https://doi.org/10.15360/1813-9779-2025-1-38-48

Efficacy of Scoring Systems for Routing and Predicting Length of ICU Stay in Severe Community-Acquired Pneumonia

Irina A. Ruslyakova*, Elvina Z. Shamsutdinova, Galina A. Mityuchenko, Alexandra O. Orlova, Elena B. Avalueva

I. I. Mechnikov North-Western State Medical University, Ministry of Health of Russia,
47 Piskarevskii prospect, 195067 St. Petersburg, Russia

For citation: *Irina A. Ruslyakova, Elvina Z. Shamsutdinova, Galina A. Mityuchenko, Alexandra O. Orlova, Elena B. Avalueva.* Efficacy of Scoring Systems for Routing and Predicting Length of ICU Stay in Severe Community-Acquired Pneumonia. *Obshchaya Reanimatologiya = General Reanimatology.* 2025; 21 (1): 38–48. https://doi.org/10.15360/1813-9779-2025-1-38-48 [In Russ. and Engl.]

***Correspondence to:** Irina A. Ruslyakova, ruslyakova777dok@gmail.com

Summary

Scoring systems based on assessment of disease severity and patient condition are widely used for routing and predicting length of stay in the ICU. However, their effectiveness varies in patients with sepsis.

The aim of the study. To evaluate the effectiveness of scoring systems in routing and predicting ICU length of stay in patients with severe community-acquired pneumonia (CAP).

Materials and methods. Medical records of 664 patients from the Intensive Care for Severe CAP database of I. I. Mechnikov Northwestern State Medical University (2013–2023) were analyzed using the following scoring scales: CURB-65, PSI/PORT, SMART-COP, SCAP, REA-ICU, NEWS2, IDSA/ATS criteria, APACHE IV, CFS, and CCI. Statistical analysis was performed using Statistica 10.0, SPSS, and Stat Research (Center for Statistical Research) software.

Results. Among the study cohort, 96 patients (15%) had bacterial severe CAP (bCAP) and 568 patients (85%) had viral severe CAP (vCAP), all of whom were admitted to the ICU. A NEWS2 score $\geqslant 2$ was observed in 74 (77.1%) bCAP patients and all vCAP patients ($P<0.001$). In contrast, 437 (76.9%) vCAP patients and 74 (77.1%) bCAP patients were classified as high risk according to SMART-COP ($P=0.966$). Delayed ICU admission (>7 days) was observed in older patients with severe bCAP, but did not significantly affect ICU length of stay or outcomes. A strong correlation was found between adverse outcome and predicted mortality using APACHE IV ($\eta=0.966$ for vCAP and $\eta=0.807$ for bCAP). However, no correlation was observed between predicted and actual ICU length of stay for both vCAP and bCAP patients ($R^2=0.0257$, Kendall's $W=0.018$ for vCAP; $R^2=0.0294$, Kendall's $W=0.050$ for bCAP). The predictive model accuracy for ICU stay >1 day or >14 days was not satisfactory. Model with vCAP patients adjusted for age ($\geqslant 60$ years) and APACHE IV exhibited moderate predictive accuracy for prolonged ICU stay (AUROC 0.610).

Conclusion. Differences were found in the applicability of the NEWS2, REA-ICU, and IDSA/ATS major criteria scoring systems for ICU routing of bCAP and vCAP patients. APACHE IV showed a strong correlation between predicted and actual mortality, but no correlation between predicted and actual ICU length of stay in severe CAP patients was found.

Keywords: community-acquired pneumonia; ICU routing; ICU length of stay; severity scoring systems

Conflict of interest. The authors declare no conflict of interest.

Information about the authors:
Irina A. Ruslyakova: ORCID 0000-0003-1507-833X
Elvina Z. Shamsutdinova: ORCID 0009-0003-5800-8697
Galina A. Mityuchenko: ORCID 0009-0000-2047-9563
Alexandra O. Orlova: ORCID 0009-0000-1428-2617
Elena B. Avalueva: ORCID 0000-0001-6011-0998

Introduction

Community-acquired pneumonia (CAP) is the second most common cause of hospitalization and the leading infectious cause of death. Advanced age is a well-established risk factor for adverse outcomes in CAP [1]. Severe community-acquired pneumonia (sCAP) is a distinct form of the disease characterized by severe acute respiratory failure (ARF), typically accompanied by signs of sepsis and organ dysfunction [2]. A pragmatic definition of sCAP refers to CAP in patients admitted to the intensive care unit (ICU). The bias inherent in this definition stems from the significant variability in ICU resources across regions and healthcare institutions. In addition, the comorbidity profile of patients [1] and the need for specialized care in «frail» patients [3] may influence the assessment of severity and increase the need for ICU admission in CAP cases.

The use of severity scales and the selection of appropriate care settings are critical to ensure the safety of patients with CAP and the appropriate allocation of hospital resources (Appendix, Table). In clinical practice, the use of the IDSA/ATS minor criteria (3 out of 9 criteria) or major criteria (shock or need for mechanical ventilation) helps to stratify patients with CAP [4]. A meta-analysis by Marti et al. showed that the minor criteria of IDSA/ATS, SCAP, and SMART-COP have superior discriminatory performance compared to the PSI/PORT and CURB-65 scoring systems in predicting the need for ICU admission in patients with sCAP [5]. Similar findings were reported in the study by Fukuyama et al, where the IDSA/ATS criteria and the SMART-COP scale showed good predictive value for ICU routing in patients with sCAP [6].

The proportion of patients with severe community-acquired pneumonia (sCAP) requiring resuscitation is 22.7% [7], and a proportion of these patients needs a prolonged stay in the intensive care unit (ICU) [8–9], which significantly increases the financial cost to hospitals [10]. Prolonged ICU stays are not only associated with high costs due to intensive therapy, but also with resource utilization, leading to disruptions in the throughput capacity of units and hospitals.

To predict ICU length of stay, the predictive ability of the APACHE III [11], APACHE IV [12], MPM III [13], and SAPS II [14] scales was evaluated. The APACHE IV scale was developed in 2006 using data from 69.652 patients admitted to 104 ICUs in the United States and later validated using data from 46.517 patients to predict ICU length of stay and hospital mortality [12]. The accuracy of predicting ICU length of stay using the APACHE IV scale in patients with sepsis shows conflicting results [15].

