

3 REVIEW ARTICLE

4 Prognostic utility of neutrophil-to-
5 lymphocyte ratio (NLR) in predicting
6 outcomes among adults with community-
7 acquired pneumonia: a systematic review
8 and meta-analysis

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14 Abstract

15 Community-acquired pneumonia (CAP) remains the primary cause of infectious mortality worldwide. Bedside
16 severity scores (CURB-65 (confusion, urea, respiratory rate, blood pressure, age ≥ 65) and the Pneumonia
17 Severity Index [PSI]) provide static triage risk but lack dynamic sensitivity to progressive clinical deterioration.
18 We synthesized evidence on the prognostic accuracy of the neutrophil-to-lymphocyte ratio (NLR) across adult
19 CAP cohorts. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines,
20 four databases were searched for adult CAP cohorts reporting NLR-associated outcomes. Area under the
21 curve (AUC) values were descriptively summarized across heterogeneous thresholds, and a random-effects
22 meta-analysis of complete dichotomous mortality data was performed with pre-specified sensitivity analyses.
23 A total of 19 adult cohorts ($N = 19,188$) were included. Across 14 studies reporting discriminative accuracy, NLR
24 demonstrated moderate prognostic discrimination (descriptive mean AUC 0.736 ± 0.107 , range 0.570-0.940).
25 Across the 12 composite models, adding NLR yielded a descriptive mean AUC gain of +0.071, with a greater
26 enhancement for simpler bedside scores. Serial monitoring (days 3-5 vs. 1) distinguished survivors (declining
27 NLR) from nonsurvivors (rising NLR). Across eight cohorts with dichotomous mortality data, elevated NLR
28 was associated with increased mortality (random-effects risk ratio [RR] = 3.92, 95% confidence interval [CI]:
29 2.23-6.88; $I^2 = 89.8\%$); sensitivity analysis excluding a zero-event outlier yielded RR = 3.48 (95% CI: 2.01-6.02;
30 $I^2 = 90.1\%$), while fixed-effect pooling yielded RR = 2.01 (95% CI: 1.78-2.28). NLR provides moderate prognostic
31 discrimination in adult patients with CAP. Its principal clinical value is as an early serial marker and adjunctive
32 tool alongside CURB-65/PSI, not a standalone replacement.

33 **Keywords:** Neutrophil-to-lymphocyte ratio, community-acquired pneumonia, prognostic biomarker, mortal-
34 ity, severity score, meta-analysis.

35 Introduction

36 Community-acquired pneumonia (CAP) is a leading
37 cause of morbidity and mortality worldwide. The global
38 Burden of Disease estimates indicate an annual incidence
39 exceeding 4,300 per 100,000 people and ~2.2 million
40 deaths worldwide, with the heaviest burden in vulnerable
41 demographics and resource-limited settings [1]. In

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hospitalized adults, the overall in-hospital mortality is 10%-21%, reaching $\geq 23\%$ among patients requiring intensive care unit (ICU) admission [2]. Additionally, CAP frequently causes prolonged functional decline and persistent neurocognitive impairment among survivors [3]. Accurate severity stratification at presentation is vital for guiding site-of-care decisions, antimicrobial selection, and clinical monitoring.

The clinical trajectory of CAP is governed by host inflammatory and immune responses. Acute pulmonary infection mobilizes neutrophils as the primary innate effectors, whereas systemic stress, hypercortisolemia, and cytokine cascades accelerate lymphocyte apoptosis and redistribution. The neutrophil-to-lymphocyte ratio (NLR), calculated immediately from a routine complete blood count (CBC) without additional turnaround time or cost, captures the balance between innate inflammatory activation and adaptive immune suppression [4,5]. Elevated NLR is associated with adverse outcomes in cardiovascular diseases, sepsis, and acute respiratory infections [4,6], making it a biologically plausible prognostic indicator in CAP.

Established severity tools, principally the CURB-65 (confusion, urea, respiratory rate, blood pressure, age ≥ 65) score and Pneumonia Severity Index (PSI) represent the clinical standard, but exhibit recognized constraints [7]. The PSI depends heavily on age and comorbidity variables, which can underestimate acute severity in younger adults and requires 20 variables that impede rapid bedside calculation. CURB-65 is simpler, but relies on coarse categorical thresholds with modest discriminative accuracy for short-term deterioration [7,8]. Neither score captures real-time immunological dysregulation nor a dynamic response to the initial therapy. Consequently, there is growing clinical interest in whether inexpensive CBC-derived biomarkers, such as NLR, can meaningfully complement these clinical scores as adjunctive bedside tools, rather than attempting to replace them.

Although multiple primary studies have investigated NLR in adult patients with CAP, the literature remains fragmented across disparate clinical settings, cutoff thresholds, and outcome definitions. Furthermore, previous syntheses have not systematically evaluated NLR against multiple comparator biomarkers and scores, characterized their serial kinetic trajectories, or examined potential distortions from zero-event outlier cohorts. This systematic review and meta-analysis aimed to synthesize the available evidence on NLR in adult CAP by addressing: (1) its discriminative accuracy relative to comparator inflammatory markers and clinical severity scores, (2) the incremental prognostic value of NLR-augmented composite models, (3) the prognostic utility of serial NLR kinetics, and (4) the pooled association between NLR and mortality, including pre-specified sensitivity analyses.

Materials and Methods

Protocol

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [9]. The review protocol and analytical framework were predefined prior to data extraction. The review was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD420261479998).

Search strategy

A systematic literature search was executed across PubMed/MEDLINE, Web of Science (Core Collection), Scopus, and Google Scholar from database inception through August 9, 2026. The search utilized combinations of Medical Subject Headings (MeSH) and free-text keywords across three core concept blocks connected by the Boolean operator AND:

- (1) Population/Condition: (“Community-Acquired Pneumonia”[Mesh] OR “CAP” OR “pneumonia” OR “severe CAP”)
- (2) Biomarker/Exposure: (“Neutrophils”[Mesh] AND “Lymphocytes”[Mesh] OR “neutrophil-to-lymphocyte ratio” OR “NLR” OR “neutrophil lymphocyte ratio” OR “NLCR”)
- (3) Prognosis/Outcomes: (“prognosis”[Mesh] OR “mortality” OR “severity” OR “ICU admission” OR “prognostic value” OR “CURB-65” OR “PSI”)

Database-specific queries were adapted for each platform. For Google Scholar, structured keyword strings were queried, and the top 1,000 search hits (the platform’s display limit) were retrieved and harvested using Publish or Perish (Harzing, 2007). After the exclusion of 99 internal query duplicates and unresolvable citation fragments, 901 unique citation records were exported. Records from all four databases ($N = 2,640$) were imported into EndNote 21 (Clarivate, Philadelphia, PA, USA) for deduplication using sequential matching of the DOI, title, author, and publication year, followed by manual inspection; 951 duplicate records were identified and removed. Although database filters restricted initial queries to January 2010 through August 2026, 41 pre-2010 citations (originating from Google Scholar historical indexing discrepancies and forward/backward citation chaining) were identified and excluded during the pre-screening date verification, resulting in the exclusion of 992 records prior to screening. The reference lists of the eligible studies and reviews were manually searched. Titles and abstracts were independently screened by two reviewers, followed by independent full-text eligibility appraisals, with discrepancies resolved by consensus.

