytes}$, $MLR = \text{monocytes} \div \text{lymphocytes}$ and $PLR = \text{platelets} \div \text{lymphocytes}$.

Table 1. Components of the CURB-65 score.

Letter	Clinical criterion	Points
C	Confusion (new disorientation)	1
U	Blood urea nitrogen > 20 mg/dL	1
R	Respiratory rate ≥ 30 / min	1
B	Systolic BP < 90 mmHg or diastolic BP < 60 mmHg	1
65	Age ≥ 65 years	1

Statistical analysis

Non-normally distributed continuous variables are summarised as median (interquartile range, IQR) and compared between survivors and non-survivors with the Mann–Whitney U test. Categorical variables are presented as counts and percentages and compared with the chi-square test. Discriminatory performance for in-hospital mortality was quantified with the area under the receiver-operating-characteristic curve (AUC) with 95% confidence intervals, and pairwise AUC comparisons used the DeLong test. Optimal cut-offs, with corresponding sensitivity and specificity, were identified using the Youden index. Associations between the ratios and the clinical scores were examined with the Spearman rank correlation. A two-sided p-value below 0.05 was considered significant. Analyses were performed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA).

RESULTS

The 143 analysed patients had a median age of 68 years (IQR 58–75; range 17–93) and 89 (62.2%) were 65 years or older. The median NEWS at admission was 8 and almost a third required assisted ventilation. The median hospital stay was 6 days (IQR 4–9). Most patients were managed on the general ward (67.8%), with the remainder in high-dependency, intensive-care or coronary-care beds. By PSI, 65.0% of patients fell into the two highest classes (IV–V), and 56.6% had a CURB-65 score of 2 or more. The overall in-hospital mortality was 7.0% (10 of 143); in the 121-patient biomarker cohort there were 8 deaths (6.6%). Baseline characteristics are summarised in Table 2.

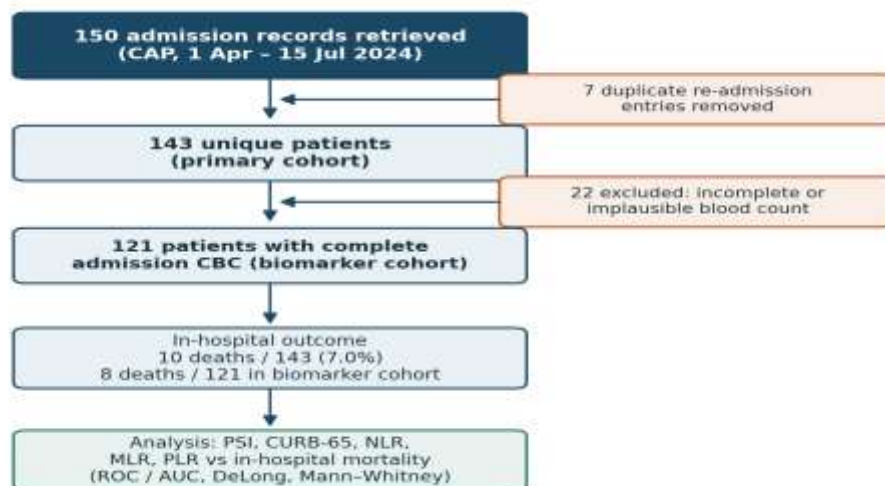


Figure 1. Participant flow through the study (STROBE diagram).

Table 2. Baseline characteristics of the study cohort (n = 143).

Characteristic	Value
Age, years — median (IQR)	68 (58–75)
Age ≥ 65 years — n (%)	89 (62.2)
NEWS — median (IQR)	8 (5–9)
Required assisted ventilation — n (%)	48 (33.6)
Length of stay, days — median (IQR)	6 (4–9)
WBC, ×10 ⁹ /L — median (IQR)	12.2 (9.3–15.6)
Haemoglobin, g/dL — median (IQR)	11.9 (10.7–13.2)
CURB-65 ≥ 2 — n (%)	81 (56.6)
PSI class IV–V — n (%)	93 (65.0)
In-hospital death — n (%)	10 (7.0)

Comparison of survivors and non-survivors

Within the biomarker cohort, non-survivors had substantially higher CURB-65 scores (median 3 vs 2, $p = 0.001$), PSI points (153 vs 100, $p < 0.001$) and NEWS (14 vs 8, $p < 0.001$) than survivors, and every patient who died had required assisted ventilation (100% vs 27%, $p < 0.001$). Admission white-cell count was higher in non-survivors but the difference reached only borderline significance ($p = 0.06$). Crucially, none of the three haematological ratios differed between the groups: median NLR was actually slightly lower in non-survivors, while MLR and PLR were statistically indistinguishable (all $p > 0.28$). These comparisons are detailed in Table 3 and the distribution of the ratios is shown in Figure 4.