Building a predictive model by incorporating additional variables based on the APACHE II, APACHE III, and SAPS II scales shows higher effectiveness in predicting the risk of prolonged ICU stay (AUC 0.827–0.839) [16]. To improve the predictive accuracy in patients with sCAP, it is suggested to use the Clinical Frailty Scale (CFS) and the Charlson Comorbidity Index (CCI). According to several researchers, the CFS provides valuable clinical information for health care managers regarding the organization and duration of intensive therapy [3], and outcome prediction based on age and comorbidities using the CCI outperforms the CURB-65 and PSI/PORT scales in terms of accuracy in patients with sCAP [17].

Improving the accuracy of predicting ICU length of stay for patients with sCAP will facilitate planning and improve resource management in hospitals.

The aim of the study — to evaluate the effectiveness of using scales for patient routing and prediction of ICU length of stay in patients with severe community-acquired pneumonia.

Materials and Methods

Data from the medical records of 853 patients with lower respiratory tract infections were collected from the «Intensive care of patients with severe community-acquired pneumonia» database at the I. I. Mechnikov Northwestern State Medical University (NSMU) from February 2013 to February 2023 (government registration certificate for the database No. 2024624611). The diagnosis of severe community-acquired pneumonia (sCAP) was made according to clinical guidelines [2]. The center received approval from the Local Ethics Committee (LEC) of NSMU (LEC Protocol No. 2, dated February 12, 2020).

The table in the appendix shows the scales used prospectively to assess the severity of patients with sCAP and to determine the need for ICU admission. A retrospective assessment of 40 patients with moderate community-acquired pneumonia (mCAP) from 2013 to 2020 was performed using the NEWS2 scale. The duration of ICU stay for patients with sCAP was also evaluated. During ICU admission, variables necessary to predict mortality and ICU length of stay were collected.

Statistical analysis was performed using the software packages Statistica 10.0, SPSS, and Stat Research (Center for Statistical Research). Patient characteristics were compared between groups according to the distribution of quantitative variables. The Shapiro–Wilk test was used to assess normality. Quantitative data were described as median *(Me)* and interquartile range *(Q1; Q3)* or mean *(M)* ± standard deviation *(SD)*.

Independent groups were compared using the Mann–Whitney and Kruskal–Wallis tests, while paired samples were analyzed using the Wilcoxon test. The Bonferroni correction was used for multiple comparisons. The structure of categorical variables was presented as frequency distributions, and Pearson's χ^2 test was used for comparative analysis of categorical data. Statistical significance was set at a two-tailed $P<0.05$.

The association between quantitative variables was assessed using Spearman's rank correlation coefficient, concordance was assessed using Kendall's W coefficient, and the association between binary and continuous variables was measured using the eta (η) coefficient.

ROC analysis was used to assess the discriminative power of the scales. The optimal threshold was selected based on a balance between sensitivity and specificity. The results were reported as threshold, sensitivity, specificity, and area under the ROC curve (AUC). Model quality was graded as follows:

— 0.9–1.0 — excellent
— 0.8–0.9 — very good
— 0.7–0.8 — good
— 0.6–0.7 — moderate
— 0.5–0.6 — poor

A higher AUC indicates a greater prognostic (diagnostic) value of the scale.

Results and Discussion

The study flowchart is shown in Fig. 1.

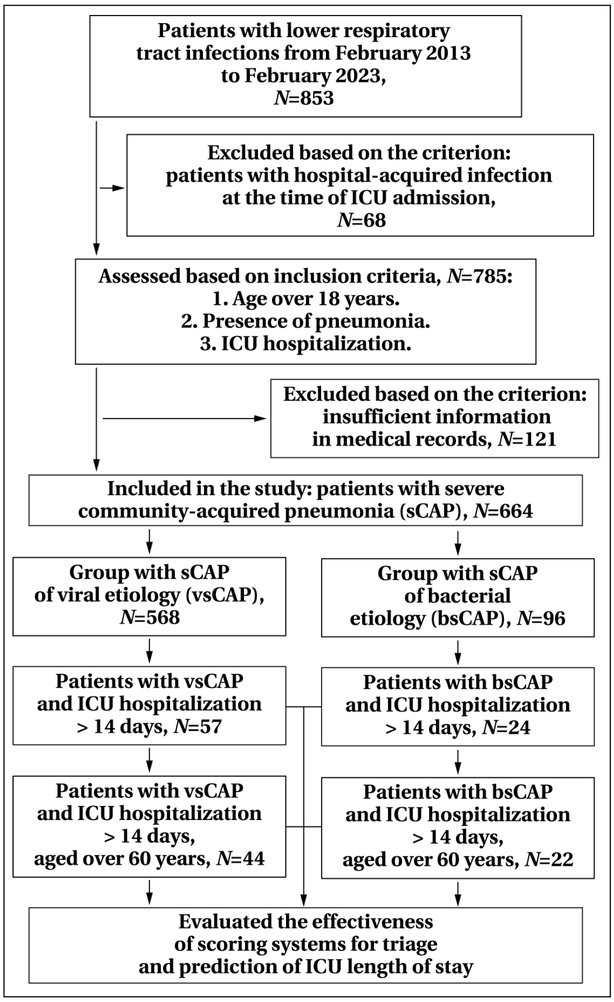

Fig. 1. Study flowchart.
Note. AUROC — area under the ROC curve; ROC — receiver operating characteristic.

The study included medical record data from 664 patients, of whom 96 (15%) had bacterial severe community-acquired pneumonia (bsCAP) and 568 (85%) had viral severe community-acquired pneumonia (vsCAP). The patient groups were comparable in age and gender, with older and geriatric patients predominant in both cohorts.

Patients with bsCAP had a higher Charlson Comorbidity Index (CCI) score, indicating a greater comorbidity burden, and their Clinical Frailty Scale (CFS) scores suggested a need for personalized care due to significant physical and cognitive impairment. Scores on the NEWS2, SMART-COP, REA-ICU scales and IDSA/ATS criteria were elevated in both groups, but showed differences between vsCAP and bsCAP patients.

A total of 567 (99.8%) vsCAP patients and 80 (83.3%) bsCAP patients required respiratory support of various modalities ($P<0.001$). However, the bsCAP group had a lower PaO_2/FiO_2 ratio. Among vsCAP patients, 203 (35.7%) had a bacterial coinfection on admission to the ICU.

The need for vasopressor support and the doses administered were higher in the bsCAP group. The groups were comparable in the use of corticosteroids but differed in the frequency of parenteral nutrition and administration of «last-resort antibiotics». Parenteral nutrition was used more frequently in vsCAP patients, while «last-resort antibiotics» were prescribed more frequently in bsCAP patients.

Patients with bsCAP required a longer ICU stay, while vsCAP patients had a longer overall hospital stay. A comparison of demographic, clinical, laboratory, and hospital-related parameters between the groups is shown in Table 1.