Eligibility criteria

Eligibility was structured according to the Population, Exposure, Comparator, and Outcome framework for prognostic review.

157	• Population (P): Adult patients (age ≥18 years)	analytical approach. Discriminative accuracy (AUC)	214
158	hospitalized with clinically and radiographically	values for NLR, comparator scores, serial kinetics, and	215
159	confirmed CAP, including general inpatient, elderly	composite models were summarized descriptively across	216
160	(≥65 years), severe CAP, and immunocompromised	studies using means, SDs, medians, and ranges. A formal	217
161	subgroups. Studies conducted exclusively in pediatric	bivariate or hierarchical summary receiver operating	218
162	cohorts were excluded.	characteristic (ROC) meta-analysis was not conducted	219
163	• Exposure (E): Baseline admission NLR and/or serial	because of the threshold heterogeneity across the cohorts.	220
164	NLR measured during early hospitalization (days		
165	3-5).	Risk ratios (RRs) and 95% confidence intervals (CIs) were	221
166	• Comparator (C): Low-NLR strata, comparator	calculated for cohorts reporting complete dichotomous	222
167	inflammatory ratios [platelet-to-lymphocyte ratio,	mortality data, stratified into high and low NLR groups.	223
168	monocyte-to-lymphocyte ratio, and C-reactive	A standard continuity correction of 0.5 was applied	224
169	protein-to-albumin ratio [CAR]), and clinical scores	to contingency cells for studies with zero observed	225
170	(CURB-65, PSI, Systolic blood pressure, Multilobar	events [11]. The DerSimonian–Laird random effects	226
171	chest radiography involvement, Albumin, Respiratory	model was pre-specified as the primary quantitative	227
172	rate, Tachycardia, Confusion, Oxygenation, and pH	method to accommodate between-study heterogeneity.	228
173	(SMART-COP), and age, dehydration, respiratory	Heterogeneity was quantified using the Cochran’s <i>Q</i>	229
174	failure, orientation disturbance, and (blood) pressure	and <i>I</i> ² tests. To address the potential distortion from an	230
175	(A-DROP)].	extreme outlier study with zero events in the low-NLR	231
176	• Outcome (O): Primary outcome: all-cause in-hospital	arm, a pre-specified sensitivity analysis excluding this	232
177	or 30-day mortality. The secondary outcomes were	zero-event study was performed. Fixed-effect inverse	233
178	ICU admission, invasive mechanical ventilation,	variance pooling was performed as an additional	234
179	length of stay, and discriminative accuracy [area	sensitivity analysis. All analyses were conducted using	235
180	under the curve (AUC)].	verified formulas and statistical packages, with two-sided	236
181	Eligible designs included prospective and retrospective	<i>p</i> < 0.05 considered statistically significant.	237
182	cohort studies, secondary analyses of clinical trials, and		
183	cross-sectional studies providing quantifiable prognostic	Results	238
184	metrics (AUC, odds ratio, relative risk, hazard ratio, or		
185	stratified event counts).	<i>Study selection</i>	239
186	The exclusion criteria were nosocomial, ventilator-	The search identified 2,640 records across four databases:	240
187	associated, or aspiration-only pneumonia; pediatric-only	PubMed/MEDLINE (851), Web of Science (541), Scopus	241
188	populations; animal or <i>in vitro</i> studies; case reports;	(347), and Google Scholar (901). Prior to screening,	242
189	narrative reviews; conference abstracts lacking complete	992 records were removed (951 duplicate citations and	243
190	peer-reviewed data; and studies in which NLR data could	41 pre-2010 records), leaving 1,648 records for title/	244
191	not be extracted.	abstract screening, of which 1,201 were excluded,	245
192	<i>Study selection and data extraction</i>	most commonly for ineligible population, exposure, or	246
193	Two authors independently extracted the data in	outcome (Table 1). Among the 447 retrieved reports, 113	247
194	duplicate using a standardized extraction template. The	could not be accessed, leaving 334 full-text articles that	248
195	extracted items included author, year, country, design,	were assessed for eligibility. In total, 315 articles were	249
196	setting, sample size, patient characteristics, NLR cutoff,	excluded based on pre-specified criteria (Tables 1 and 2,	250
197	and sampling timing, discriminative AUCs for NLR and	Figure 1), most frequently due to a lack of quantifiable	251
198	comparators, multivariable effect estimates, and 2 × 2	NLR outcome associations (<i>n</i> = 93), publication type (<i>n</i>	252
199	mortality contingency tables.	= 84), or non-CAP etiology (<i>n</i> = 65). Nineteen adult CAP	253
200	<i>Risk of bias assessment</i>	cohorts met all inclusion criteria (<i>N</i> = 19,188).	254
201	The risk of bias was appraised independently by two	<i>Study characteristics</i>	255
202	reviewers using the Quality in Prognosis Studies (QUIPS)	The 19 included adult cohorts comprised 19,188 patients,	256
203	tool [10], which has been specifically validated for	with sample sizes ranging from 81 to 7,862 [12-30].	257
204	prognostic biomarker studies. The following six domains	Studies originated from China (<i>n</i> = 9) and Türkiye (<i>n</i> =	258
205	were evaluated: study participation, study attrition,	3), and single studies from Australia, the United States,	259
206	prognostic factor measurement, outcome measurement,	Brazil, South Korea, Spain, Italy, and Japan. The mean or	260
207	confounding factors, and statistical analysis/reporting.	median patient age ranged from 52 to 87 years, and the	261
208	Each domain was judged to have a low, moderate, or high	reported mortality rate ranged from 3.2% to 37.0%. The	262
209	risk of bias.	included cohorts comprised general hospitalized adults as	263
210	<i>Statistical analysis</i>	well as the elderly, patients with severe ICU pneumonia,	264
211	Given the marked clinical and methodological	and immunocompromised subgroups (renal transplant	265
212	heterogeneity in the cutoffs, patient subgroups, and	recipients). The study characteristics are summarized in	266
213	outcome windows, narrative synthesis was the primary	Table 3.	267

268 *Discriminative accuracy of NLR for CAP severity* 294
269 *and mortality* 295
270 Across the 14 studies reporting a quantifiable NLR AUC, 296
271 the discriminative accuracy for the primary outcome 297
272 ranged from 0.570 [13] to 0.940 [26], with a descriptive 298
273 mean AUC of 0.736 (SD 0.107, median 0.720). In head- 299
274 to-head comparisons, the NLR demonstrated a moderate
275 discriminative capacity that was broadly comparable
276 to, but did not consistently exceed, the established
277 composite clinical scores. The mean AUC values across
278 the reporting cohorts were 0.706 for CURB-65 and 0.763
279 for PSI (Figure 2). While NLR outperformed traditional
280 single biomarkers such as CRP in certain cohorts [20], it
281 was outperformed by lymphocyte count and albumin in
282 others [19] and was generally inferior to multivariable
283 scores in isolation [13,20,22]. These findings highlight
284 that NLR alone functions as a moderate standalone
285 discriminator, whose greatest utility emerges when
286 combined with clinical scores.

