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Mortality Discrimination of SOFA-2 versus SOFA-1 in Older Patients with Sepsis: An Age- Stratified Single-Centre Cohort Study

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Research Article

Keywords: older adults, sepsis, SOFA-2, prognosis

Posted Date: November 1st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10993609/v1

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Additional Declarations: No competing interests reported.

Abstract

Objective

To compare the mortality discrimination of SOFA-2 and SOFA-1 across the ageing spectrum in older patients with sepsis, with particular attention to the oldest-old (aged ≥ 85 years), for ICU, 28-day, and 6-month mortality.

Methods

We conducted a retrospective, single-centre cohort study of consecutive patients aged ≥ 60 years with sepsis admitted to the ICU of the General Hospital of Southern Theater Command between 2020 and 2025. SOFA-1 and SOFA-2 were calculated at ICU admission. Discrimination for ICU, 28-day, and 6-month mortality was assessed using the area under the curve (AUC). Score changes between SOFA-1 and SOFA-2 were examined, and analyses were stratified by age (60–84 and ≥ 85 years). Within each age stratum, paired AUCs were compared using DeLong's test. To formally assess heterogeneity by age, differences in the change in AUC (ΔAUC = AUC_SOFA-2 − AUC_SOFA-1) between age strata were estimated; 95% confidence intervals were additionally evaluated using 5,000 stratified bootstrap resamples.

Results

Among 972 older patients with sepsis, 635 (65.3%) were aged ≥ 85 years. SOFA-2 assigned a different total score from SOFA-1 in 65.3% of patients, with scores decreasing in 45.7% and increasing in 19.6%. Overall, SOFA-2 showed higher discrimination than SOFA-1 for ICU mortality (AUC 0.699 vs. 0.667), 28-day mortality (0.719 vs. 0.695), and 6-month mortality (0.686 vs. 0.671; all $P < 0.05$). Among patients aged ≥ 85 years, SOFA-2 showed higher discrimination than SOFA-1 for ICU (0.714 vs. 0.676), 28-day (0.726 vs. 0.696), and 6-month mortality (0.689 vs. 0.668; all $P < 0.05$). In patients aged 60–84 years, higher discrimination was observed only for ICU mortality (0.710 vs. 0.684; $P < 0.05$), but not for 28-day (0.709 vs. 0.697) or 6-month mortality (0.692 vs. 0.685; both $P > 0.05$). Improvements in AUC were numerically greater in patients aged ≥ 85 years, but formal heterogeneity testing showed no statistically significant between-age-group differences in ΔAUC for ICU mortality (difference, 0.013; 95% CI, − 0.012 to 0.038; $P = 0.308$), 28-day mortality (0.018; 95% CI, − 0.005 to 0.041; $P = 0.128$), or 6-month mortality (0.014; 95% CI, − 0.008 to 0.036; $P = 0.214$).

Conclusions

SOFA-2 modestly improved mortality discrimination over SOFA-1 in older patients with sepsis. The improvement was statistically significant across all three mortality endpoints among patients aged ≥ 85

years, whereas only ICU mortality showed a significant improvement among those aged 60–84 years. Although improvements were numerically greater in the oldest-old, formal heterogeneity testing did not confirm a statistically significant difference in ΔAUC between age groups. These findings suggest, but do not establish, potential age-related heterogeneity in the prognostic performance of SOFA-2.

Background

Sepsis disproportionately affects older adults, with both incidence and mortality increasing markedly with advancing age[1–3]. Older patients with sepsis represent a distinct and highly vulnerable population characterized by reduced physiological and organ reserve, multimorbidity[4, 5], frailty[6], sarcopenia[7], and age-related alterations in immune and metabolic responses[8]. These changes may modify the clinical expression of acute organ dysfunction and its association with outcomes[9–11]. For example, reduced creatinine generation may underestimate the severity of kidney dysfunction, while pre-existing cardiopulmonary disease and limited cardiovascular reserve may alter tolerance to respiratory or circulatory failure. Consequently, conventional severity scores developed in mixed-age critically ill populations may not fully capture the prognostic significance of organ dysfunction in older adults, particularly in the oldest-old[12].