In the study by Covino et al, the NEWS2 score showed a high predictive accuracy (AUROC 0.901) for ICU admission and/or mortality within 24 hours with a score $\geqslant 2$ [29], which is consistent with our findings, where 568 (100%) of patients with vsCAP and 74 (77.1%) with bsCAP were at high risk for ICU admission. In the study by Lazar Neto et al. of patients with community-acquired pneumonia hospitalized with COVID-19, a SMART-COP score $\geqslant 3$ was observed in 437 (76.9%) patients [30], which is consistent with our results [6, 18].

The SCAP scale, with a threshold >10.0 points, also showed a high efficacy in predicting ICU admission in patients with vsCAP and bsCAP. A comparative analysis by Marti et al. showed that the IDSA/ATS minor criteria, SCAP score, and SMART-COP score had better discriminatory properties than PSI/PORT and CURB-65 for predicting ICU admission [5], which is consistent with our results. A PSI/PORT score >130 (class V) was observed in 365 (64.2%) patients with vsCAP versus 53 (55.2%) with bsCAP, higher than in the similar study by Charles et al. However, the number of patients with a SMART-COP score $\geqslant 3$ was lower than in the study by P. G. Charles et al. [18].

The SCAP and REA-ICU scales showed differences between vsCAP and bsCAP patients requiring intensive care, as did the IDSA/ATS major criteria. Liapikou et al. showed that the predictive value of the IDSA/ATS criteria for ICU admission was 71% [31]. In the study by Renaud et al, the risk of ICU admission increased significantly from risk class I ($\leqslant 3$ points) to risk class IV ($\geqslant 9$ points) on the REA-ICU scale [20], similar to the data of the current study.

The threshold values of the scales for ICU admission and the number of patients in the severe CAP groups reaching the corresponding scores at ICU admission are shown in Table 2.

Seventy-three (76%) patients with bsCAP were admitted to the ICU within 48 hours vs. 266 (46.8%) patients with typical vsCAP. Delayed ICU admission was associated with increased hospital mortality and unplanned readmissions in both groups, although these differences between groups were not

Table 1. Demographic, clinical, laboratory, and hospitalization-related parameters in the study groups.

Parameter	Values in groups		P
	vsCAP	bsCAP	
Total, *N* (%)	568 (85.5)	96 (14.5)	
Demographic parameters			
Age, years	67.14±14.02 68 (58.5–78)	70.07±13.96 70 (61.5–82)	0.053
Elderly, *N* (%)	232 (40.85)	39 (40.62)	0.297
Senile, *N* (%)	173 (30.46)	37 (38.54)	
Middle-aged, *N* (%)	110 (19.37)	12 (12.50)	
Young, *N* (%)	42 (7.39)	5 (5.21)	
Long-lived individuals, *N* (%)	11 (1.94)	3 (3.12)	
Women, *N* (%)	265 (46.6)	57 (59.4)	
BMI, kg/m², Me (IQR)	27.8 (8.16)	25.4 (8.56)	0.002
Scores and evaluation systems, *Me (Q1–Q3)*			
NEWS2, points	9 (8–10)	5 (2–7.5)	<0.001
CCI, points	3 (2–6)	7 (6–8)	<0.001
CFS, points	2 (0–5)	6 (0–7)	<0.001
SOFA	5 (4–7)	4 (3–6)	0.056
APACHE IV, points	69.00 (48.00–123.25)	99.00 (65.00–126.00)	<0.001
CURB-65, points	3 (2–3)	3 (2–3)	0.854
SMART-COP, points	4 (3–4)	5 (3–7)	<0.001
PSI/PORT, points	136.0 (120.5–150.5)	132.0 (114.25–156.0)	0.443
SCAP, points	11.0 (11.0–18.0)	12.0 (8.5–18.0)	0.137
IDSA/ATS: Minor criteria, points	2 (2–4)	2 (1–3)	<0.001
IDSA/ATS: Major criteria, points	0 (0–1)	1 (0–1)	0.013
REA-ICU, points	5 (2–12)	10 (7–12)	<0.001
Organ support			
Respiratory support, *N* (%)	567 (99.8)	80 (83.3)	<0.001
High-flow oxygen therapy, *N* (%)	409 (72.0)	14 (14.6)	<0.001
NILV, *N* (%)	427 (75. 2)	14 (14.6)	<0.001
MLV > 24 hours, *N* (%)	248 (43.7)	40 (41.7)	0.777
PaO_2/FiO_2, mmHg in patients on NILV/MLV, Me (IQR)	156 (35.0)	116 (62.5)	<0.001
Vasopressor support (norepinephrine at a dose of > 0.5 μg/kg/min), *N* (%)	129 (22.71)	55 (57.29)	<0.001
Vasopressor support >72 hours	85 (14.96)	55 (57.29)	<0.001
Renal replacement therapy, *N* (%)	58 (10.2)	36 (38.7)	<0.001
Intensive care			
«Last-resort antibiotics», *N* (%)	124 (21.8)	36 (37.5)	<0.001
Steroids, *N* (%)	220 (38.7)	39 (40.6)	0.006
Parenteral nutrition, *N*, (%)	201 (35.4)	30 (31.25)	<0.001
Length of hospitalization and outcomes			
ICU stay > 14 days, *N* (%)	57 (10.0)	24 (25.0)	<0.001
Days in ICU, Me (IQR)	5.0 (6.0)	7.0 (9.75)	0.001
Days from Hospital Admission to ICU, Me (IQR)	2.0 (5.0)	1.0 (1.0)	<0.001
Length of hospital stay, days, Me (IQR)	17.0 (14.0)	12.5 (13.75)	0.002
Fatal outcome, *N* (%)	236 (41.55)	58 (60.42)	0.001

Note. *Me* — median; *IQR* — interquartile range; BMI — body mass index; NILV — non-invasive lung ventilation; MLV — mechanical lung ventilation.

Table 2. Use of assessment systems to identify high-risk patients for ICU admission.