287 *Serial NLR kinetics* 300
288 Four cohorts evaluated serial NLR measurements at 301
289 admission (day 1) and early follow-up (days 3-5) stratified 302
290 by survival (including Lee et al. [24] and Curbelo et al. 303
291 [25]). Across these studies, discriminative accuracy 304
292 improved from a mean admission AUC of 0.722 to 0.875 305
293 on days 3-5 (mean gain of +0.153). Patients who survived 306
hospitalization exhibited a marked downward trajectory 307
(mean NLR declining from 9.2 to 4.7), whereas non- 308
survivors exhibited persistently elevated or increasing 309
ratios (mean NLR 14.4 to 15.3; Figure 3). Serial NLR 310
kinetics provided a dynamic prognostic separation that 311
exceeded static baseline measurements. 312
299

NLR-augmented composite prognostic models 300
Twelve composite models were used to evaluate the 301
integration of NLR into existing clinical scores or 302
biomarkers. Across these models, the baseline stand- 303
alone score AUC averaged 0.727, whereas that of the 304
NLR-augmented composite models averaged 0.798 305
(descriptive mean improvement +0.071; Figure 4). The 306
largest improvements occurred when NLR was added to 307
simpler bedside tools lacking inflammatory parameters 308
(A-DROP-NLR, +0.139; CRB65-NLR, +0.110; SII- 309
PNI, +0.138). Conversely, a minimal incremental gain 310
was observed when the NLR was combined with models 311
that already incorporated cellular inflammatory metrics 312
(e.g., PSI + SIRI, +0.008). 313

Pooled analysis of NLR and mortality risk 314
Eight adult studies (5,721 high-NLR and 9,812 low-NLR 315
patients; 602 vs. 455 deaths) provided complete 2 × 2 316
mortality data for quantitative synthesis (Table 4). Under 317
the pre-specified DerSimonian-Laird random-effects 318

Table 1. PRISMA 2020 study selection and screening counts.

Stage	Records/articles	Notes
Records identified: PubMed/MEDLINE	851	MeSH and free-text queries, 2010-August 2026
Records identified: Web of Science	541	Core Collection TS = strategy, 2010-August 2026
Records identified: Scopus	347	TITLE-ABS-KEY strategy, 2010-August 2026
Records identified: Google Scholar	901	Top 1,000 search hits harvested; 901 unique records exported
Total records identified	2,640	Sum across all four database searches
Records removed before screening	992	951 duplicates + 41 pre-2010 records
Records screened (title/abstract)	1,648	Total identified minus pre-screening exclusions
Records excluded at title/abstract	1,201	Ineligible population, exposure, or outcome
Reports sought for retrieval	447	Full-text sought for screened records
Reports not retrieved	113	Full text unavailable (paywalled/unlinked)
Reports assessed for eligibility	334	Full-text articles reviewed in detail
Reports excluded, per criteria	315	Full-text exclusions detailed in Table 2
Studies included in review	19	19 adult CAP cohorts (N = 19,188)

Table 2. Reasons for exclusion at the full-text eligibility stage (n = 315).

Reason for full-text exclusion	Articles excluded (n)
No quantifiable NLR-outcome association reported	93
Review, editorial, or conference abstract without accessible full text	84
Nosocomial, ventilator-associated, or aspiration pneumonia only (no CAP component)	65
Exclusively pediatric population (outside adult-only scope)	4
Duplicate cohort or population reported in another eligible publication	36
Animal or in vitro study	26
Non-English full text unavailable for translation	6
Systematic review or meta-analysis (ineligible study design)	1
Total excluded at full-text stage	315

319 model, elevated NLR was associated with a significant
 320 increase in mortality risk (pooled RR = 3.92, 95% CI:
 321 2.23-6.88; $p < 0.001$). The between-study heterogeneity
 322 was substantial (Cochran's $Q = 68.40$, $df = 7$, $p < 0.001$;
 323 $I^2 = 89.8\%$; Figure 5). Because Cataudella et al. [26]
 324 reported no deaths in the low-NLR group (47/95 vs.
 325 0/100; continuity-corrected RR = 98.95), a prespecified
 326 sensitivity analysis excluding this extreme study was
 327 performed. In this seven-study analysis, elevated NLR
 328 remained strongly associated with mortality (pooled

random-effects RR = 3.48, 95% CI: 2.01-6.02; $P = 90.1\%$,
 $p < 0.001$). Fixed-effect inverse-variance pooling of all
 eight studies yielded RR = 2.01 (95% CI: 1.78-2.28; $Z =$
 11.10, $p < 0.001$), heavily weighted by the largest cohort
 (Sharma et al. [12], 66.9% weight; RR = 1.60); excluding
 Cataudella et al. [26] yielded RR = 2.00 (95% CI: 1.76-
 2.26). Across all models, an elevated NLR consistently
 conferred a two- to four-fold increase in mortality risk.
 Heterogeneity across the eight studies was substantial
 ($I^2 = 89.8\%$), reflecting distinct clinical settings and cut-

