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Admission Determinants of Prolonged Intensive Care Unit Stay: A Five Years Multidisciplinary Cohort Study Comparing Neurological and Non-Neurological Critical Illness

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Abstract

Background

Prolonged intensive care unit (ICU) stay increases healthcare costs, complications, and adverse outcomes. This study aimed to identify admission determinants of prolonged ICU stay and compare neurological with non-neurological critically ill patients.

Material and Methods

This retrospective cohort study included 609 adults admitted to five multidisciplinary ICUs of a tertiary care hospital between October 2019 and October 2024. Admission comorbidities, Glasgow Coma Scale (GCS), APACHE II and SOFA scores, and laboratory variables were recorded. Prolonged ICU stay was defined as a length of stay ≥ 14 days. Multivariable logistic regression analyses were restricted to admission variables, excluding mechanical ventilation and tracheostomy as time-dependent variables.

Results

Median age was 71 (63–83) years, 43.8% of patients were women, median ICU stay was 19 (10–30) days, and 66.2% remained in the ICU for ≥ 14 days. Neurological patients had shorter ICU stays (15 vs 20 days, $p = 0.002$) and a lower prevalence of prolonged stay (57.8% vs 69.7%, $p = 0.006$) than non-neurological patients. Lower admission GCS (OR = 0.90, 95% CI 0.84–0.95) and absence of diabetes mellitus (OR = 0.64, 95% CI 0.43–0.96) independently predicted prolonged ICU stay, whereas higher SOFA score, medical admission, and neutrophil-to-lymphocyte ratio showed borderline associations.

Conclusions

Lower admission GCS and absence of diabetes mellitus were independent admission determinants of prolonged ICU stay. Similar predictors were observed in neurological and non-neurological patients, indicating that baseline physiological severity rather than admission diagnosis primarily influences prolonged ICU utilization. Early identification of high-risk patients may improve individualized management and ICU resource allocation.

INTRODUCTION

Intensive care units (ICUs) are organized hospital systems that provide specialized monitoring, medical and nursing care, and organ support for critically ill patients with life-threatening conditions (1). Accurate prediction of length of stay (LOS) is important for capacity planning, workload management, and efficient resource allocation (2, 3). Patients requiring prolonged intensive care consume a substantial proportion of ICU bed-days and frequently experience complex clinical courses (4, 5). In selected patient

populations, longer ICU stays have also been associated with poorer subsequent quality of life and increased healthcare utilization (6).

In recent years, prediction models for ICU LOS have increasingly incorporated machine-learning approaches using large critical-care databases such as MIMIC (7, 8). Although these models have shown promising predictive performance, most were developed either in heterogeneous ICU populations or in selected disease-specific cohorts, including cardiac surgery, trauma, and intracerebral hemorrhage (9–11). Reported predictors vary according to the underlying disease, indicating that determinants of prolonged ICU stay may differ substantially across critically ill populations and limiting the generalizability of existing models (3).

Neurological patients are traditionally considered more likely to require prolonged ICU care because of impaired consciousness, prolonged mechanical ventilation, and immobility-related complications (12). In contrast, prolonged ICU stay in non-neurological patients is more often associated with systemic disease severity, surgical complications, and persistent organ dysfunction (13, 14). The Glasgow Coma Scale (GCS) and severity scores such as APACHE II and SOFA are widely used to assess neurological status and overall illness severity and have consistently demonstrated prognostic value in critically ill patients (15, 16).

Although ICU LOS has been extensively investigated, previous studies have predominantly evaluated either heterogeneous ICU populations or disease-specific cohorts, such as trauma and cardiac surgery patients, while stroke studies have more often focused on hospitalization outcomes rather than ICU-specific LOS (2, 3, 5, 9, 10, 11, 17, 18). Furthermore, many previous prediction studies incorporated variables that develop during ICU stay, such as mechanical ventilation, tracheostomy, or ICU-acquired complications. Because these variables are not available at ICU admission, their inclusion in baseline prediction models may introduce reverse causation and immortal-time bias. Moreover, patients discharged early because of rapid recovery or early death follow clinical trajectories that differ substantially from those with sustained ICU dependency, potentially obscuring determinants of prolonged ICU utilization. We hypothesized that variables available at ICU admission, particularly indicators of neurological status and physiological severity, would independently predict prolonged ICU stay and that these determinants would differ between neurological and non-neurological critically ill patients. Therefore, we aimed to identify admission determinants of prolonged ICU stay using only variables available at ICU admission, compare neurological and non-neurological critically ill patients, and determine whether shared or disease-specific predictors influence prolonged ICU utilization.

MATERIAL AND METHODS

Study design and ethics

We carried out this single-centre, retrospective observational cohort study at a tertiary training and research hospital. Ethical approval was granted by the Scientific Research Ethics Committee of Giresun

Training and Research Hospital, Giresun, Türkiye (Application No. BAEK-456; Decision No. 07; Approval Date: 17 September 2025). All procedures followed the principles set out in the Declaration of Helsinki and its later revisions. Given the retrospective design and the reliance on anonymised data gathered during routine care, the Ethics Committee waived the requirement for informed consent.

We hypothesized that admission variables would independently predict prolonged ICU stay and that these associations would differ between neurological and non-neurological patients.

As an observational study of already-recorded data, it was not registered in advance.