Assessment system, points	Frequency in groups, *N* (%)		P
	vsCAP, *N*=568	bsCAP, *N*=96	
1. CURB-65 ⩾3	291 (51.2)	50 (52.1)	0.877
2. PSI/PORT >130	365 (64.2)	53 (55.2)	0.092
3. SMART-COP ⩾3	437 (76.9)	74 (77.1)	0.966
4. IDSA/ ATS: Major criteria ⩾1	263 (46.3)	62 (64.6)	0.001
5. IDSA/ ATS: Minor criteria ⩾3	281 (49.5)	40 (41.7)	0.158
6. SCAP ⩾10	451 (79.4)	62 (64.6)	0.001
7. REA-ICU ⩾7	265 (46.7)	72 (75.0)	<0.001
8. NEWS2 ⩾2	568 (100.0)	74 (77.1)	<0.001

statistically significant. Similar findings were reported in a large British cohort study that showed worse outcomes with delayed ICU admission. Mortality was 46.3% for those admitted to the ICU within 2 days of hospital admission, rising to 50.4% for those admitted within 2–7 days and 57.6% for those admitted after 7 days [32]. When comparing patients based on ICU admission time, delayed ICU admission (> 7 days) was more common in older patients with vsCAP (P=0.026) and was associated with longer hospital stay (P<0.0001). However, it did not significantly affect ICU length of stay or outcome. Patients with bsCAP admitted to the ICU after a delay of > 7 days also had longer hospital stays (P=0.002), but no differences in ICU length of stay or outcome were observed between groups (Table 3).

Table 3. Study parameters at different time points prior to ICU admission.

Parameter	Values at different time points prior to ICU admission			P
	<48 hours	From 2 to 7 days	>7 days	
Patients with vsCAP, *N* (%)	266 (46.8)	191 (33.6)	111 (19.5)	—
Age of patients with vsCAP, *Me (Q1; Q3)*	68.0 (59.25; 78.0)	64.0 (57.0; 76.5)	71.0 (60.5; 80.0)	0.026 p_{23}=0.039
Length of stay in ICU, *Me (Q1; Q3)*	6.0 (3.0; 9.0)	5.0 (3.0; 9.0)	5.0 (2.0; 8.0)	0.283
Length of stay in the hospital, *Me (Q1; Q3)*)	15.0 (9.0; 21.0)	17.0 (12.0; 24.0)	25.0 (17.5; 32.0)	<0.001 p_{13}<0.001 p_{13}<0.001 p_{12}=0.002
Hospital mortality in patients with vsCAP, *N* (%)	106 (39.8)	76 (39.8)	54 (48.6)	0.239
Patients with bsCAP, *N* (%)	73 (76.0)	14 (14.6)	9 (9.4)	—
Age of patients with bsCAP, *Me (Q1; Q3)*	69.0 (62; 82.0)	70.5 (62.75; 80.5)	72.0 (66.0; 77.0)	0.955
Length of stay in ICU, *Me (Q1; Q3)*	7.0 (4.0; 13.3)	9.0 (7.0; 23.0)	7.0 (3.0; 10.0)	0.324
Length of stay in the hospital, *Me (Q1; Q3)*	7.5 (3.5; 17.0)	15.0 (11.0; 27.0)	29.0 (18.0; 32.0)	0.002 p_{13}=0.003
Hospital mortality in patients with bsCAP, *N* (%)	44 (60.3)	8 (57.1)	6 (66.7)	0.900

Table 4. Distribution in study groups according to APACHE IV scores.

APACHE IV score range	Frequency, *N* (%)			P
	vsCAP, *N*=568	bsCAP, *N*=96	Total, *N*=664	
41–52	160 (28.20)	11 (11.50)	171 (25.8)	0.0002
112–127	96 (16.90)	25 (26.00)	121 (18.2)	
53–60	73 (12.90)	8 (8.30)	81 (12.2)	
128–143	59 (10.40)	8 (8.30)	67 (10.1)	
79–92	43 (7.60)	10 (10.40)	53 (8.0)	
93–111	37 (6.50)	15 (15.60)	52 (7.8)	
144–195	34 (6.00)	11 (11.50)	45 (6.8)	
3–40	33 (5.80)	1 (1.00)	34 (5.1)	
61–68	17 (3.00)	5 (5.20)	22 (3.3)	
69–78	16 (2.80)	2 (2.10)	18 (2.7)	

A very strong correlation was found between actual adverse outcomes and the predicted mortality rate using the APACHE IV scale (η=0.966 for vsCAP and η=0.807 for bsCAP). The APACHE IV scale was used to predict ICU length of stay. The distribution of patients with sCAP across APACHE IV scores showed that 25.8% scored between 41–52 points. 18.2% scored between 112–127, 10.1% scored between 128–143 points, and 6.8% scored between 144–195 points (Table 4). Differences in APACHE IV score distribution between groups are shown in Table 4.

The median length of stay in the ICU for patients with vsCAP was 5 (3.0, 9.0) days compared to 7 (4.0, 14.0) days for patients with bsCAP. In the study by C. Dupuis et al., the median ICU stay for patients with bsCAP was 8.0 (4.0, 16.0) days [8]. According to an international report, the ICU length of stay for patients with vsCAP ranged from 5 to 19 days; our results are consistent with a British study [33]. Patients with bsCAP who scored 41–52 points had a significantly longer mean ICU length of stay than patients with vsCAP (*P*=0.001). The data of ICU length of stay for patients with vsCAP and bsCAP are shown in Table 5.

Patients with vsCAP whose APACHE IV scores ranged from 93 to 111 had ICU stays of 9 (5–12) or more days (Table 5). In the vsCAP group, the actual number of ICU days was significantly higher than predicted by APACHE IV scores in the 3–40 and 79–92 ranges, in contrast to the study by K. Zangmo et al. in which predicted days significantly exceeded actual days for patients with APACHE IV scores of 81–90 [15]. At a mean APACHE IV score of 99.92, actual and predicted ICU days were equivalent, a trend that persisted at higher mean scores (Table 6).

No significant correlation or concordance was found between predicted and actual ICU length of stay for patients with vsCAP (R^2=0.0257, Kendall's *W*=0.018). Fig. 2, *a* shows the correlation between actual and APACHE IV predicted ICU length of stay in the vsCAP.

In the bsCAP group, most patients (26.0%) had APACHE IV scores between 112 and 127, with a median ICU length of stay of 7.5 days (IQR 4.75–15.5). Ten patients (10.4%) with an APACHE IV score of 86.6 had an ICU length of stay of 10 days (IQR 6–13). In the bsCAP group, actual ICU length of stay was significantly longer than that predicted by APACHE IV scores in the 53–60 range, in contrast to the study by K. Zangmo et al. [15], which found that predicted ICU length of stay was significantly longer than actual ICU length of stay for APACHE IV scores of 50–60. No significant difference was found between predicted and actual ICU length of stay in bsCAP patients reaching a mean APACHE IV score of 64 (Table 7).

Table 5. Actual ICU length of stay in patients with vsCAP and bsCAP and different APACHE IV scores, *M±SD*; *Me* *(Q1–Q3)*.