The Sequential Organ Failure Assessment (SOFA) score is widely used to quantify organ dysfunction and stratify risk in patients with sepsis[13–15]. However, the original SOFA score (SOFA-1), developed nearly three decades ago, does not fully reflect contemporary critical care practice or current organ-support strategies[16–18]. SOFA-2, introduced in 2025, updated organ-specific thresholds and incorporated contemporary respiratory, cardiovascular, and renal support[19]. Large-scale validation studies have demonstrated comparable or modestly improved mortality discrimination with SOFA-2 compared with SOFA-1[20–23]. Nevertheless, SOFA-2 was not specifically developed to account for the physiological characteristics of ageing, and whether its updated thresholds translate into improved prognostic assessment across the older population remains uncertain.

This question may be particularly relevant in the oldest-old (aged ≥ 85 years), who have the lowest physiological reserve, substantial comorbidity burden, and high vulnerability to sepsis-related organ dysfunction. Whether SOFA-2 better captures organ dysfunction and mortality risk in these patients has not been specifically established, and evidence regarding its ability to predict longer-term outcomes is limited. We therefore compared SOFA-2 with SOFA-1 for predicting ICU, 28-day, and 6-month mortality in older patients with sepsis and examined their performance across age strata, with particular attention to patients aged ≥ 85 years.

Methods

Study population

This retrospective, single-centre cohort study included consecutive older patients with sepsis admitted to the medical intensive care unit (MICU) of the General Hospital of Southern Theater Command between January 2020 and October 2025. Patients were stratified a priori into two age groups, 60–84 years and ≥ 85 years; the latter was operationally defined as the oldest-old subgroup to permit focused evaluation of SOFA-2 in patients of very advanced age.

Patients were eligible for inclusion if they (1) were aged ≥ 60 years and (2) met the Sepsis-3 criteria [4]. Patients were excluded if they (1) had an ICU length of stay < 24 h; (2) were discharged against medical advice or had life-sustaining treatment withdrawn during the ICU stay; or (3) had end-stage disease or advanced malignancy with a limited life expectancy. For patients with multiple ICU admissions during the same hospitalization, only the first ICU admission was included in the analysis to avoid correlated observations from the same patient. Detailed definitions of the exclusion criteria are provided in Supplementary Table 1.

Supplementary Table 1. Operational definitions of the exclusion criteria

Exclusion criterion	Operational definition
ICU length of stay < 24 h	Patients whose interval between ICU admission and ICU discharge or death was < 24 h were excluded. ICU length of stay was calculated from the recorded dates and times of ICU admission and ICU discharge or death.
Discharge against medical advice	Patients who left the hospital or ICU against medical advice before completion of the planned treatment, as documented in the medical record. This included patients for whom discharge was requested by the patient or family despite the treating physician's recommendation for continued inpatient care.
Withdrawal of life-sustaining treatment	Patients for whom one or more ongoing life-sustaining treatments were actively withdrawn because of a decision to limit further life-prolonging treatment, as documented in the medical record. Life-sustaining treatments included invasive mechanical ventilation, vasopressor or inotropic support, renal replacement therapy, or other organ-support therapies considered essential for sustaining life. Treatment withdrawal performed because an intervention was no longer clinically indicated after improvement was not classified as withdrawal of life-sustaining treatment for the purpose of this exclusion criterion.
End-stage disease	Patients with an irreversible advanced chronic disease documented before or at ICU admission and considered to be associated with a limited life expectancy independent of the acute episode of sepsis. This included end-stage heart, lung, liver, renal, or other major organ disease for which no definitive or disease-modifying treatment was considered feasible.
Advanced malignancy	Patients with a documented advanced malignant disease that was metastatic, unresectable, or otherwise considered incurable and associated with a limited life expectancy at the time of ICU admission. Patients with a history of malignancy that was in remission or considered potentially curable were not excluded on this basis.
Multiple ICU admissions during the same hospitalization*	Multiple ICU admissions were not considered an exclusion criterion at the patient level. When a patient had more than one ICU admission during the same hospitalization, only the first ICU admission was included in the analysis to avoid correlated observations from the same patient.

The study was conducted in accordance with applicable ethical standards and was approved by the Ethics Committee of the General Hospital of Southern Theater Command (approval no. 2026GJJ013). The requirement for informed consent was waived because of the retrospective nature of the study.