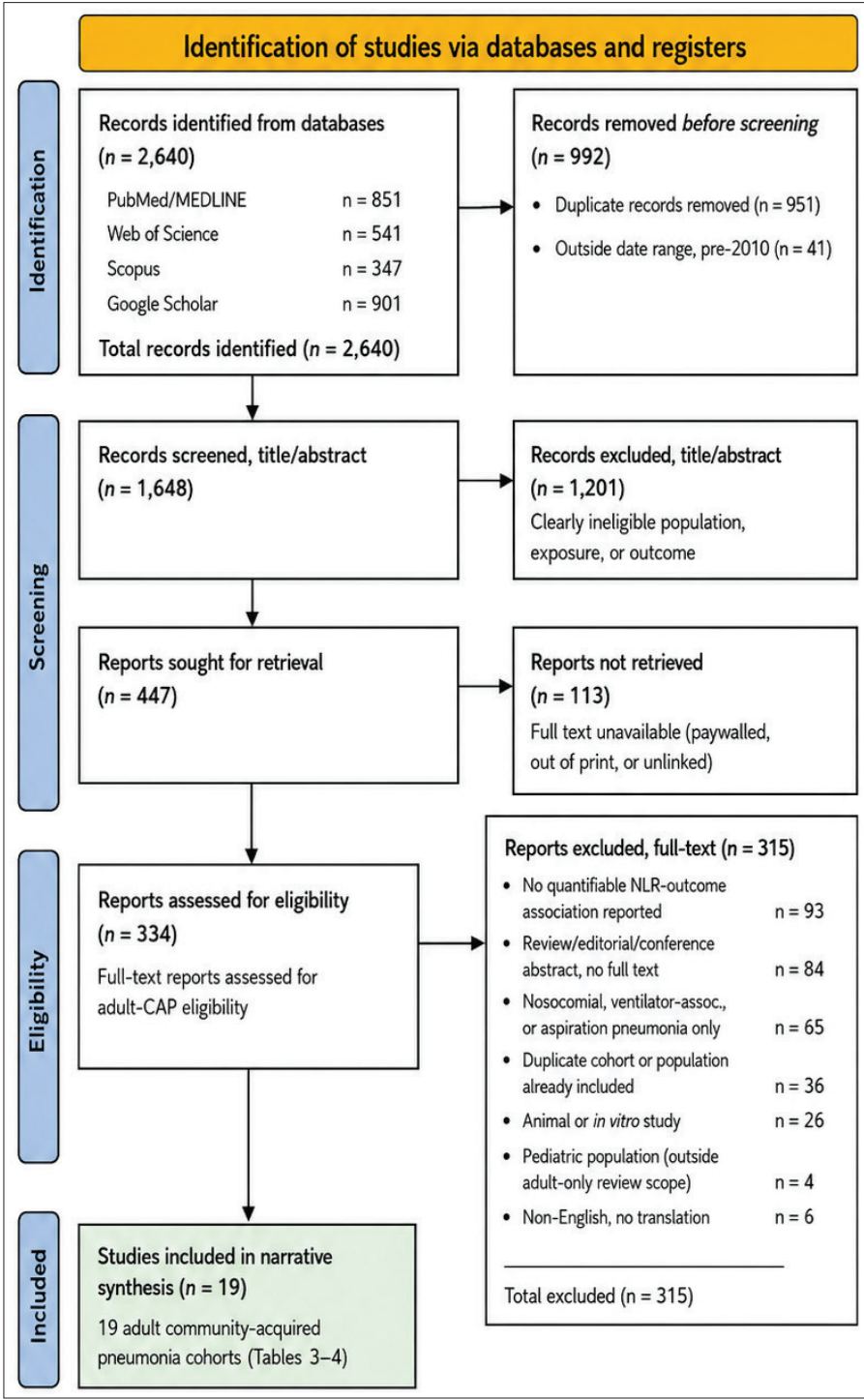


Figure 1. PRISMA 2020 flow diagram of study selection for systematic review and meta-analysis of NLR in adult CAP.

Table 3. Key characteristics and clinical findings of included adult CAP cohorts (N = 19). Detailed extraction variables are available in Supplementary Table S1.

#	Study	Country	Design	N	NLR Cutoff	NLR AUC	Mortality Effect Size	Key Finding
1	Sharma et al. [12]	Australia	Multicenter retrospective	7,862	12.0	0.580	OR 1.27 (1.06-1.53)	NLR >12 independently predicted LOS, ICU admission, and mortality; AUC inferior to CURB-65.
2	Tekin et al. [13]	USA	Single-center retrospective	4,039	12.0	0.570	OR 1.12 (0.77-1.61)	NLR not superior to PSI for mortality; associated with ICU admission.
3	Feng et al. [14]	China	Single-center retrospective	2,028	9.06	0.720	HR 1.052 (1.029-1.075)	NLR × CURB-65 product score achieved superior AUC of 0.755.
4	Huang et al. [15]	China	Secondary analysis cohort	812	6.50	N/A	OR 1.017 (1.002-1.032)	Adding NLR to CRB-65/CURB-65/SMART-COP significantly boosted AUCs (>0.80).
5	Cury et al. [16]	Brazil	Single-center retrospective	646	6.80	0.706	OR 4.87 (1.87-15.22)	Pneumonia-Optimized Ratio (NLCR × CURB-65) reached AUC 0.753.
6	Guo et al. [17]	China	Steroid-treated CAP cohort	570	0.275*	N/A	HR 1.21 (1.14-1.28)	NLR independently predicted 30-/90-day mortality.
7†	Cui et al. [18]†	China	Severe CAP cohort	554	11.91	N/A	OR 1.569 (1.066-2.309)	NLR and BLR associated with reduced overall survival and increased ICU mortality.
8	Karakaya et al. [19]	Türkiye	Single-center retrospective	526	8.18	0.715	p < 0.001	Lymphocyte count (AUC 0.794) and albumin (0.787) outperformed NLR and PCT.
9	Yang et al. [20]	China	Single-center retrospective	318	7.12	0.799	p < 0.001	NLR outperformed CRP; NLR + PCT combination reached AUC 0.828.
10	Terzi et al. [21]	Türkiye	Single-center retrospective	240	8.53	0.605	OR 1.574 (1.103-2.245)	SII and SIRI provided modest adjunctive value to CURB-65/PSI.
11	Baran et al. [22]	Türkiye	Single-center cross-sectional	207	N/A	N/A	p = 0.009	NLR, CAR, CLR, SII, SIRI, and CALLY index (highest AUC) all predicted mortality.
12	Meng et al. [23]	China	Single-center retrospective	206	6.68	0.695	HR 4.20 (2.12-8.34)	Heparin-binding protein (AUC 0.723) plus NLR combined AUC reached 0.760.
13	Lee et al. [24]	South Korea	Serial-NLR cohort	175	N/A	0.719	OR 7.10 (2.19-23.06)	Day-4/Day-1 NLR ratio > 1 predicted 30-day mortality; serial NLR + PSI AUC rose to 0.853.
14	Curbelo et al. [25]	Spain	Prospective cohort	154	10.0	0.760	OR 1.04 (1.00-1.10)	Admission NLR AUC 0.76; Day 3-5 NLR AUC rose to 0.88.
15	Cataudella et al. [26]	Italy	Elderly prospective	195	11.12	0.940	p < 0.001	NLR <11.12: 0% mortality; NLR >28.3: 100% 30-day mortality.
16†	Chen et al. [27]†	China	SCAP cohort	138	N/A	0.822	OR 14.11 (3.18-62.66)	Combined SII–PNI score = 2 strongly predicted 28-day mortality.
17†	Qiu et al. [28]†	China	Renal-transplant SCAP	81	15.25	0.880	aOR 1.07 (1.02-1.14)	NLR AUC 0.88 outperformed PSI (0.65) and CURB-65 (0.65) in this immunocompromised cohort.
18†	Chen et al. [29]†	China	Severe ICU pneumonia	100	N/A	0.789	OR 2.12 (1.14-3.95)	SIRI and NLR were the only independent predictors of 28-day ICU mortality.
19	Tonouchi and Kataoka [30]	Japan	Elderly cohort (≥75 y)	337	5.00	N/A	aOR 2.42 (1.12-5.14)	Discharge NLR ≥5 predicted 30-day post-discharge readmission.

*Guo et al. [17] reported NLR as a continuous hazard-ratio predictor (per-unit cutoff of 0.275 on a transformed scale), not a diagnostic threshold.

†Special subgroup cohorts nested within the adult total.

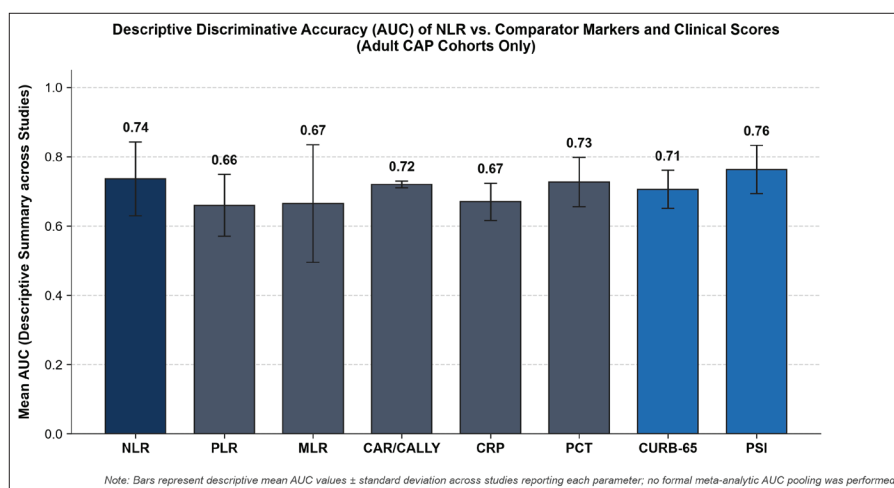


Figure 2. Descriptive discriminative accuracy (mean AUC ± SD error bars) of NLR compared with comparator biomarkers and clinical scores across adult CAP cohorts. Note: Summarized descriptively; no formal meta-analytic AUC pooling was performed.