APACHE IV		Mean ICU length of stay in groups		*P*
Score range	Mean score	vsCAP, *N*=568	bsCAP, *N*=96	
3–40	32.85	7.73±5.08 7 (4–10)	2.00	—
41–52	47.32	4.73±4.27 3 (2–6)	12.36±10.85 7 (5.5–14)	0.001
53–60	57.38	6.84±6.84 6 (3–8)	11.12±8.41 7.5 (7–11.75)	0.050
61–68	65.00	6.59±4.95 5 (4–7)	10.00±11.25 4 (2–16)	0.813
69–78	74.44	6.38±4.30 5 (4–8)	7.00±7.07 7 (4.5–9.5)	0.943
79–92	86.30	9.12±10.63 6 (4–9.5)	9.89±5.35 10 (6–13)	0.178
93–111	99.92	9.46±6.35 9 (5–12)	13.73±19.07 8 (5–11.5)	0.960
112–127	122.02	7.60±5.99 7 (3–10)	11.96±13.75 7.5 (4.75–15.5)	0.214
128–143	132.85	7.17±6.10 6 (3–9.5)	7.00±11.41 2 (1–5.75)	0.173
144–195	144.91	7.94±5.85 7.5 (4–10)	12.00±11.71 6 (4.5–16)	0.499

Table 6. Actual and predicted ICU length of stay in vsCAP patients with different APACHE IV scores, *M±SD*; *Me* *(Q1–Q3)*.

APACHE IV		vsCAP group, *N*=568	Mean ICU length of stay		*P*
Score range	Mean score	Number of patients, N (%)	Actual	Predicted	
3–40	32.88	33 (5.8)	7.73±5.08 7 (4–10)	3.34±0.86 3.3 (3.2–3.7)	<0.001
41–52	47.32	160 (28.1)	4.73±4.27 3 (2–6)	2.95±1.44 3.5 (1.2–4.2)	<0.001
53–60	57.38	73 (12.9)	6.84±6.84 6 (3–8)	4.44±0.71 4.2 (4.1–4.6)	<0.001
61–68	65.00	17 (3.0)	6.59±4.95 5 (4–7)	2.44±2.11 1.3 (1.0–3.3)	<0.001
69–78	74.44	16 (2.8)	6.38±4.30 5 (4–8)	3.39±2.07 4.1 (1.67–4.7)	0.016
79–92	86.30	43 (7.6)	9.12±10.63 6 (4–9.5)	5.48±2.44 4.8 (3.35–8)	0.043
93–111	99.92	37 (6.5)	9.46±6.35 9 (5–12)	7.22±1.01 7.5 (7.5–7.8)	0.101
112–127	122.02	96 (16.9)	7.60±5.99 7 (3–10)	7.62±0.47 7.65 (7.4–7.9)	0.220
128–143	132.85	59 (10.4)	7.17±6.10 6 (3–9.5)	6.88±0.51 6.9 (6.55–7.2)	0.435
144–195	144.91	34 (6.0)	7.94±5.85 7.5 (4–10)	6.13±0.37 6 (6.0–6.4)	0.096

Similar to the vsCAP group, we found no significant association or concordance between predicted and actual ICU length of stay in the bsCAP group (R^2=0.0294, Kendall's W=0.050). The correlation between actual and predicted ICU days using APACHE IV in the bsCAP group is shown in Fig. 2, *b*.

The accuracy of the APACHE IV model for predicting ICU length of stay > 1 and > 14 days was unsatisfactory for patients with vsCAP [AUROC 0.51 (95% CI: 0.441, 0.585) for > 1 day and 0. 595 (95% CI: 0.517, 0.674) for > 14 days] and for patients with bsCAP [AUROC 0.59 (95% CI: 0.379, 0.792) for > 1 day and 0.508 (95% CI: 0.371, 0.644) for > 14 days]. After adjustment for age ⩾ 60 years, the APACHE IV prediction model showed moderate performance in patients with vsCAP (AUROC 0.610).

In the bsCAP patient group, the use of the Charlson Comorbidity Index (CCI) yielded a predictive model of moderate quality (Table 8).

Predicting intensive care unit (ICU) bed occupancy is one of the most important tasks, as it enables planning and helps prevent overcrowding.

Accurate identification of high-risk groups, followed by appropriate patient routing to the ICU, is of paramount importance. An analysis of scoring systems revealed differences between patients with vsCAP and bsCAP according to major IDSA/ATS criteria, the NEWS2 scale (threshold ⩾ 2 points), and the REA-ICU scale (threshold ⩾ 7 points). In contrast, their scores on the SCAP scale (threshold ⩾ 10 points), PSI/PORT

Table 7. Actual and predicted ICU length of stay in bsCAP patients with different APACHE IV scores, *M±SD*; *Me (Q1–Q3)*.

APACHE IV		bsCAP group, *N*=96	Mean ICU length of stay		*P*
Score range	Mean score	Number of patients, *N* (%)	Actual	Predicted	
3–40	32.00	1 (1.0%)	2.00	5.50	—
41–52	47.36	11 (11.5%)	12.36±10.85 7 (5.5–14)	4.82±1.27 5.2 (5.2–5.2)	0.011
53–60	58.38	8 (8.3%)	11.12±8.41 7.5 (7–11.75)	4.85±2.68 6.3 (4.85–6.30)	0.014
61–68	64.00	5 (5.2%)	10.00±11.25 4 (2–16)	5.66±2.83 7.2 (5.5–7.4)	0.625
69–78	70.50	2 (2.1%)	7.00±7.07 7 (4.5–9.5)	4.40±0.85 4.4 (4.1–4.7)	1.000
79–92	86.60	10 (10.4%)	9.89±5.35 10 (6–13)	7.07±2.40 8.1 (8–8.28)	0.129
93–111	97.47	15 (15.6%)	13.73±19.07 8 (5–11.5)	7.05±1.22 7.5 (7.45–7.70)	0.410
112–127	120.32	25 (26.0%)	11.96±13.75 7.5 (4.75–15.5)	7.15±1.03 7.5 (7.3–7.8)	0.141
128–143	132.00	8 (8.3%)	7.00±11.41 2 (1–5.75)	6.20±0.84 6.5 (5.4–6.85)	0.622
144–195	147.73	11 (11.5%)	12.00±11.71 6 (4.5–16)	5.65±0.93 6 (5.15–6.30)	0.262

(> 130 points), SMART-COP (⩾ 3 points), CURB-65 (⩾ 3 points), and minor IDSA/ATS criteria did not show significant differences.