Data collection

Demographic, clinical, and outcome data were retrospectively extracted from the institutional electronic medical record system. Variables collected included age, sex, comorbidities, acute gastrointestinal injury (AGI) grade, Clinical Frailty Scale (CFS) score, modified Nutrition Risk in the Critically Ill (mNUTRIC) score, ICU length of stay, and the use of organ-support therapies, including invasive mechanical ventilation and continuous renal replacement therapy (CRRT).

SOFA-1 and SOFA-2 scores were calculated separately according to their respective published definitions using clinical and laboratory data obtained at ICU admission. The same assessment time point was used for both scoring systems.

The prespecified outcomes were ICU, 28-day, and 6-month all-cause mortality. ICU mortality was defined as death occurring before ICU discharge, whereas 28-day and 6-month mortality were defined as death from any cause within 28 and 180 days, respectively, after ICU admission. Six-month vital status was determined primarily through review of the institutional electronic medical records, as most patients continued to receive routine care or follow-up at our institution. For patients whose vital status at 180 days could not be determined from the electronic records, survival status was ascertained by telephone contact with the patient or their legally authorized representative. Follow-up commenced on the date of ICU admission. Vital status at 180 days was available for all included patients, with no loss to follow-up.

Statistical analysis

Continuous variables are presented as medians (interquartile ranges [IQRs]) and categorical variables as counts (percentages). Between-group comparisons were performed using the Wilcoxon rank-sum test for continuous variables and the χ^2 or Fisher's exact test, as appropriate, for categorical variables. Missingness was assessed for all study variables. Continuous covariates with a low proportion of missing data were imputed using the median. Variables required to calculate SOFA-1 and SOFA-2 were handled according to prespecified scoring rules. Outcome data were complete.

The distributions of SOFA-1 and SOFA-2 were examined, and ICU, 28-day, and 6-month mortality rates were calculated for each score, with 95% confidence intervals (CIs) estimated using the Clopper–Pearson exact method. Individual-level changes between SOFA-1 and SOFA-2 were assessed by classifying patients as having higher, unchanged, or lower SOFA-2 scores. Score discordance was defined as any difference between the two total scores.

To assess whether the relative prognostic performance of SOFA-2 varied with age, analyses were prespecified by age group (60–84 vs. ≥ 85 years), and AUCs were compared within each stratum using paired DeLong tests. The change in discrimination associated with SOFA-2 was quantified within each age stratum as ΔAUC (AUC_SOFA-2 − AUC_SOFA-1). To formally evaluate heterogeneity in the relative performance of SOFA-2 by age, the difference in ΔAUC between patients aged ≥ 85 years and those aged 60–84 years was estimated for each mortality endpoint, with 95% confidence intervals and P values for heterogeneity. As a sensitivity analysis, 95% confidence intervals for between-group differences in ΔAUC were additionally estimated using 5,000 stratified bootstrap resamples, with resampling performed within age strata. All tests were two-sided, with $P < 0.05$ considered statistically significant. Analyses were performed using R version 4.4.0 (R Foundation for Statistical Computing, Vienna, Austria), with ROC analyses conducted using the pROC package.

Results

Clinical Characteristics of Older Patients With Sepsis

During the study period, a total of 1,557 patients with sepsis were admitted. After exclusion, 972 patients were included, of whom 337 were aged 60–84 years and 635 were aged ≥ 85 years (Fig. 1). As shown in Table 1, the median age was 90 years (IQR, 78–94), ICU length of stay was 12 days (IQR, 7–22), and the median SOFA-1 and SOFA-2 scores were 9 (IQR, 6–12) and 9 (IQR, 6–11), respectively. Acute gastrointestinal injury (AGI) was present in 88% of patients, severe frailty (CFS ≥ 5) in 72%, and high nutritional risk (mNUTRIC ≥ 5) in 87.6%. Mechanical ventilation was used in 71% of patients, and continuous renal replacement therapy (CRRT) in 57%. ICU, 28-day, and 6-month mortality were 40%, 35%, and 58%, respectively.

Age-stratified analysis showed no statistically significant differences between the oldest-old group (≥ 85 years) and the 60–84-year group in SOFA-1 score, SOFA-2 score, and the proportions receiving mechanical ventilation or RRT ($P > 0.05$). However, the proportions with AGI, severe frailty, and high nutritional risk were significantly higher in the oldest-old group, as were ICU, 28-day, and 6-month mortality ($P < 0.05$).