Table 3. Admission variables in survivors versus non-survivors (biomarker cohort, n = 121).
Values are median (IQR); p from the Mann–Whitney U test.

Variable	Survivors (n=113)	Non-survivors (n=8)	p
Age (years)	68.0 (58.0–75.0)	67.5 (64.5–82.5)	0.38
CURB-65 score	2.0 (1.0–2.0)	3.0 (2.0–3.2)	0.001
PSI (points)	100 (78–127)	153 (146–156)	<0.001
NEWS	8.0 (5.0–9.0)	13.5 (12.0–14.5)	<0.001
WBC (×10 ⁹ /L)	12.0 (9.1–15.4)	15.4 (12.3–22.3)	0.06
NLR	4.81 (2.36–8.30)	3.50 (1.65–8.75)	0.60
MLR	0.26 (0.16–0.40)	0.31 (0.16–0.41)	0.86
PLR	120.6 (73–204)	73.3 (42–223)	0.29

Discrimination for in-hospital mortality

Receiver-operating-characteristic analysis confirmed a clear separation between the clinical scores and the ratios (Figure 2, Figure 3). PSI achieved the best discrimination (AUC 0.88, 95% CI 0.75–0.96), followed closely by CURB-65 (AUC 0.84, 95% CI 0.72–0.94). A PSI threshold above 134 points gave a sensitivity of 87.5% and specificity of 80.5%, while a CURB-65 score of 2 or more identified every non-survivor (sensitivity 100%) at the cost of modest specificity (about 47%); in the full cohort no death occurred below this threshold. By contrast, all three haematological ratios performed at or below chance level, MLR 0.52 (95% CI 0.27–0.75), NLR 0.44 (0.18–0.70) and PLR 0.39 (0.11–0.66), with confidence intervals that comfortably crossed 0.5. On DeLong testing, both PSI and CURB-65 discriminated significantly better than every ratio (all comparisons $p \leq 0.005$), whereas the two clinical scores did not differ from each other ($p = 0.52$). The categorical strata reinforced this pattern: mortality was 12.3% among patients with CURB-65 ≥ 2 versus 0% below ($p = 0.011$), and 10.8% in PSI class IV–V versus 0% in classes I–III ($p = 0.039$). Performance metrics are summarised in Table 4.

Table 4. Discriminative performance for in-hospital mortality (biomarker cohort, n = 121). Cut-offs and operating characteristics from the Youden index.

Predictor	AUC (95% CI)	Cut-off	Sens. %	Spec. %
PSI	0.88 (0.75–0.96)	> 134	87.5	80.5
CURB-65	0.84 (0.72–0.94)	≥ 2	100	47
MLR	0.52 (0.27–0.75)	> 0.30	62.5	61.9
NLR	0.44 (0.18–0.70)	> 11.0	25.0	86.7
PLR	0.39 (0.11–0.66)	> 221	37.5	77.0

Correlation between ratios and clinical scores

Spearman analysis found essentially no association between any of the ratios and either clinical score. Correlation coefficients ranged from $\rho = 0.02$ to $\rho = 0.08$ and none approached statistical significance (all $p > 0.38$). In other words, in this cohort the haematological ratios carried no information that tracked with measured pneumonia severity.

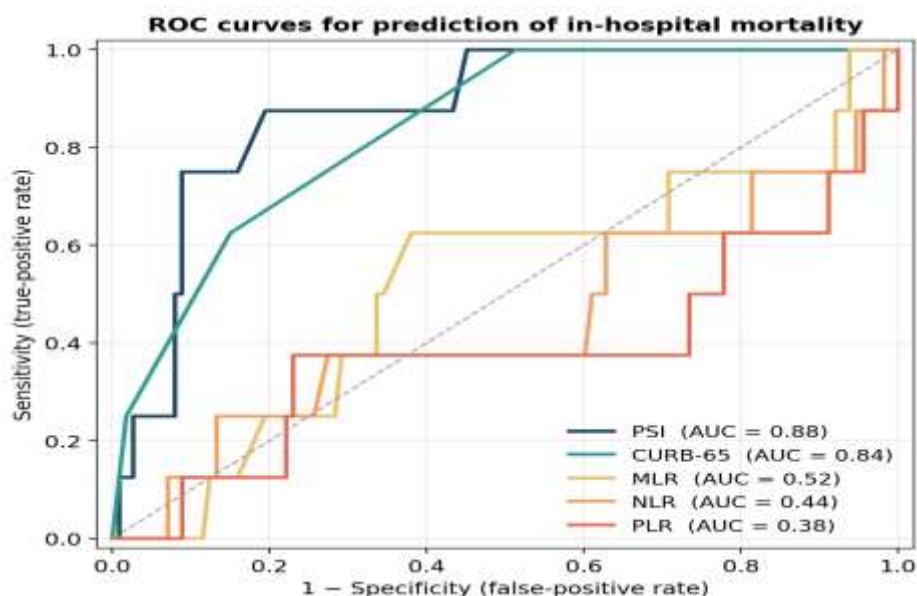


Figure 2. Receiver-operating-characteristic curves for the five predictors of in-hospital mortality. PSI and CURB-65 lie well above the line of no discrimination, whereas NLR, MLR and PLR track close to or below it.