It was found that 73 (76.0%) patients with bsCAP and 266 (46.8%) patients with vsCAP were admitted to the ICU within < 48 hours. A delay in ICU admission of more than 7 days was observed in older patients with severe CAP. This delay was associated with longer hospital stay (*P*<0.0001), but did not have a significant impact on ICU length of stay or patient outcomes.

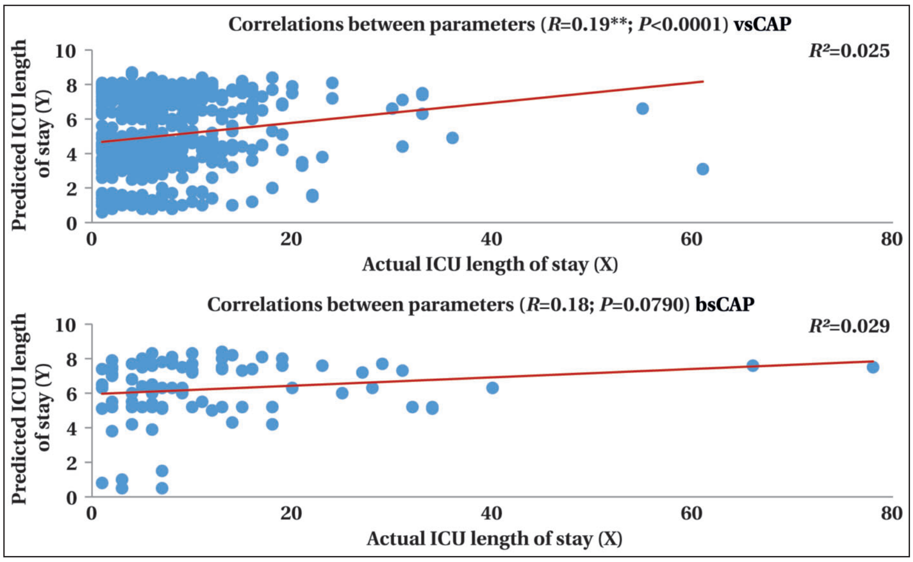

Fig. 2. Correlation between actual and predicted ICU length of stay based on APACHE IV in vsCAP *(a)* and bsCAP *(b)* groups.

Notably, 37 patients (6.5%) with vsCAP and APACHE IV scores of 93–111 and 10 patients (10.4%) with bsCAP and APACHE IV scores of 79–92 required prolonged ICU hospitalization.

A very strong correlation was found between actual adverse outcomes and predicted mortality according to the APACHE IV scale. However, no significant association and concordance was found

Table 8. Prediction of prolonged ICU stay (> 14 days) in patients (*N*=81).

Scale	Values in different groups							*P*
	Threshold	AUROC 95% CI	Se/Sp,%	*P*	Threshold	AUROC 95% CI	Se/Sp,%	
vsCAP								
All patients with vsCAP (*N*=57)					Patients with vsCAP ⩾60 years old (*N*=44)			
APACHE IV	⩾65.0	0.595 [0.517; 0.674]	71.93/49.71	0.002	⩾66.0	0.610 [0.528; 0.692]	84.09/43.82	<0.001
CFS	⩾4.0	0.575 [0.496; 0.653]	52.63/63.46	0.018	⩾4.0	0.579 [0.492; 0.665]	65.91/50.27	0.042
CCI	⩾4.0	0.544 [0.467; 0.620]	59.65/53.62	0.057	⩾4.0	0.529 [0.444; 0.614]	68.18/44.62	0.105
bsCAP								
All patients with bsCAP (*N*=24)					Patients with bsCAP ⩾60 years old (*N*=22)			
APACHE IV	⩾115.0	0.508 [0.371; 0.644]	45.83/64.29	0.379	⩾115.0	0.517 [0.373; 0.661]	45.45/64.29	0.426
CFS	⩾7.0	0.625 [0.452; 0.797]	54.55/67.44	0.178	⩾7.0	0.539 [0.331; 0.746]	60.00/54.84	0.414
CCI	⩾7.0	0.615 [0.481; 0.749]	79.17/44.93	0.037	⩾7.0	0.586 [0.441; 0.732]	81.82/34.55	0.156

Note. AUC — area under the ROC curve; Se — sensitivity; Sp — specificity; CCI — Charlson Comorbidity Index; CFS — Clinical Frailty Scale.

between actual and predicted ICU length of stay in patients with severe CAP, which may be due to the specific characteristics of the ICU and the hospital, as well as the severity of the patients' conditions at the time of ICU admission.

Elderly and senile patients predominated in both groups. Respiratory support of various modalities was required in 567 patients (99.8%) with vsCAP and 80 patients (83.3%) with bsCAP ($P<0.001$). In addition, 203 patients (35.7%) with vsCAP had a bacterial co-infection on admission to the ICU. Patients with bsCAP had higher Charlson Comorbidity Index (CCI) scores, while their Clinical Frailty Scale (CFS) scores indicated a need for personalized care due to significant physical and cognitive impairment.

Age-adjusted analysis of the predictive model, including only patients older than 60 years, showed moderate predictive accuracy of ICU length of stay for the APACHE IV scale in patients with vsCAP. However, in the bsCAP group, the APACHE IV scale showed poor predictive performance. In this group, moderate predictive accuracy was achieved using the Charlson Comorbidity Index (CCI).

Study limitation. Data were obtained from a single-center study.

Conclusion

Significant differences were found in the NEWS2, REA-ICU, and major IDSA/ATS criteria for ICU routing of patients with bacterial and viral severe community-acquired pneumonia.

The APACHE IV scale showed a very strong correlation between predicted and actual mortality rates and no correlation between predicted and actual ICU length of stay for patients with severe community-acquired pneumonia.

Appendix

Table of scales used in the study of patients with sCAP.