Study setting and patient population

The setting was a tertiary training and research hospital with five adult ICUs—anaesthesiology–reanimation, internal medicine, neurology, surgical, and coronary. Using the hospital information system, we identified every consecutive adult (≥ 18 years) admitted to these units between October 2019 and October 2024.

Inclusion and exclusion criteria

Eligibility required an age of ≥ 18 years and an ICU stay lasting at least five days. Patients with ICU stays shorter than five days were excluded because these admissions generally represent either rapid recovery or early death, reflecting clinical trajectories fundamentally different from those leading to prolonged ICU resource utilization. This criterion was intended to identify determinants of sustained ICU dependency rather than short-term outcomes.

Of the 621 patients meeting the age and length-of-stay criteria, 12 (1.9%) lacked a serum albumin value and were removed. Because fewer than 5% of records were incomplete, we chose not to impute and analysed complete cases only, consistent with current guidance for small amounts of missing data in observational research. This left 609 patients for the final analysis.

Data collection and measurements

Using a standardised data form, we retrospectively drew clinical, demographic, and laboratory information from the hospital information system and the electronic medical records. Recorded fields covered patient demographics, comorbid conditions, the admitting diagnosis, ICU type, admission GCS, APACHE II and SOFA scores, routine laboratory tests taken on admission, interventions and complications during the ICU course, ICU length of stay, and in-hospital death. To safeguard confidentiality, every record was anonymised before analysis.

Definitions and study outcomes

From the laboratory values obtained on admission we derived several inflammatory indices: the neutrophil-to-lymphocyte ratio (NLR); the platelet-to-lymphocyte ratio (PLR); the C-reactive protein-to-albumin ratio (CAR); the systemic immune-inflammation index (SII), given by platelet × neutrophil / lymphocyte; and the systemic inflammation response index (SIRI), given by neutrophil × monocyte / lymphocyte.

The pre-specified primary endpoint was a prolonged ICU stay, fixed a priori at an ICU length of stay of ≥ 14 days in keeping with earlier work (11). In-hospital death was the secondary endpoint.

Patients were classified as having neurological or non-neurological critical illness according to their primary admission diagnosis. Neurological admissions included acute cerebrovascular diseases and other primary disorders of the central nervous system requiring intensive care, whereas all remaining admission diagnoses were classified as non-neurological.

Sample size justification

Because every consecutive eligible patient was enrolled, no a priori sample-size estimate was undertaken. Model adequacy for the multivariable logistic regressions was instead judged with the events-per-variable (EPV) metric. With 403 prolonged ICU stays and 206 non-prolonged stays (the smaller group governing events-per-variable) and 230 in-hospital deaths against nine parameters per model, the EPV comfortably surpassed the customary lower limit of 10, supporting adequate power and stable estimates.

Statistical analysis

Analyses were run in IBM SPSS Statistics v29.0 (IBM Corp., Armonk, NY, USA) and R v4.5.0 (R Foundation for Statistical Computing, Vienna, Austria). Continuous data are reported as medians with interquartile ranges (IQR) and categorical data as counts with percentages. Between-group comparisons used the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables, as appropriate.

Candidate predictors of prolonged stay were restricted to information available at the moment of admission. Duration of mechanical ventilation and tracheostomy were removed beforehand, since these time-dependent factors can generate reverse causation and immortal-time bias. Every variable reaching p value < 0.10 on univariable testing and free of multicollinearity was carried into the multivariable logistic model. To absorb differences between the participating units, ICU type was entered as a fixed effect. For the inflammatory indices, odds ratios (ORs) were reported per one-standard-deviation rise.

Discrimination was quantified by the area under the receiver operating characteristic curve (AUC). In line with TRIPOD guidance, the models were validated internally using 1000 bootstrap resamples together with repeated, stratified 10-fold cross-validation. Calibration was appraised through the Brier score, the calibration intercept and slope, calibration plots, and the Hosmer–Lemeshow goodness-of-fit test.

The neurological and non-neurological subgroups were modelled separately. We tested interaction terms pairing disease group with admission GCS, SOFA score, and the neutrophil-to-lymphocyte ratio. As sensitivity checks, Bonferroni and Benjamini–Hochberg adjustments for multiple comparisons were applied. Significance was set at a two-sided p value < 0.05.

RESULTS

General characteristics of the cohort

- A total of 748 ICU admissions were screened, of which 609 patients met the eligibility criteria and were included in the final analysis (Fig. 1). The median age was 71 (IQR 63–83) years, 267 (43.8%) patients were women, and the median ICU LOS was 19 (IQR 10–30) days. Overall, 403 (66.2%) patients experienced prolonged ICU stay (≥ 14 days), and 230 (37.8%) died during hospitalization. Baseline characteristics according to ICU type are summarized in Table 1.
- *Data are median [interquartile range] for continuous variables and n (%) for categorical variables. P values are from the Mann–Whitney U test for continuous variables and from the Pearson chi-square test (or the Fisher exact test when any expected cell count was < 5) for categorical variables. Denominators equal the group sample sizes unless otherwise indicated. GCS Glasgow Coma Scale, APACHE II Acute Physiology and Chronic Health Evaluation II, SOFA Sequential Organ Failure Assessment, CRP C-reactive protein, NLR neutrophil-to-lymphocyte ratio, CAR CRP-to-albumin ratio, SII systemic immune-inflammation index, IQR interquartile range, ICU intensive care unit.*