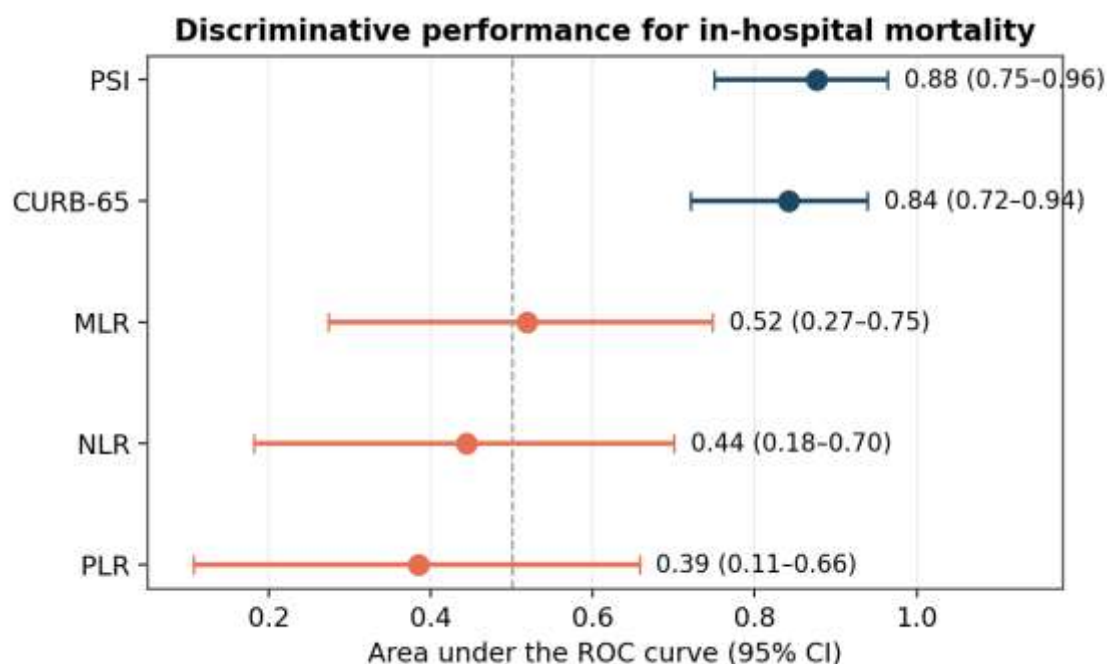


Figure 3. Area under the ROC curve with 95% confidence intervals. Intervals for the three ratios all include 0.5 (no discrimination); those for PSI and CURB-65 lie entirely above it.