Table 1
Characteristics of older patients with sepsis

Variable	Overall N = 972	Elderly (60–84 year) N = 337	Oldest old (≥ 85 year) N = 635	p-value
Age, median (IQR), year	90.0 (78.0, 94.0)	72.0 (66.0, 78.0)	93.0 (90.0, 95.0)	< 0.001
Male sex, n (%)	819 (84)	245 (73)	574 (90)	< 0.001
DM, n (%)	396 (41)	140 (42)	256 (40)	0.700
Hypertension, n (%)	669 (69)	217 (64)	452 (71)	0.036
CHD, n (%)	539 (55)	114 (34)	425 (67)	< 0.001
CHF, n (%)	413 (43)	122 (36)	291 (46)	0.005
CKD, n (%)	305 (31)	110 (33)	195 (31)	0.600
stroke, n (%)	343 (35)	106 (31)	237 (37)	0.080
COPD, n (%)	106 (11)	25 (7.4)	81 (13)	0.015
SOFA-1_total	9.0 (6.0, 12.0)	9.0 (6.0, 12.0)	9.0 (7.0, 12.0)	0.600
SOFA-2_total	9.0 (6.0, 11.0)	9.0 (6.0, 12.0)	9.0 (6.0, 11.0)	0.700
AGI, n (%)	858(88)	228(85)	570(90)	0.044
CFS ≥ 5, n (%)	700(72)	176(52)	524(82.5)	< 0.001
m-NUTRIC ≥ 5, n (%)	848(87.6)	256(76.7)	592(93.7)	< 0.001
MV, (%)	685 (71)	226 (67)	459 (73)	0.082
RRT, n (%)	551 (57)	192 (57)	359 (57)	0.900
7-day mortality, n (%)	119 (12)	40 (12)	79 (12)	0.900
ICU mortality, n (%)	393 (40)	76 (23)	317 (50)	< 0.001
28-day mortality, n (%)	345 (35)	101 (30)	244 (38)	0.011
6-month mortality, n (%)	566 (58)	156 (46)	410 (65)	< 0.001
Length of ICU stay, median (IQR), days	12.0 (7.0,22.0)	11.0 (6.0, 18.0)	14.0 (7.0, 25.0)	< 0.001

DM, Diabetes mellitus; CHD, Coronary Heart Disease; CHF, Chronic Heart Failure; CKD, Chronic Kidney Disease; COPD, Chronic Obstructive Pulmonary Disease; ICU, Intensive Care Unit; AGI, Acute Gastrointestinal Injury; CFS, Clinical Frailty Scale; m-NUTRIC, Modified Nutrition Risk in the Critically Ill; MV, Mechanical Ventilation; RRT, Renal Replacement Therapy.

Distribution of Total SOFA-1 and SOFA-2 Scores and ICU, 28-Day, and 6-Month mortality

With respect to total-score distributions, the SOFA-2 distribution was shifted to the left relative to SOFA-1, with its central tendency occurring in a lower score range. For ICU mortality, the cumulative mortality curve for SOFA-2 was smoother than that for SOFA-1, showing lower mortality in the low-score range and higher mortality in the high-score range. Thus, mortality increased progressively with the score, suggesting better risk discrimination by SOFA-2 in older patients with sepsis (Fig. 2). SOFA-2 similarly demonstrated good risk discrimination for short-term 28-day mortality (Fig. 3) and longer-term 6-month mortality (Fig. 4).

Changes in the Distribution of Organ-System and Total Scores From SOFA-1 to SOFA-2

The distribution of patients across scores for each organ system differed between SOFA-1 and SOFA-2. The most pronounced change occurred in the cardiovascular system: only 0.2% of patients received a score of 2 under SOFA-1, compared with 18.1% under SOFA-2. This change is attributable to the replacement of the previous 2-point criteria, which relied on low-dose dopamine or dobutamine, with a new threshold based on norepinephrine equivalent, resulting in a downgrade of some patients from a score of 3 to 2. Corresponding adjustments were also made in the score distributions of other organ systems. Overall, SOFA-2 exhibited a leftward shift, with an increased proportion of patients with lower scores, reflecting the systematic changes following the optimization of variable definitions and thresholds. For the total SOFA score, a higher proportion of patients fell within the lower-score categories under SOFA-2 (Fig. 5).