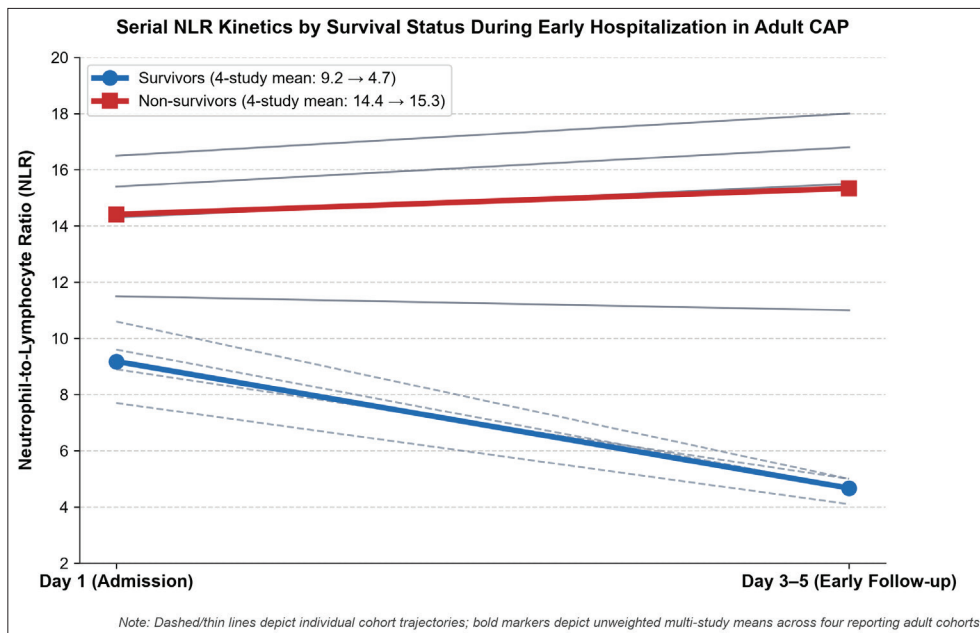


Figure 3. Serial NLR kinetics from admission (Day 1) to early follow-up (Day 3-5) in survivors versus non-survivors across reporting adult CAP cohorts.

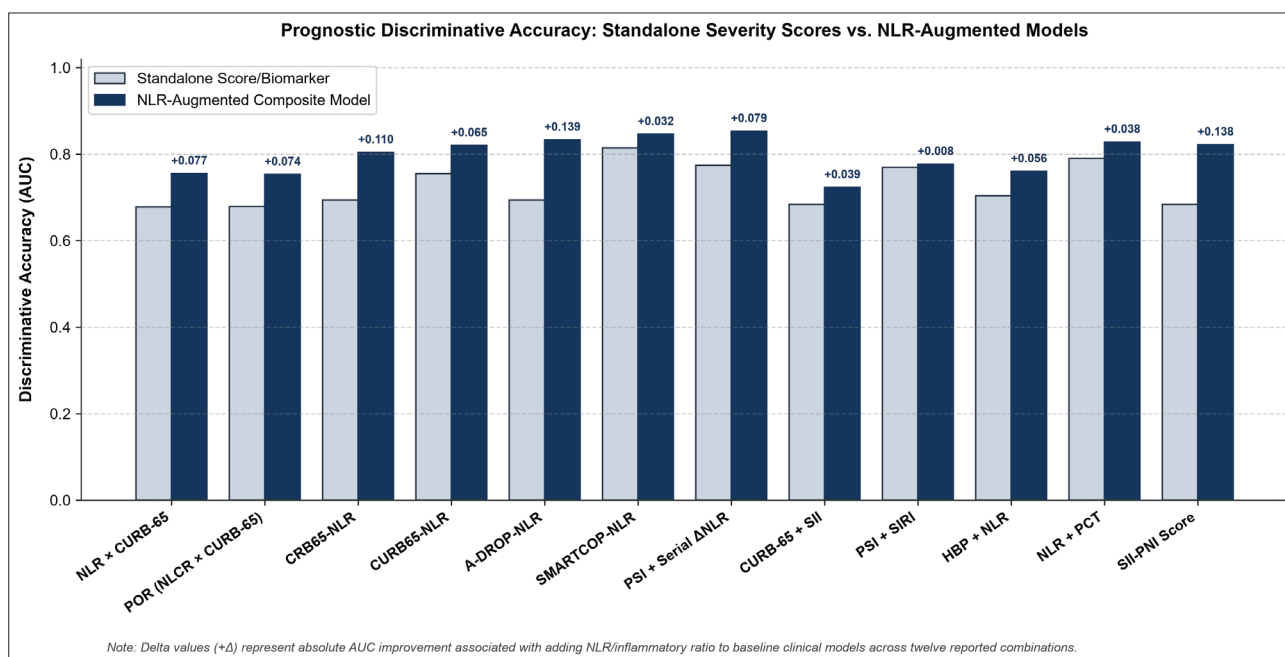


Figure 4. Prognostic discriminative accuracy of standalone severity scores/markers versus NLR-augmented composite models across twelve reported combinations.

off thresholds. The exclusion of Cataudella et al. [26] in the sensitivity analysis reduced the point estimate from 3.92 to 3.48 while maintaining statistical significance ($p < 0.001$), indicating that the qualitative conclusion is robust to zero-event correction. The fixed-effects model yielded a lower point estimate (RR = 2.01) because of the disproportionate weighting by Sharma et al. [12] (66.9% weight). Regardless of the model choice, an elevated NLR was reliably associated with significantly increased mortality across adult CAP cohorts.

Risk of bias assessment

The risk of bias across the 19 cohorts was rated using QUIPS (Table 5). Four studies (21.1%) demonstrated an overall low risk [12,14,24,25], 12 (63.2%) moderate risk, and three (15.8%) high risk of bias [22,27,28]. Confounding adjustment and statistical reporting (domains 5 and 6) were the most frequent sources of potential bias, as several single-center retrospective studies reported unadjusted estimates without multivariable control.

Table 4. Dichotomous mortality contingency data, study-level RRs, and pooled meta-analytic estimates with sensitivity analyses.