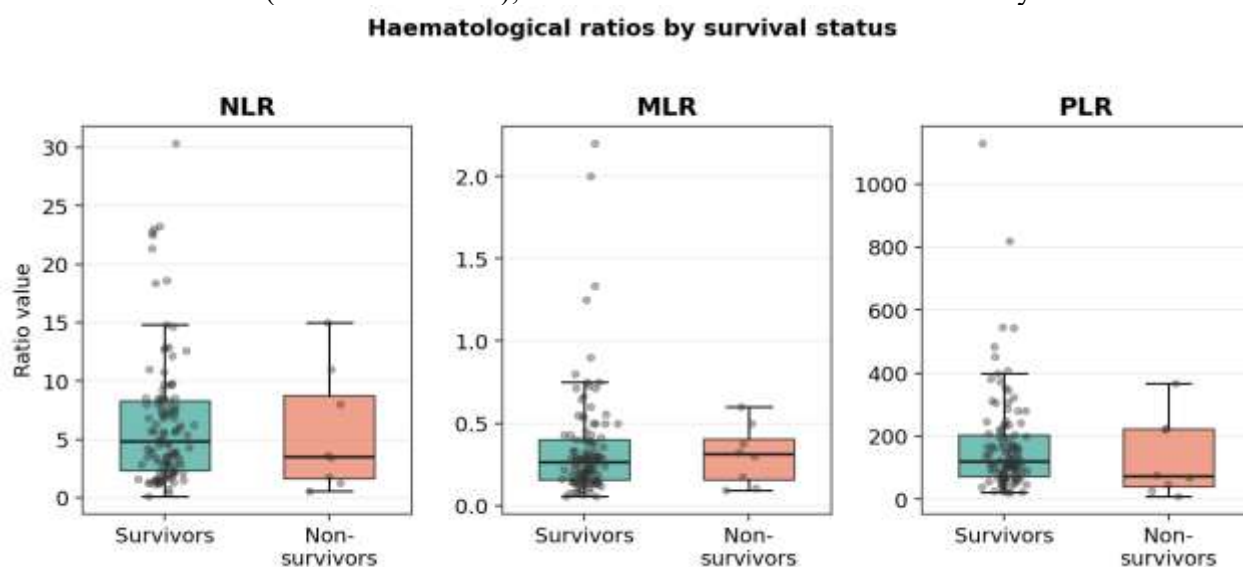


Figure 4. Distribution of NLR, MLR and PLR by survival status. Boxes show median and IQR; points are individual patients. No ratio separates survivors from non-survivors.

DISCUSSION

In this single-centre Pakistani cohort, the two established severity tools clearly outperformed the haematological ratios for predicting in-hospital mortality. PSI and CURB-65 both achieved good discrimination and were strongly elevated in patients who died, whereas NLR, MLR and PLR showed no discriminatory ability and no correlation with measured severity. The finding that a CURB-65 of 2 or more captured every death echoes the high sensitivity repeatedly reported for this score^{6,7,18} and supports its continued use as a rapid bedside triage tool, particularly where the laboratory inputs needed for the full PSI are not immediately available.

A meta-analysis by Alzoubi and colleagues and several cohort studies have linked a high NLR to worse outcomes,^{10,11,12} yet the same body of work, including the analysis of Tekin and earlier cohorts, found that adding the NLR did not improve the predictive performance of PSI or CURB-65.¹⁵ The recent multicentre study by Calis et al., from which our research question was drawn, reported that

NLR, MLR and PLR were higher in non-survivors but still did not outperform the clinical scores.¹⁴ Our data are consistent with the conclusion that the ratios add little beyond established severity assessment; in our cohort they performed even more poorly, failing to separate survivors from non-survivors at all, and the DeLong comparisons confirmed that both clinical scores were statistically superior to each ratio.

Several factors plausibly explain the null biomarker result. The most important is statistical power: with only eight deaths in the biomarker cohort, the confidence intervals around each ratio's AUC are wide, and a true but modest effect could be missed. The ratios are also exquisitely sensitive to the denominator, so that a handful of patients with marked reactive lymphocytosis or with transcription artefacts can distort the distribution, as the implausible counts we had to exclude illustrate.⁹ Timing matters too: a single admission value may not capture the dynamic trajectory of the inflammatory response, and serial measurements have shown more promise in other infections.^{17,19} Finally, unlike PSI and CURB-65, the ratios do not incorporate age, comorbidity or physiological derangement, which were the variables most strongly associated with death in our cohort, where every non-survivor required ventilation.

The clinical message is pragmatic rather than dismissive. PSI and CURB-65 remain the reference standards and should anchor decisions about admission and level of care.^{18,20} The ratios are appealing because they are free, but a marker that is cheap yet uninformative offers no benefit. If NLR, MLR or PLR are to find a role, it is most likely as adjuncts, perhaps combined with a clinical score, as recent work pairing CURB-65 with the PLR or with the NLR has suggested,^{21,22} rather than as replacements, and that role, alongside other emerging markers and machine-learning models, needs to be established prospectively.^{23,24,25}

This study has clear limitations. It was retrospective, single-centre and modest in size. Five candidate predictors were tested against a small number of deaths, which limited power for the biomarker comparisons, raised the possibility of type II error and multiplicity, and precluded multivariable adjustment. Microbiological aetiology, comorbidity burden, sex and vaccination status were not consistently recorded, and outcomes beyond discharge were not captured. The exclusion of records with incomplete or implausible blood counts may have introduced selection bias. These findings should therefore be regarded as hypothesis-generating and confirmed in larger, prospective, multicentre cohorts.

CONCLUSION

Among adults hospitalised with community-acquired pneumonia at a tertiary-care hospital in Pakistan, the PSI and CURB-65 scores discriminated in-hospital mortality well, while the neutrophil-, monocyte- and platelet-to-lymphocyte ratios provided no independent prognostic information and did not correlate with disease severity. Established severity scores should continue to guide risk stratification; the inexpensive haematological ratios warrant further evaluation only as potential adjuncts in adequately powered studies.

Declarations

Ethics: The study used routinely collected, de-identified data and was conducted in accordance with the Declaration of Helsinki. Institutional review board approval / exemption: [approval number to be inserted].

Funding: None.

Conflicts of interest: The authors declare no conflict of interest.

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