№	Scale	Description
		Severity Assessment
1.	SMART-COP/SMRT-CO (systolic blood pressure, multilobar infiltration, albumin, respiratory rate, tachycardia, confusion, oxygenation, pH), 2008 [18].	Australian model for identifying patients needing respiratory support and catecholamine infusion based on 8 clinical parameters.
2.	PSI/PORT (Pneumonia Severity Index — Pneumonia Patient Outcomes Research Team), 1997 [19].	A two-step scoring system based on demographic, clinical, laboratory, and radiological parameters. Patients are classified into one of five classes (I–V), which guide routing and mortality prediction.
3.	REA-ICU (Risk of Early Admission to the ICU) 2009 [20].	A mixed French-American risk assessment for early ICU admission.
4.	CURB-65 (confusion, uremia, respiratory rate, blood pressure, age ⩾65 years), 2003 [21].	Proposed by the British Thoracic Society to assess the severity of community-acquired pneumonia and guide patient routing.
5.	IDSA/ATS (American Thoracic Society Criteria for Defining Severe Community-acquired Pneumonia) 2007 [22].	American Thoracic Society and Infectious Diseases Society model, consisting of major and minor criteria based on the need for respiratory and vasopressor support, as well as clinical, radiological, and laboratory parameters.
6.	SCAP (Severe Community-Acquired Pneumonia score) 2009 [23].	Spanish model used to predict 30-day mortality based on 8 clinical, laboratory, and radiological parameters.
7.	NEWS 2 (National Early Warning Score), 2017 [24].	British standardized patient severity assessment based on 7 clinical parameters.
8.	SOFA (Sequential Organ Failure Assessment) 1996 [25].	Organ dysfunction assessed based on 6 organ systems every 24 hours from admission to transfer.
		Duration of ICU stay
9.	APACHE IV (Acute Physiology and Chronic Health Evaluation IV) 2006 [26].	APACHE IV model used for predicting mortality and ICU stay duration.
10.	CFS (The Clinical Frailty Scale) [27].	A frailty assessment tool based on judgment, evaluating comorbidities, performance, and cognitive status, providing a frailty score from 1 (very fit) to 9 (terminally ill).
11.	CCI (Charlson Comorbidity Index) [28].	Index predicting 10-year survival based on age and comorbidities.
12.	MPM (Mortality Probability Model 0–III) 2007 г. [13]	A scale for predicting mortality.
13.	SAPS II (new Simplified Acute Physiology	A scale for assessing ICU severity and predicting mortality based on 17 variables: 12 clinical-laboratory parameters, age, type of hospitalization (elective surgery, emergency surgery, or medical), and three variables of primary disease (AIDS, metastatic cancer, and hematological malignancies).

References

1. *Song Y., Wang X., Lang K., Wei T., Luo J., Song Y., Yang D.* Development and validation of a nomogram for predicting 28-day mortality on admission in elderly patients with severe community-acquired pneumonia. *J Inflamm Res.* 2022; 15: 4149–4158. DOI: 10.2147/JIR.S369319. PMID: 35903289.
2. *Авдеев С. Н., Белобородов В. Б., Белоцерковский Б. З., Грицан А. И., Дехнич А. В., Зайцев А. А., Киров М. Ю., и др.* Тяжелая внебольничная пневмония у взрослых. Клинические рекомендации Федерации анестезиологов и реаниматологов России. *Анестезиология и реаниматология.* 2022; (1): 6–35. *Avdeev S. N., Beloborodov V. B., Belotserkovskiy B. Z., Gritsan A. I., Dekhnich A. V., Zaitsev A. A., Kirov M. Yu., et al.* Severe community-acquired pneumonia in adults. Clinical recommendations from Russian Federation of Anaesthesiologists and Reanimaologists. *Russian Journal of Anesthesiology and Reanimatology = Anesteziologiya i Reanimatologiya.* 2022; (1): 6–35. (In Russ.). DOI: 10.17116/anaesthesiology20220116
3. *Church S., Rogers E., Rockwood K., Theou O.* A scoping review of the Clinical Frailty Scale. *BMC Geriatr.* 2020; 20 (1): 393. DOI: 10.1186/s12877-020-01801-7. PMID: 33028215
4. *Martin-Loeches I., Torres A.* Severe Community-Acquired Pneumonia. *Semin Respir Crit Care Med.* 2024; 45 (2): 141–142. DOI: 10.1055/s-0044-1780515. PMID: 38604187
5. *Marti C., Garin N., Grosgurin O., Poncet A., Combescure C., Carballo S., Perrier A.* Prediction of severe community-acquired pneumonia: a systematic review and meta-analysis. *Crit Care.* 2012; 16 (4): R141. DOI: 10.1186/cc11447. PMID: 22839689.
6. *Fukuyama H., Ishida T., Tachibana H., Nakagawa H., Iwasaku M., Saigusa M., Yoshioka H., et al.* Validation of scoring systems for predicting severe community-acquired pneumonia. *Intern Med.* 2011; 50 (18): 1917–1922. DOI: 10.2169/internalmedicine.50.5279. PMID: 21921369.
7. *Divino V., Schranz J., Early M., Shah H., Jiang M., DeKoven M.* The annual economic burden among patients hospitalized for community-acquired pneumonia (CAP): a retrospective US cohort study. *Curr Med Res Opin.* 2020; 36 (1): 151–160. DOI: 10.1080/03007995.2019.1675149. PMID: 31566005.
8. *Dupuis C., Sabra A., Patrier J., Chaize G., Saighi A., Feger C., Vainchtock A., et al.* Burden of pneumococcal pneumonia requiring ICU admission in France: 1-year prognosis, resources use, and costs. *Crit Care.* 2021; 25 (1): 24. DOI: 10.1186/s13054-020-03442-z. PMID: 33423691.
9. *Çelikhisar H., Daşdemir Ilkhan G., Arabaci Ç.* Prognostic factors in elderly patients admitted to the intensive care unit with community-acquired pneumonia. *Aging Male.* 2020; 23 (5): 1425–1431. DOI: 10.1080/13685538.2020.1775192. PMID: 32543939.
10. *Haessler S., Guo N., Deshpande A., Zilberberg M. D., Lagu T., Lindenauer P. K., Imrey P. B., et al.* Etiology, treatments, and outcomes of patients with severe community-acquired pneumonia in a large U.S. sample. *Crit Care Med.* 2022; 50 (7): 1063–1071. DOI: 10.1097/CCM.0000000000005498. PMID: 35191410.
11. *Woods A. W., MacKirdy F. N., Livingston B. M., Norrie J., Howie J. C.* Evaluation of predicted and actual length of stay in 22 Scottish intensive care units using the APACHE III system. Acute Physiology and Chronic Health Evaluation. *Anaesthesia.* 2000; 55 (11): 1058–1065. DOI: 10.1046/j.1365-2044.2000.01552.x. PMID: 11069331
12. *Vasilevskis E. E., Kuzniewicz M. W., Cason B. A., Lane R. K., Dean M. L., Clay T., Rennie D. J., et al.* Mortality probability model III and simplified acute physiology score II: assessing their value in predicting length of stay and comparison to APACHE IV. *Chest.* 2009; 136 (1): 89–101. DOI: 10.1378/chest.08-2591. PMID: 19363210.
13. *Higgins T. L., Teres D., Copes W. S., Nathanson B. H., Stark M., Kramer A. A.* Assessing contemporary intensive care unit outcome: an updated Mortality Probability Admission Model (MPM0-III). *Crit Care Med.* 2007; 35 (3): 827–835. DOI: 10.1097/01.CCM.0000257337.63529.9F. PMID: 17255863.
14. *Le Gall J. R., Lemeshow S., Saulnier F.* A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study [published correction appears in JAMA 1994 May 4; 271 (17): 1321]. *JAMA.* 1993; 270 (24): 2957–2963. DOI: 10.1001/jama.270.24.2957. PMID: 8254858.
15. *Zangmo K., Khwannimit B.* Validating the APACHE IV score in predicting length of stay in the intensive care unit among patients with sepsis. *Sci Rep.* 2023; 13 (1): 5899. DOI: 10.1038/s41598-023-33173-4. PMID: 37041277.