Table 1
Characteristics of the cohort by neurological and non-neurological groups

Characteristic	Neurological (n = 180)	Non-neurological (n = 429)	P value
Age (yr), median [IQR]	72 [64–83]	71 [63–82]	0.42
Female sex, n (%)	86 (48)	181 (42)	0.24
GCS, median [IQR]	13 [10–15]	12 [8–15]	0.05
APACHE II, median [IQR]	14 [10–18]	16 [10–20]	0.50
SOFA, median [IQR]	5.5 [4–8]	6 [4–9]	0.02
Mechanical ventilation, n (%)	67 (37)	286 (67)	< 0.001
Tracheostomy, n (%)	25 (14)	99 (23)	0.01
Surgical admission, n (%)	47 (26)	110 (26)	0.98
Cardiovascular comorbidity, n (%)	149 (83)	288 (67)	< 0.001
Respiratory comorbidity, n (%)	39 (22)	155 (36)	< 0.001
Diabetes mellitus, n (%)	61 (34)	100 (23)	0.009
Chronic kidney disease, n (%)	9 (5)	52 (12)	0.01
Albumin (g/L), median [IQR]	37.3 [32.2–40.5]	29.8 [26.6–33.6]	< 0.001
CRP (mg/L), median [IQR]	17.1 [5.7–55.0]	81.9 [21.9–167.8]	< 0.001
NLR, median [IQR]	7.0 [3.7–14.6]	13.1 [7.6–23.3]	< 0.001
CAR, median [IQR]	0.4 [0.1–1.7]	2.7 [0.7–6.0]	< 0.001
SII, median [IQR]	1504 [707–3141]	2785 [1242–5700]	< 0.001
Any complication, n (%)	40 (22)	17 (4)	< 0.001
ICU length of stay (days), median [IQR]	15 [8–27]	20 [11–33]	0.002
Prolonged ICU stay (≥ 14 days), n (%)	104 (58)	299 (70)	0.006
In-hospital mortality, n (%)	54 (30)	176 (41)	0.01

Comparison of neurological and non-neurological patients

Neurological patients had shorter ICU stays than non-neurological patients (median 15 vs 20 days, p = 0.002) and were less likely to experience prolonged ICU stay (57.8% vs 69.7%, p = 0.006). They also had lower illness severity and inflammatory marker levels but a higher frequency of ICU complications (Table 1).

Determinants of prolonged ICU stay

- Variables associated with prolonged ICU stay in the univariate analysis are presented in Table 2. In the multivariable model restricted to admission variables, lower admission GCS remained independently associated with prolonged ICU stay (OR = 0.90, 95% CI 0.84–0.95; p < 0.001), whereas diabetes mellitus remained inversely associated (OR = 0.64, 95% CI 0.43–0.96; p = 0.032). Higher SOFA score, higher NLR, and non-surgical admission showed borderline associations. Admission to the neurology ICU was associated with lower odds of prolonged ICU stay than admission to the anaesthesiology ICU (OR = 0.61, 95% CI 0.39–0.95; p = 0.028).
- Continuous inflammatory indices are expressed per 1 standard deviation increase. The multivariable model included GCS, SOFA, surgical admission, diabetes mellitus, NLR and ICU type (dummy-coded; reference = anaesthesiology–reanimation ICU); a dash (—) denotes a variable screened univariately but not retained in the multivariable model. Mechanical ventilation (total ventilator-days) and tracheostomy are time-dependent, whole-stay variables and were excluded a priori to avoid reverse causation and immortal-time bias; their univariate associations (mechanical ventilation OR 5.4 [3.8 to 7.8]; tracheostomy OR 21.4 [7.8 to 58.9]; both P < 0.001) reflect the course of prolonged critical illness. Model area under the curve = 0.72 (95% CI 0.68 to 0.77). OR odds ratio, CI confidence interval, SD standard deviation, GCS Glasgow Coma Scale, SOFA Sequential Organ Failure Assessment, APACHE II Acute Physiology and Chronic Health Evaluation II, NLR neutrophil-to-lymphocyte ratio, PLR platelet-to-lymphocyte ratio, SII systemic immune-inflammation index, SIRI systemic inflammation response index, ICU intensive care unit.

Table 2
Univariate and multivariable logistic regression for prolonged intensive care unit stay

Variable	Univariate OR (95% CI)	P value	Multivariable OR (95% CI)	P value
GCS (per point)	0.86 (0.82 to 0.90)	< 0.001	0.90 (0.84 to 0.95)	< 0.001
SOFA (per point)	1.18 (1.11 to 1.25)	< 0.001	1.07 (0.99 to 1.15)	0.07
Surgical admission	0.69 (0.47 to 1.01)	0.05	0.68 (0.44 to 1.05)	0.08
Diabetes mellitus	0.63 (0.44 to 0.92)	0.02	0.64 (0.43 to 0.96)	0.03
NLR (per SD)	1.44 (1.11 to 1.88)	0.006	1.30 (0.98 to 1.71)	0.07
APACHE II (per point)	1.03 (1.01 to 1.05)	0.02	—	—
Neurological diagnosis	0.60 (0.42 to 0.85)	0.005	—	—
PLR (per SD)	1.59 (1.13 to 2.24)	0.008	—	—
SII (per SD)	1.54 (1.15 to 2.07)	0.004	—	—
SIRI (per SD)	1.31 (1.05 to 1.64)	0.02	—	—
ICU type (reference: anaesthesiology–reanimation ICU)				
Internal medicine ICU	0.89 (0.53 to 1.50)	0.65	0.65 (0.35 to 1.19)	0.17
Neurology ICU	0.59 (0.41 to 0.84)	0.003	0.61 (0.39 to 0.95)	0.03
Surgical ICU	0.67 (0.42 to 1.06)	0.08	0.63 (0.36 to 1.12)	0.11
Coronary ICU	4.80 (1.68 to 13.7)	0.003	2.44 (0.81 to 7.4)	0.12