Study	High-NLR deaths/N	Low-NLR deaths/N	RR (95% CI)	Weight, fixed- effect (%)
Cataudella et al. [26]*	47/95	0/100*	98.95 (6.19-1582.83)	0.2
Curbelo et al. [25]	10/85	2/69	4.06 (0.92-17.91)	0.7
Feng et al. [14]	81/576	40/1,452	5.10 (3.54-7.36)	11.4
Huang et al. [15]	37/202	4/204	9.34 (3.39-25.73)	1.5
Cury et al. [16]	34/161	6/161	5.67 (2.45-13.13)	2.2
Sharma et al. [12]	297/2,878	321/4,985	1.60 (1.38-1.86)	66.9
Tekin et al. [13]	59/1,526	69/2,513	1.41 (1.00-1.98)	13.1
Karakaya et al. [19]	37/198	13/328	4.71 (2.57-8.65)	4.1
Pooled Random-Effects (Primary, all eight studies)	602/5,721	455/9,812	3.92 (2.23-6.88)	I ² = 89.8%
Sensitivity: Excl. zero-event outlier [26] (seven studies)	555/5,626	455/9,712	3.48 (2.01-6.02)	I ² = 90.1%
Pooled Fixed-Effect (Sensitivity, all eight studies)	602/5,721	455/9,812	2.01 (1.78-2.28)	100.0%

*Continuity correction of 0.5 applied to zero cell.

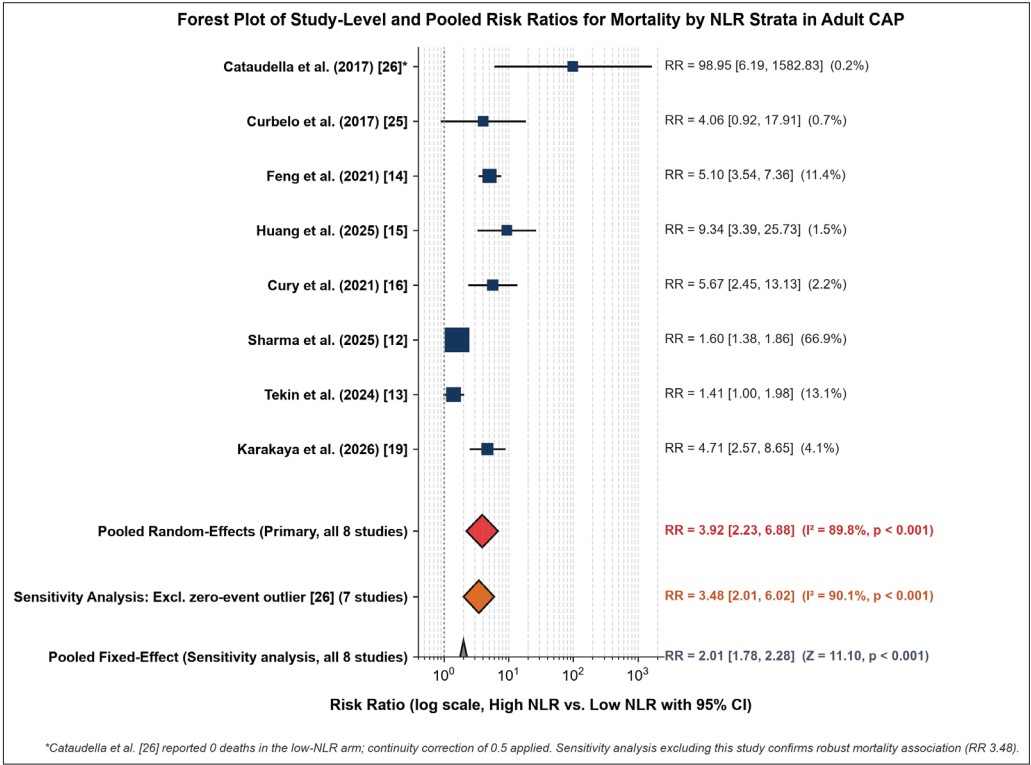


Figure 5. Forest plot of study-level and pooled RRs for mortality (High NLR vs. Low NLR), showing primary random-effects pooling, sensitivity analysis excluding zero-event outlier, and fixed-effect pooling.

Discussion

This systematic review synthesized evidence from 19 adult CAP cohorts to characterize the NLR (NLR) as a prognostic biomarker. Three consistent patterns emerged across an otherwise heterogeneous evidence-based study. First, NLR showed moderate discriminative accuracy for severity and mortality (mean AUC 0.736), which is comparable to but not consistently superior to established severity scores such as CURB-65 (mean AUC 0.706) and PSI (mean AUC 0.763). Individual studies illustrated

both ends of this range: Cataudella et al. [26] reported an unusually strong single-marker performance, with 0% 30-day mortality below an NLR of 11.12 and 100% mortality above 28.3 in an elderly prospective cohort, whereas [19] found that simple lymphocyte count (AUC 0.794) and serum albumin (AUC 0.787) both outperformed NLR in a similarly sized retrospective series. Second, NLR's clearest value is incremental rather than standalone; combining it with an existing score improved discriminative accuracy across all 12 reported composite models, most substantially when

Table 5. QUIPS domain-level risk-of-bias ratings for included adult CAP cohorts (N = 19).

Study	D1: Particip.	D2: Attrition	D3: PF Measure	D4: Outcome measure	D5: Confound.	D6: Analysis / report	Overall
Sharma et al. [12]	Low	Low	Low	Low	Low	Low	Low
Tekin et al. [13]	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
Feng et al. [14]	Low	Low	Low	Low	Low	Low	Low
Huang et al. [15]	Moderate	Low	Low	Low	Low	Moderate	Moderate
Cury et al. [16]	Moderate	Low	Low	Moderate	Moderate	Moderate	Moderate
Guo et al. [17]	Moderate	Low	Low	Low	Low	Moderate	Moderate
Cui et al. [18] [†]	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate
Karakaya et al. [19]	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
Yang et al. [20]	Moderate	Low	Low	Low	Moderate	Moderate	Moderate
Terzi et al. [21]	Moderate	Low	Low	Low	Low	Moderate	Moderate
Baran et al. [22]	High	High	Low	Moderate	High	Moderate	High
Meng et al. [23]	Moderate	Low	Low	Low	Low	Moderate	Moderate
Lee et al. [24]	Low	Moderate	Low	Low	Low	Low	Low
Curbelo et al. [25]	Low	Moderate	Low	Low	Low	Low	Low
Cataudella et al. [26]	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate
Chen et al. [27] [†]	High	Moderate	Low	Moderate	Moderate	High	High
Qiu et al. [28] [†]	High	Moderate	Moderate	Low	Moderate	High	High
Chen et al. [29] [†]	Moderate	Moderate	Low	Low	Low	Moderate	Moderate
Tonouchi and Kataoka (2023) [30]	Moderate	Moderate	Low	Moderate	Low	Moderate	Moderate

[†]Special subgroup cohorts nested within the adult total.

added to bedside scores that do not already incorporate an inflammatory component (A-DROP-NLR, +0.139 AUC; SII-PNI, +0.138 AUC) and least when added to scores that already do (CURB-65 + SII, +0.039, not significant). Third, the trajectory of NLR over the first 3-5 days of hospitalization carries more prognostic information than a single admission value: across the four studies reporting serial measurements, mean AUC rose from 0.722 at admission to 0.875 by day 3-5, with survivors showing a declining NLR and non-survivors a rising or persistently elevated one.

A quantitative meta-analysis confirmed a significant association between elevated NLR and mortality. Given the marked between-study heterogeneity ($I^2 = 89.8\%$), the random-effects estimate (RR = 3.92, 95% CI: 2.23-6.88) was prespecified as primary. Importantly, our sensitivity analysis demonstrated that excluding the zero-event study by Cataudella et al. [26] yielded a consistent and robust association (RR = 3.48, 95% CI: 2.01-6.02). Furthermore, fixed-effect analysis yielded a conservative RR of 2.01 (95% CI: 1.78-2.28). These findings demonstrate that, while point estimates vary depending on model weighting and outlier handling, the direction and statistical significance of mortality risk are unambiguous.