16. *Takekawa D., Endo H., Hashiba E., Hirota K.* Predict models for prolonged ICU stay using APACHE II, APACHE III and SAPS II scores: A Japanese multicenter retrospective cohort study. *PLoS One.* 2022; 17 (6): e0269737. DOI: 10.1371/journal.pone.0269737. PMID: 35709080.
17. *Bahlis L. F., Diogo L. P., Fuchs S. C.* Charlson Comorbidity Index and other predictors of in-hospital mortality among adults with community-acquired pneumonia. *J Bras Pneumol.* 2021; 47 (1): e20200257. DOI: 10.36416/1806-3756/e20200257. PMID: 33656092.
18. *Charles P. G., Wolfe R., Whitby M., Fine M. J., Fuller A. J., Stirling R., Wright A. A., et al.* SMART-COP: a tool for predicting the need for intensive respiratory or vasopressor support in community-acquired pneumonia. *Clin Infect Dis.* 2008; 47 (3): 375–84. DOI: 10.1086/589754. PMID: 18558884.
19. *Fine M. J., Auble T. E., Yealy D. M., Hanusa B. H., Weissfeld L. A., Singer D. E., Coley C. M., et al.* A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med.* 1997; 336 (4): 243–250. DOI: 10.1056/NEJM199701233360402. PMID: 8995086.
20. *Renaud B., Labarère J., Coma E., Santin A., Hayon J., Gurgui M., Camus N., et al.* Risk stratification of early admission to the intensive care unit of patients with no major criteria of severe community-acquired pneumonia: development of an international prediction rule. *Crit Care.* 2009; 13 (2): R54. DOI: 10.1186/cc7781. PMID: 19358736.
21. *Liu J.-L., Xu F., Zhou H., Wu X-.J., Shi L.-X., Lu R.-Q., Farcomeni A., Farcomeni A., Venditti M., et al.* Expanded CURB-65: a new score system predicts severity of community-acquired pneumonia with superior efficiency. *Sci Rep.* 2016; 6: 22911. DOI: 10.1038/srep22911. PMID: 26987602.
22. *Mandell L. A., Wunderink R. G., Anzueto A., Bartlett J. G., Campbell G. D., Dean N. C., Dowell S. F., et al.* Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clin Infect Dis.* 2007; 44 (Suppl 2): S27–72. DOI: 10.1086/511159. PMID: 17278083.
23. *España P. P., Capelastegui A., Quintana J. M., Bilbao A., Diez R., Pascual S., Esteban C., et al.* Validation and comparison of SCAP as a predictive score for identifying low-risk patients in community-acquired pneumonia. *J Infect.* 2010; 60 (2): 106–113. DOI: 10.1016/j.jinf.2009.11.013. PMID: 19961875.
24. National Early Warning Score (NEWS) 2 — Standardising the assessment of acute illness severity in the NHS. ISBN 978-1-86016-682-2.588210.
25. *Zimmerman J. E., Kramer A. A., McNair D. S., Malila F. M., Shaffer V. L.* Intensive care unit length of stay: benchmarking based on Acute Physiology and Chronic Health Evaluation (APACHE) IV. *Crit Care Med.* 2006; 34 (10): 2517–2529. DOI: 10.1097/01.CCM.0000240233.01711.D9. PMID: 16932234
26. *Sternberg S. A., Wershof Schwartz A., Karunananthan S., Bergman H., Mark Clarfield A.* The identification of frailty: a systematic literature review. *J Am Geriatr Soc.* 2011; 59 (11): 2129–2138. DOI: 10.1111/j.1532-5415.2011.03597.x. PMID: 22091630.
27. *Charlson M. E., Pompei P., Ales K. L., MacKenzie C. R.* A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987; 40 (5): 373–383. DOI: 10.1016/0021-9681(87)90171-8. PMID: 3558716.
28. *Covino M., Sandroni C., Della Polla D., De Matteis G., Piccioni A., De Vita A., Russo A., et al.* Predicting ICU admission and death in the Emergency Department: a comparison of six early warning scores. *Resuscitation.* 2023; 190: 109876. DOI: 10.1016/j.resuscitation.2023.109876. PMID: 37331563.
29. *Neto F. L., Marino L. O., Torres A., Cilloniz C., Marchini J. F. M., de Alencar J. C. G., Palomeque A., et al.* Community-acquired pneumonia severity assessment tools in patients hospitalized with COVID-19: a validation and clinical applicability study. *Clin Microbiol Infect.* 2021; 27 (7): 1037.e1–1037.e8. DOI: 10.1016/j.cmi.2021.03.002. PMID: 33813111.
30. *Liapikou A., Ferrer M., Polverino E., Balasso V., Esperatti M., Piner R., Mensa J., et al.* Severe community-acquired pneumonia: validation of the Infectious Diseases Society of America/American Thoracic Society guidelines to predict an intensive care unit admission. *Clin Infect Dis.* 2009; 48 (4): 377–385. DOI: 10.1086/596307. PMID: 19140759.
31. *Woodhead M., Welch C. A., Harrison D. A., Bellingan G., Ayres J. G.* Community-acquired pneumonia on the intensive care unit: secondary analysis of 17,869 cases in the ICNARC Case

Mix Programme Database. *Crit Care*. 2006; 10 (Suppl 2): S1.
DOI: 10.1186/cc4927. PMID: 16934135.

32. *Rees E. M., Nightingale E. S., Jafari Y., Waterlow N. R., Clifford S., Pearson C. A. B., Jombart T., et al*. COVID-19 length of hospital stay: a systematic review and data synthesis. *BMC Med*. 2020; 18 (1): 270.
DOI: 10.1186/s12916-020-01726-3.
PMID: 32878619.

Received 02.04.2024
Accepted 05.11.2024