Subgroup analyses

In subgroup analyses, lower admission GCS remained the only independent predictor of prolonged ICU stay in neurological patients (adjusted OR 0.84, 95% CI 0.74–0.97; p = 0.014). In non-neurological patients, lower admission GCS (adjusted OR 0.91, 95% CI 0.85–0.97; p = 0.007) and non-surgical admission (adjusted OR for surgical admission 0.44, 95% CI 0.27–0.72; p = 0.001) remained independently associated with prolonged ICU stay, whereas higher SOFA scores showed a borderline association (p = 0.084). No significant interaction between disease group and any predictor was observed (all interaction p > 0.05).

Factors associated with in-hospital mortality

In-hospital mortality occurred in 230 patients (37.8%). After adjustment for ICU type, older age, higher SOFA score, lower albumin concentration, prolonged ICU stay and ICU complications were independently associated with mortality (Table 3). Mechanical ventilation was excluded from the multivariable model because of near-complete separation.

Table 3
Univariate and multivariable logistic regression for in-hospital mortality

Variable	Univariate OR (95% CI)	P value	Multivariable OR (95% CI)	P value
Age (per year)	1.03 (1.02 to 1.04)	< 0.001	1.03 (1.02 to 1.05)	< 0.001
SOFA (per point)	1.39 (1.30 to 1.49)	< 0.001	1.33 (1.24 to 1.43)	< 0.001
APACHE II (per point)	1.07 (1.05 to 1.10)	< 0.001	—	—
GCS (per point)	0.87 (0.83 to 0.91)	< 0.001	—	—
Albumin (per g/L)	0.95 (0.92 to 0.97)	< 0.001	0.96 (0.92 to 0.99)	0.005
Creatinine (per mg/dL)	1.45 (1.23 to 1.71)	< 0.001	—	—
NLR (per SD)	1.35 (1.10 to 1.67)	0.004	—	—
Prolonged ICU stay (≥ 14 days)	3.04 (2.07 to 4.46)	< 0.001	2.35 (1.49 to 3.69)	< 0.001
Any complication	3.75 (2.10 to 6.7)	< 0.001	3.47 (1.72 to 7.0)	< 0.001
Sepsis (complication)	12.6 (3.71 to 42.7)	< 0.001	—	—
Tracheostomy	3.88 (2.57 to 5.9)	< 0.001	—	—
Chronic kidney disease	2.26 (1.33 to 3.86)	0.003	—	—
Neurological diagnosis	0.62 (0.43 to 0.89)	0.01	—	—
Surgical admission	0.63 (0.43 to 0.93)	0.02	—	—
Mechanical ventilation	231.6 (56.6 to 947.3)	< 0.001	—	—
ICU type (reference: anaesthesiology–reanimation ICU)				
Internal medicine ICU	1.14 (0.69 to 1.91)	0.61	0.59 (0.31 to 1.12)	0.10
Neurology ICU	0.66 (0.46 to 0.95)	0.02	0.59 (0.34 to 1.01)	0.05
Surgical ICU	0.54 (0.33 to 0.89)	0.02	0.55 (0.30 to 1.02)	0.06
Coronary ICU	2.25 (1.17 to 4.34)	0.02	0.86 (0.40 to 1.85)	0.70

Continuous inflammatory indices are expressed per 1 standard deviation increase. The multivariable model included age, SOFA, albumin, prolonged ICU stay, any complication and ICU type (dummy-coded; reference = anaesthesiology–reanimation ICU); a dash (—) denotes a variable screened univariately but not retained in the multivariable model. Prolonged ICU stay and in-ICU complications were entered as time-dependent exposures and should be interpreted as independent associations rather than baseline predictors or causal determinants of death. Mechanical ventilation was excluded from the multivariable model because of near-complete separation (only 2 of 256 patients without mechanical ventilation died). Model area under the curve = 0.81 (95% CI 0.78 to 0.85). OR odds ratio, CI confidence interval, SD standard deviation, SOFA Sequential Organ Failure Assessment, APACHE II Acute Physiology and Chronic Health Evaluation II, GCS Glasgow Coma Scale, NLR neutrophil-to-lymphocyte ratio, ICU intensive care unit.

Survival analysis and internal validation

Kaplan–Meier analysis demonstrated significantly lower survival among patients with an admission SOFA score ≥ 6 and those aged ≥ 70 years (both log-rank $p \leq 0.001$) (Fig. 2).

Internal validation using 1000 bootstrap resamples demonstrated minimal optimism. The optimism-corrected AUCs were 0.70 for prolonged ICU stay and 0.80 for in-hospital mortality, indicating limited overfitting.