Clinical implications

From a clinical standpoint, NLR should be conceptualized as an adjunctive, dynamic biomarker rather than a standalone replacement for established clinical tools such as CURB-65 or PSI. Three practical applications are supported by the evidence: (1) Serial dynamic monitoring: tracking NLR at 48-72 hours

provides actionable feedback on therapeutic response, where failure to decline flags treatment failure or secondary complications; (2) Score augmentation: adding NLR to simple bedside metrics (e.g., CRB-65, A-DROP) captures systemic inflammatory stress without cumbersome scoring calculations; and (3) Resource-limited and specialized settings: because NLR requires only a standard CBC differential, it provides an accessible risk marker where advanced biomarkers (procalcitonin, mid-regional pro-adrenomedullin) or serial imaging are unavailable, including immunocompromised cohorts where clinical scores are unvalidated [28].

Strengths and limitations

The key strengths of this review include adherence to the PRISMA 2020 guidelines, rigorous QUIPS quality appraisal, explicit synthesis of serial kinetics and composite models, transparent sensitivity analyses exploring outlier effects, and model selection in meta-analyses.

This study had several limitations. First, substantial clinical and threshold heterogeneity existed; NLR cutoff values ranged widely (5.0-15.25), reflecting post-hoc ROC optimization rather than prospectively validated decision thresholds. Second, most of the included cohorts were from single-center retrospective studies, several with unadjusted risk estimates subject to residual confounding factors. Third, although 19 cohorts were synthesized narratively, only eight reported 2×2 data for meta-analysis. Fourth, the search was restricted to the specified databases and to literature indexed through August 2026. Finally, the study-level pooling precluded individual patient-level covariate adjustments.

444	Conclusion	
445	In adult CAP, the NLR is a moderate prognostic	
446	discriminator that is most effectively utilized as an	
447	inexpensive adjunctive biomarker and dynamic serial	
448	monitoring tool alongside CURB-65 and PSI, rather	
449	than as a standalone replacement. An elevated NLR	
450	consistently correlated with increased mortality (random-	
451	effects RR = 3.92; sensitivity analysis excluding zero-	
452	event outlier RR = 3.48; fixed-effect RR = 2.01). Future	
453	prospective studies should focus on validating the	
454	standardized cutoffs and establishing protocolized serial	
455	measurement algorithms.	
456	List of Abbreviations	
457	A-DROP	Age, Dehydration, Respiratory failure,
458		Orientation disturbance, Pressure and Meta-
459		Analyses
460	aOR	Adjusted odds ratio
461	AUC	Area under the curve
462	BLR	Basophil-to-lymphocyte ratio
463	CALLY	C-reactive protein–Albumin–Lymphocyte
464		index
465	CAP	Community-acquired pneumonia
466	CAR	C-reactive protein-to-albumin ratio
467	CI	Confidence intervals
468	CLR	C-reactive protein-to-lymphocyte ratio
469	CRP	C-reactive protein
470	CURB-65	Confusion, Urea, Respiratory rate, Blood
471		pressure, age ≥65
472	HBP	Heparin-binding protein
473	HR	Hazard ratio
474	ICU	Intensive care unit
475	LOS	Length of stay
476	MLR	Monocyte-to-lymphocyte ratio
477	MR-proADM	Mid-regional pro-adrenomedullin
478	NLCR	Neutrophil-to-Lymphocyte Cell Ratio
479	NLR	Neutrophil-to-lymphocyte ratio
480	OR	Odds ratio
481	PCT	Procalcitonin
482	PLR	Platelet-to-lymphocyte ratio
483	PNI	Prognostic nutritional index
484	POR	Pneumonia-Optimized Ratio
485	PRISMA	Preferred Reporting Items for Systematic
486		Reviews
487	PROSPERO	International Prospective Register of
488		Systematic Reviews
489	PSI	Pneumonia Severity Index
490	QUIPS	Quality in Prognosis Studies
491	ROC	Receiver operating characteristic
492	RR	Risk ratios
493	SCAP	Severe community-acquired pneumonia
494	SII	Systemic immune-inflammation index
495	SIRI	Systemic inflammation response index
496	SMART-COP	Systolic blood pressure, Multilobar chest
497		radiography involvement, Albumin,
498		Respiratory rate, Tachycardia, Confusion,
499		Oxygenation, pH
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	References	523
	1. GBD 2021 Lower Respiratory Infections and Antimicrobial	524
	Resistance Collaborators. Global, regional, and national	525
	incidence and mortality burden of non-COVID-19 lower	526
	respiratory infections and aetiologies, 1990-2021: a	527
	systematic analysis from the Global Burden of Disease	528
	Study 2021. Lancet Infect Dis. 2024;24(9):974–1002.	529
	2. Regunath H, Oba Y. Community-acquired pneumonia	530
	[Updated 2024 Jan 26]. StatPearls [Internet]. Treasure	531
	Island: StatPearls Publishing; 2024. Available from:	532
	https://www.ncbi.nlm.nih.gov/books/NBK430749/	533
	3. Girard TD, Self WH, Edwards KM, Grijalva CG, Zhu Y,	534
	Williams DJ, et al. Long-term cognitive impairment after	535
	hospitalization for community-acquired pneumonia:	536
	a prospective cohort study. J Gen Intern Med.	537
	2018;33(6):929–35. https://doi.org/10.1007/s11606-	538
	017-4301-x	539
	4. Tang Y, Zhai Y, Song W, Zhu T, Xu Z, Jiang L, et al. Association	540
	between complete blood count-derived inflammatory	541
	markers and the risk of frailty and mortality in middle-aged	542
	and older adults. Front Public Health. 2024;12:1427546.	543
	https://doi.org/10.3389/fpubh.2024.1427546	544
	5. Chmielewski PP, Strzelec B, Mozdziak P, Kempisty B.	545
	Neutrophil-to-lymphocyte ratio as a prognostic biomarker	546
	for long-term survival in older adults at a mental health	547
	care center: a historical cohort analysis. J Clin Med.	548
	2025;14(7):2509. https://doi.org/10.3390/jcm14072509	549
	6. García-Escobar A, Vera-Vera S, Tébar-Márquez D,	550
	Rivero-Santana B, Jurado-Román A, Jiménez-Valero S,	551
	et al. Neutrophil-to-lymphocyte ratio an inflammatory	552
	biomarker, and prognostic marker in heart failure,	553
	cardiovascular disease and chronic inflammatory	554
	diseases: new insights for a potential predictor of	555
	anti-cytokine therapy responsiveness. Microvasc	556
	Res. 2023;150:104598. https://doi.org/10.1016/j.	557
	mvr.2023.104598	558
	7. Pomerantz A, Yaacov A, Goldman A, Moshkovits Y, Zlotnik	559
	A, Deri O, et al. Evaluation of PSI, CURB-65, and CRB-65	560
	as prognostic tools in hospitalized immunocompetent	561
	patients with pneumonia: real-world outcomes from	562
	internal medicine wards. Pneumonia. 2026;18(1):3.	563
	https://doi.org/10.1186/s41479-025-00191-x	564