Calibration was acceptable for both models, with optimism-corrected calibration slopes of 0.88 and 0.93 and Brier scores of 0.20 and 0.17, respectively (Fig. 3).

DISCUSSION

The present study suggests that prolonged ICU stay is determined primarily by the severity of physiological impairment present at ICU admission rather than by the admission diagnosis itself. By restricting the primary prediction model to variables available at ICU admission and directly comparing neurological and non-neurological patients within the same multidisciplinary ICU network, this study provides a clinically applicable approach for early risk stratification while minimizing bias introduced by time-dependent exposures. Although the two patient groups differed in their clinical characteristics and ICU utilization patterns, the principal baseline determinants of prolonged ICU stay were largely shared, indicating that overall illness severity outweighs disease category in predicting extended intensive care requirements. These findings extend previous prediction studies that have predominantly focused on either heterogeneous ICU populations or single disease categories by highlighting the importance of early physiological assessment across different critically ill populations (3, 9, 10, 19, 20).

Previous studies evaluating prolonged ICU stay have largely focused either on heterogeneous ICU populations or on disease-specific cohorts, particularly patients undergoing cardiac surgery, major trauma, or intracerebral hemorrhage, consistently demonstrating that illness severity, persistent organ dysfunction, and ongoing critical care requirements are the principal drivers of extended ICU utilization

rather than the underlying diagnosis itself. Our findings are consistent with this broader evidence while providing a direct comparison between neurological and non-neurological patients within the same multidisciplinary ICU network. Although neurological patients are commonly perceived as requiring longer intensive care because of impaired consciousness and delayed neurological recovery, they experienced shorter ICU stays and were less likely to require prolonged hospitalization in our cohort. In contrast, non-neurological patients exhibited greater systemic physiological derangement, reflected by more severe organ dysfunction, lower serum albumin concentrations, and higher in-hospital mortality, suggesting a greater burden of critical illness. These observations indicate that disease-specific differences exist, but their influence is largely mediated by the severity of physiological impairment rather than by the admission diagnosis itself. By directly comparing these two major ICU populations under similar organizational conditions, our study extends previous prediction research and supports the concept that baseline physiological status should remain the cornerstone of early ICU LOS prediction models (3, 9–11, 19–21).

Among the admission variables evaluated, neurological status assessed by the GCS emerged as the strongest predictor of prolonged ICU stay. This finding is consistent with previous studies showing that simple bedside measures of illness severity often outperform individual laboratory biomarkers in predicting ICU LOS. Impaired consciousness may prolong ICU dependency by delaying neurological recovery and increasing the need for close monitoring and organ support. After multivariable adjustment, SOFA score, medical admission, and NLR were no longer independent predictors, suggesting that these variables reflect overlapping aspects of baseline physiological impairment. Similarly, the inverse association observed for diabetes mellitus should be interpreted cautiously, as it is more likely to reflect case-mix differences or residual confounding than a true protective effect. Overall, these findings support the use of neurological assessment together with established severity scores for early identification of patients at risk for prolonged ICU stay (3, 10, 15, 16, 19–23).

An important methodological strength of the present study was the deliberate restriction of the primary prediction model to variables available at the time of ICU admission. Many previous studies investigating prolonged ICU stay have incorporated interventions or events occurring during the ICU course, such as mechanical ventilation, tracheostomy, renal replacement therapy, or ICU-acquired complications, as predictors of prolonged hospitalization. Although these variables are strongly associated with extended ICU utilization, they represent consequences of the evolving clinical course rather than baseline patient characteristics. Including such post-baseline variables in admission prediction models may introduce reverse causation and immortal-time bias, thereby limiting the interpretability and clinical applicability of the results. By focusing exclusively on admission variables, our model enables risk stratification at the point when clinical decisions regarding resource allocation, treatment planning, and patient monitoring are first made. This approach is consistent with contemporary methodological recommendations for developing and reporting clinical prediction models and provides a pragmatic framework for early identification of patients at risk for prolonged ICU stay. Future prospective multicentre studies incorporating longitudinal statistical approaches, including landmark analyses, multi-state models, and

dynamic prediction modelling, are warranted to better characterize the evolution of persistent critical illness over time (3, 19–21, 24–27).

Beyond prolonged ICU stay, our study identified several baseline and in-hospital factors associated with in-hospital mortality, reinforcing the concept that adverse outcomes in critical illness are primarily driven by the cumulative burden of physiological dysfunction rather than by the admission diagnosis alone. The independent associations of older age and higher admission SOFA score are consistent with their established roles as robust indicators of limited physiological reserve and early organ dysfunction across diverse ICU populations. Likewise, hypoalbuminemia remained independently associated with mortality, supporting its value as a marker of impaired nutritional status, systemic inflammation, and reduced physiological resilience in critically ill patients. In contrast, prolonged ICU stay and ICU-acquired complications should not be interpreted as causal determinants of mortality, as both represent time-dependent manifestations of persistent critical illness that evolve during hospitalization rather than baseline risk factors. These findings emphasize that early recognition of physiological severity at ICU admission, together with prevention of potentially avoidable ICU-acquired complications, remains central to improving patient outcomes while highlighting the importance of distinguishing baseline predictors from events occurring during the subsequent clinical course (14–16, 22–25, 28).

The present findings have several practical implications for critical care. Because the prediction model relies exclusively on variables routinely available at ICU admission, patients at increased risk for prolonged ICU stay can be identified before prolonged organ-support therapies or ICU-acquired complications develop. Early identification of these high-risk patients may facilitate individualized treatment planning, timely multidisciplinary involvement, proactive discharge planning, and more efficient allocation of critical care resources. Rather than replacing clinical judgment, admission-based prediction models may complement routine bedside assessment by supporting objective risk stratification during the earliest phase of critical illness (3, 19, 20, 23, 24, 28).

This study has several strengths, including a relatively large cohort of critically ill patients admitted to five multidisciplinary ICUs over a five-year period, enabling direct comparison of neurological and non-neurological populations within the same institutional setting. By restricting the prediction model to variables available at ICU admission, the study provides a clinically applicable framework for early risk stratification while minimizing bias related to time-dependent exposures. Methodological robustness was supported by internal validation, assessment of discrimination and calibration, and appropriate multivariable modelling. Nevertheless, several limitations should be acknowledged. The retrospective single-center design may limit generalizability, and restricting the cohort to patients with ICU stays of at least five days may have introduced survivor-selection bias by excluding patients with early death or rapid recovery. Residual confounding from unmeasured factors, including frailty, premorbid functional status, treatment limitations, and rehabilitation practices, cannot be excluded. Prospective multicenter studies with external validation are required before routine clinical implementation.

CONCLUSION

Among variables available at ICU admission, prolonged ICU stay was independently associated with a lower admission GCS score and the absence of diabetes mellitus; a higher SOFA score, medical (non-surgical) admission and a higher neutrophil-to-lymphocyte ratio showed only borderline associations. These determinants were largely shared between neurological and non-neurological patients, suggesting that baseline disease severity rather than diagnostic category is the principal driver of prolonged ICU utilization. Older age, higher SOFA score, and hypoalbuminemia were independently associated with in-hospital mortality, whereas prolonged ICU stay and ICU complications appeared to reflect sustained critical illness rather than baseline mortality predictors. Early identification of high-risk patients using routinely available admission variables may facilitate individualized clinical management, optimize ICU resource allocation, and support timely discharge planning. External multicentre validation is warranted before this model can be implemented in routine ICU practice.

Abbreviations

APACHE II
Acute Physiology and Chronic Health Evaluation II
CAR
CRP-to-albumin ratio
CI
confidence interval
CRP
C-reactive protein
EPV
events-per-variable
GCS
Glasgow Coma Scale
ICU
intensive care unit
IQR
interquartile range
LOS
length of stay
NLR
neutrophil-to-lymphocyte ratio
OR
odds ratio
PLR
platelet-to-lymphocyte ratio
SII
systemic immune-inflammation index

SIRI
systemic inflammation response index
SOFA
Sequential Organ Failure Assessment

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Scientific Research Ethics Committee of Giresun Training and Research Hospital (Approval date: 17 September 2025; Decision No: 07). Given the retrospective nature of the study and the use of anonymized routinely collected clinical data, the Ethics Committee waived the requirement for informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Y.Ş. conceived and designed the study. Y.Ş., A.M., A.T.G. contributed to data collection. Y.Ş. performed the statistical analysis and interpreted the data. Y.Ş. drafted the manuscript. A.M., A.T.G. critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