8. Gaire M, Koirala D, Gautam A, Mishra B, Sapkota R, Niraula S, et al. Comparison of CURB-65 and qSOFA scores in predicting outcomes in community-acquired pneumonia. *Ann Med Surg (Lond)*. 2026;88(2):1287–96. <https://doi.org/10.1097/MS9.0000000000004444>
9. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372(71):n71. <https://doi.org/10.1136/bmj.n71>
10. Hayden JA, van der Windt DA, Cartwright JL, Côté P, Bombardier C. Assessing bias in studies of prognostic factors. *Ann Intern Med*. 2013;158(4):280–6. <https://doi.org/10.7326/0003-4819-158-4-201302190-00009>
11. Deeks JJ, Higgins JP, Altman DG. Chapter 10: Analysing data and undertaking meta-analyses. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. *Cochrane handbook for systematic reviews of interventions*. Version 6.4. London, UK: Cochrane; 2023.
12. Sharma Y, Thompson C, Zinellu A, Shahi R, Horwood C, Mangoni AA. The role of the neutrophil-to-lymphocyte ratio in predicting outcomes among patients with community-acquired pneumonia. *Clin Med (Lond)*. 2025;25(1):100278. <https://doi.org/10.1016/j.clinme.2024.100278>
13. Tekin A, Wireko FW, Gajic O, Odeyemi YE. The neutrophil/lymphocyte ratio and outcomes in hospitalized patients with community-acquired pneumonia: a retrospective cohort study. *Biomedicine*. 2024;12(2):260. <https://doi.org/10.3390/biomedicine12020260>
14. Feng DY, Zou XL, Zhou YQ, Wu WB, Yang HL, Zhang TT. Combined neutrophil-to-lymphocyte ratio and CURB-65 score as an accurate predictor of mortality for community-acquired pneumonia in the elderly. *Int J Gen Med*. 2021;14:1133–9. <https://doi.org/10.2147/IJGM.S300776>
15. Huang L, Weng B, Wang M, Weng J, Du X, Ju Y, et al. The improved prediction value of neutrophil to lymphocyte ratio to pneumonia severity scores for mortality in the older people with community-acquired pneumonia. *BMC Geriatr*. 2025;25(1):485. <https://doi.org/10.1186/s12877-025-06121-2>
16. Cury VF, Antoniazzi LQ, Oliveira PH, Borelli WV, Cunha SV, Frison GC, et al. Developing the Pneumonia-Optimized Ratio for Community-acquired pneumonia: an easy, inexpensive and accurate prognostic biomarker. *PLoS One*. 2021;16(3):e0248897. <https://doi.org/10.1371/journal.pone.0248897>
17. Guo J, Jiang C, Ran J, Tang L. Association between neutrophil percentage-to-albumin ratio and mortality in patients with community acquired pneumonia receiving systemic glucocorticoids: a retrospective cohort study. *Front Med (Lausanne)*. 2025;12:1689323. <https://doi.org/10.3389/fmed.2025.1689323>
18. Cui XJ, Xie B, Zhu KW, Liao QQ, Zhou JC, Du S, et al. Prognostic value of the platelet, neutrophil, monocyte, basophil, and eosinophil to lymphocyte ratios in patients with severe community-acquired pneumonia (SCAP). *Sci Rep*. 2024;14(1):30406. <https://doi.org/10.1038/s41598-024-80727-1>
19. Karakaya S, Parmaksiz ET, Tunçay E, Koçak ND. Use of routine hematological and biochemical parameters to predict clinical outcomes in community-acquired pneumonia. *Saudi J Med Med Sci*. 2026;14(1):56–62. https://doi.org/10.4103/sjmms.sjmms_473_25
20. Yang T, Wan C, Wang H, Qin J, Chen L, Shen Y, et al. The prognostic and risk-stratified value of neutrophil-lymphocyte ratio in Chinese patients with community-acquired pneumonia. *Eur J Inflamm*. 2017;15(1):22–7. <https://doi.org/10.1177/1721727X17702150>
21. Terzi OE, Afşar GÇ, Çetin N, Dülger S. Systemic inflammatory indices (SII and SIRI) in 30-day mortality risk stratification for community-acquired pneumonia: a study alongside CURB-65 and PSI. *Pathogens*. 2025;14(12):142. <https://doi.org/10.3390/pathogens14121235>
22. Baran B, Yetkin NA, Rabahoğlu B, Tutar N, Gülmez İ. Assessment of mortality risk in patients with community-acquired pneumonia: role of novel inflammatory biomarkers. *J Clin Lab Anal*. 2025;39(17):e70081. <https://doi.org/10.1002/jcla.70081>
23. Meng Y, Zhang L, Huang M, Sun G. Blood heparin-binding protein and neutrophil-to-lymphocyte ratio as indicators of the severity and prognosis of community-acquired pneumonia. *Respir Med*. 2023;208:107144. <https://doi.org/10.1016/j.rmed.2023.107144>
24. Lee H, Kim I, Kang BH, Um SJ. Prognostic value of serial neutrophil-to-lymphocyte ratio measurements in hospitalized community-acquired pneumonia. *PLoS One*. 2021;16(4):e0250067. <https://doi.org/10.1371/journal.pone.0250067>
25. Curbelo J, Luquero Bueno S, Galván-Román JM, Ortega-Gómez M, Rajas O, Fernández-Jiménez G, et al. Inflammation biomarkers in blood as mortality predictors in community-acquired pneumonia admitted patients: importance of comparison with neutrophil count percentage or neutrophil-lymphocyte ratio. *PLoS One*. 2017;12(3):e0173947. <https://doi.org/10.1371/journal.pone.0173947>
26. Cataudella E, Giraffa CM, Di Marca S, Pulvirenti A, Alaimo S, Pisano M, et al. Neutrophil-to-lymphocyte ratio: an emerging marker predicting prognosis in elderly adults with community-acquired pneumonia. *J Am Geriatr Soc*. 2017;65(8):1796–801. <https://doi.org/10.1111/jgs.14894>
27. Chen X, Hao L, Zhou Y, Zhang H, Wang H, Yu W. Combined systemic immune-inflammation index-prognostic nutritional index score in evaluating the prognosis of patients with severe community-acquired pneumonia. *J Inflamm Res*. 2025;18:7105–14. <https://doi.org/10.2147/JIR.S521440>
28. Qiu Y, Su Y, Tu GW, Ju MJ, He HY, Gu ZY, et al. Neutrophil-to-lymphocyte ratio predicts mortality in adult renal transplant recipients with severe community-acquired pneumonia. *Pathogens*. 2020;9(11):913. <https://doi.org/10.3390/pathogens9110913>
29. Chen X, Huang W, Dai W, Zhang W, Zhong X, Hu M. Systemic inflammatory indices and 28-day mortality in severe pneumonia: a retrospective single-center exploratory study. *Front Med (Lausanne)*. 2026;13:1787128. <https://doi.org/10.3389/fmed.2026.1787128>
30. Tonouchi Y, Kataoka Y. Predictive factors for 30-day readmissions in elderly patients with pneumonia: a single-center retrospective cohort study. *Cureus*. 2023;15(12):e51380. <https://doi.org/10.7759/cureus.51380>