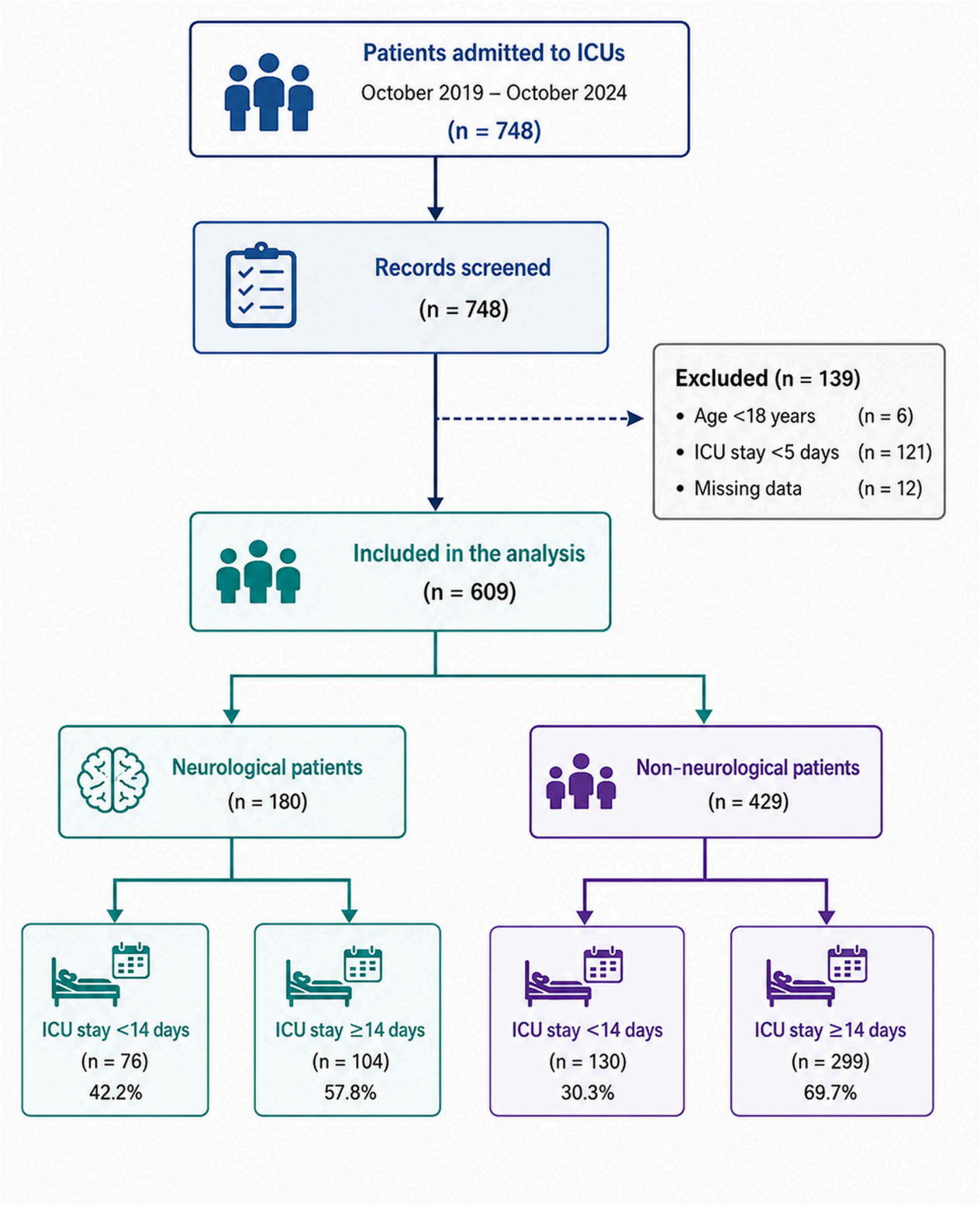


Figure 1

Flow diagram of the study cohort selection. A total of 748 ICU admissions between October 2019 and October 2024 were screened. Patients younger than 18 years (n=6), those with an ICU stay of fewer than 5 days (n=121), and those with missing data (n=12) were excluded. The final cohort comprised 609 patients, including 180 neurological and 429 non-neurological patients.

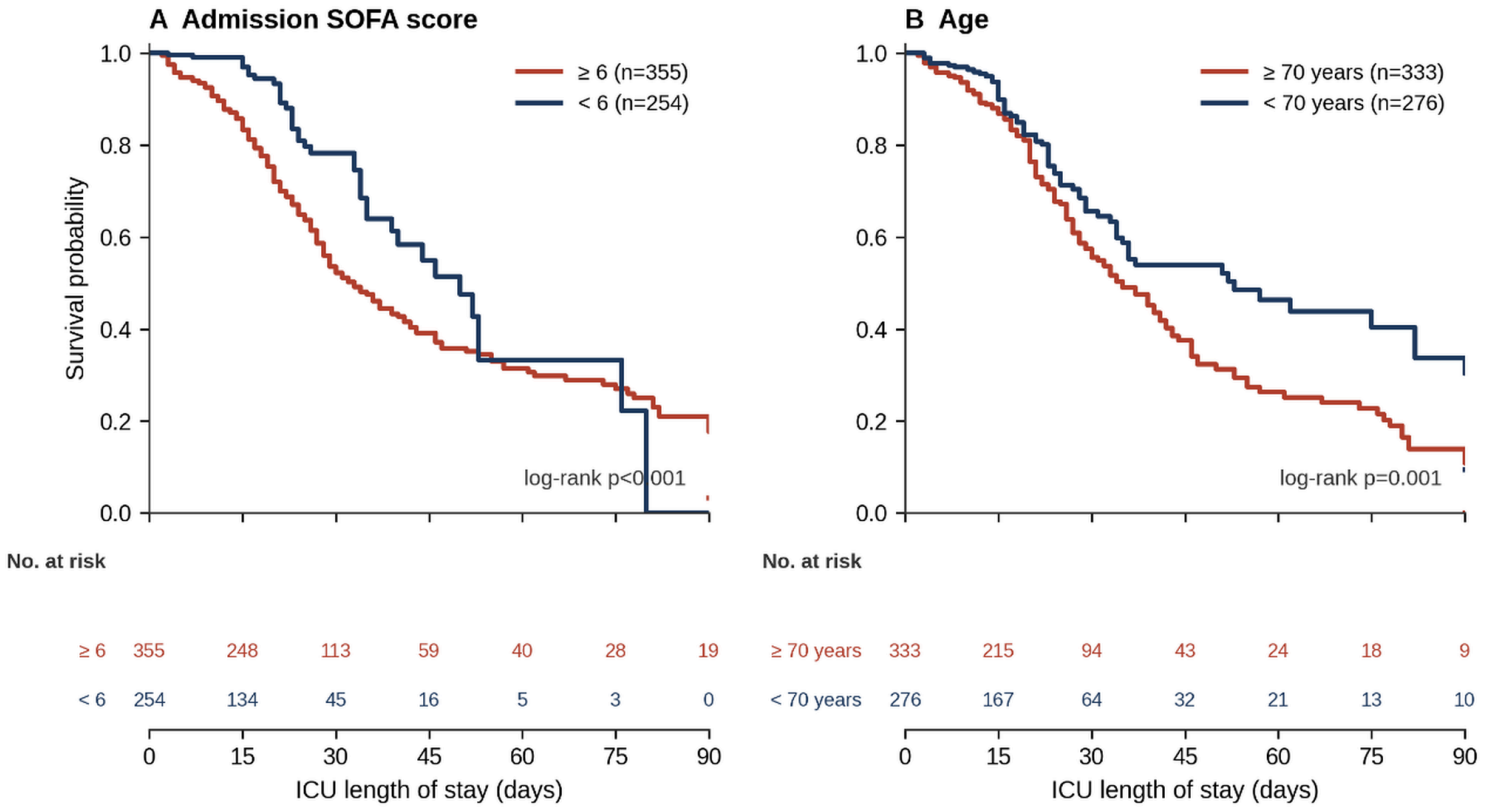


Figure 2

Kaplan–Meier survival curves for in-hospital mortality according to admission SOFA score (≥6 vs <6) (A) and age (≥70 vs <70 years) (B). The time axis represents ICU length of stay (days), the event was in-hospital death, and patients discharged alive were censored at the time of discharge. Because prolonged ICU stay (≥14 days), mechanical ventilation (total ventilator-days) and tracheostomy are time-dependent exposures, survival analyses were stratified according to baseline characteristics available at admission rather than time-dependent variables to minimize immortal-time bias.

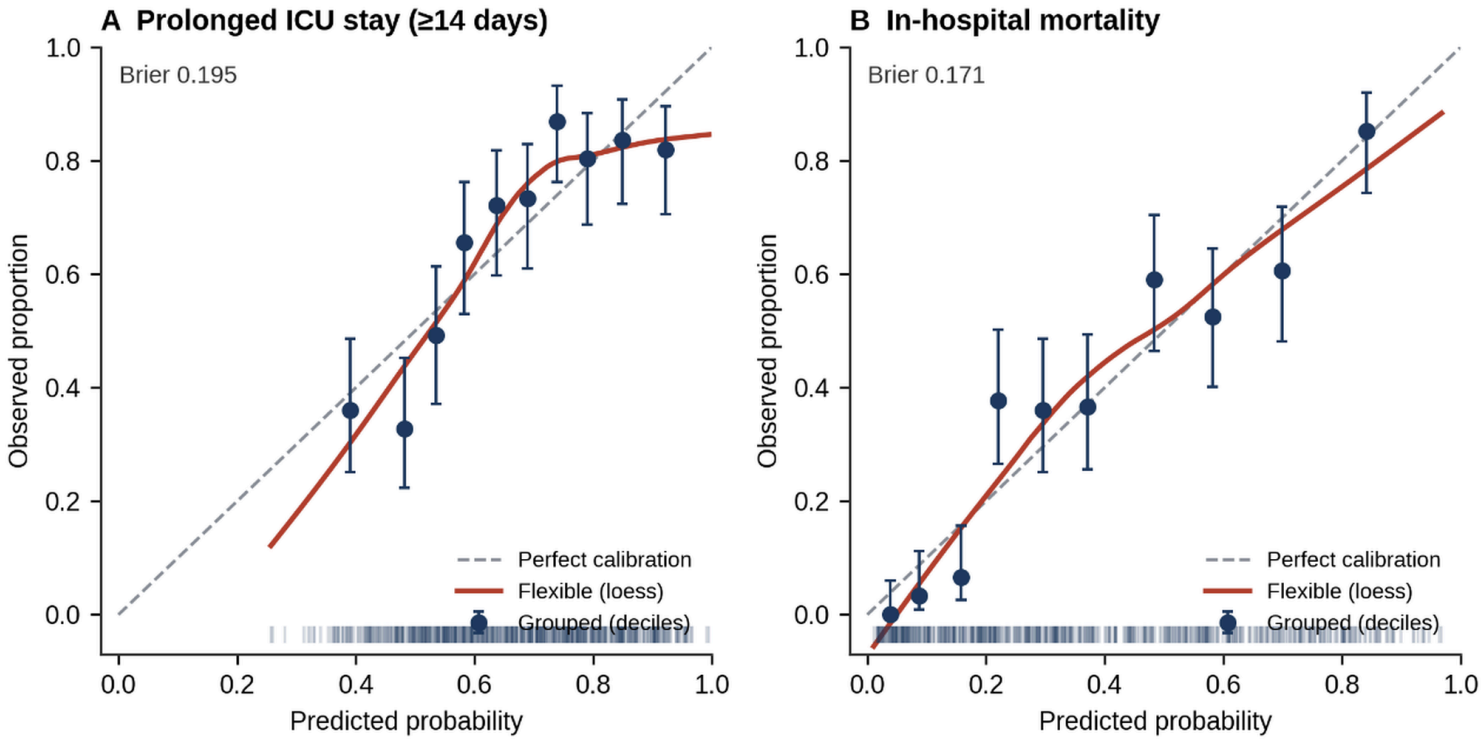


Figure 3

Calibration of the multivariable models for prolonged ICU stay (A) and in-hospital mortality (B). Points show observed proportions versus mean predicted probabilities grouped by tenths of predicted risk (with 95% confidence intervals); the solid line is a locally weighted (loess) smoother and the dashed line denotes perfect calibration. Brier scores, Hosmer–Lemeshow p values, and calibration slopes are annotated within each panel.