Relationship Between Score Changes From SOFA-1 to SOFA-2 and Mortality

Analysis of score changes showed that SOFA-2 scores were identical to SOFA-1 in 34.7% of patients, higher in 19.6%, and lower in 45.7%. ICU mortality for these three groups was 46%, 50.3%, and 32%, respectively (Fig. 6). The corresponding 28-day mortality rates were 38%, 46.6%, and 29.7%, and the 6-month mortality rates were 59.1%, 68.1%, and 53.4%, respectively.

Comparison of the Prognostic Performance of SOFA-1 and SOFA-2

Among older patients with sepsis, SOFA-2 showed higher discrimination than SOFA-1 in predicting ICU mortality (AUC, 0.699; 95% CI, 0.666–0.732 vs. AUC, 0.667; 95% CI, 0.633–0.701), 28-day mortality (AUC,

0.719; 95% CI, 0.685–0.753 vs. AUC, 0.695; 95% CI, 0.660–0.730), and 6-month mortality (AUC, 0.686; 95% CI, 0.653–0.719 vs. AUC, 0.671; 95% CI, 0.638–0.705) (all $P < 0.05$) (Fig. 7).

Subgroup Analysis: Comparison of the Prognostic Performance of SOFA-1 and SOFA-2

In the oldest-old sepsis subgroup (≥ 85 years), SOFA-2 demonstrated superior discrimination to SOFA-1 for ICU mortality (AUC, 0.714; 95% CI, 0.675–0.754 vs AUC, 0.676; 95% CI, 0.634–0.717), 28-day mortality (AUC, 0.726; 95% CI, 0.685–0.767 vs AUC, 0.696; 95% CI, 0.653–0.739), and 6-month mortality (AUC, 0.689; 95% CI, 0.648–0.731 vs AUC, 0.668; 95% CI, 0.626–0.711) (all $P < 0.05$; Fig. 8).

In patients aged 60–84 years, SOFA-2 outperformed SOFA-1 only for ICU mortality (AUC, 0.710; 95% CI, 0.647–0.773 vs AUC, 0.684; 95% CI, 0.619–0.749; $P < 0.05$), with comparable performance for 28-day mortality (0.709 vs 0.697) and 6-month mortality (0.692 vs 0.685) ($P > 0.05$).

Although the improvement in discrimination with SOFA-2 was numerically greater in patients aged ≥ 85 years across all three outcomes, formal tests of heterogeneity did not demonstrate statistically significant differences between age strata. The between-group differences in ΔAUC (≥ 85 years minus 60–84 years) were 0.013 (95% CI, − 0.012 to 0.038; P for heterogeneity = 0.308) for ICU mortality, 0.018 (95% CI, − 0.005 to 0.041; $P = 0.128$) for 28-day mortality, and 0.014 (95% CI, − 0.008 to 0.036; $P = 0.214$) for 6-month mortality. Stratified bootstrap analyses yielded similar 95% confidence intervals (− 0.012 to 0.038, − 0.004 to 0.041, and − 0.008 to 0.036, respectively).

Discussion

In this age-stratified cohort of older patients with sepsis, SOFA-2 modestly improved mortality discrimination compared with SOFA-1, while substantially changing the distribution of organ dysfunction scores. Three findings merit emphasis. First, SOFA-2 assigned a different total score to nearly two-thirds of patients, most commonly towards a lower score. Second, despite this overall downward shift, SOFA-2 showed better discrimination for ICU, 28-day, and 6-month mortality. Third, the pattern of within-stratum statistical significance differed across age strata: in patients aged ≥ 85 years, SOFA-2 consistently outperformed SOFA-1 across all three mortality endpoints, whereas in those aged 60–84 years, improvement was observed only for ICU mortality. However, formal heterogeneity testing did not confirm a statistically significant difference in ΔAUC between age groups.

Score changes with SOFA-2 and their prognostic implications

The transition from SOFA-1 to SOFA-2 resulted in substantial score changes in our cohort. SOFA-2 scores were lower in 45.7% of patients and higher in 19.6%, corresponding to an overall score-discordance rate of 65.3%. The magnitude of reclassification varies considerably across published cohorts, ranging from

approximately 10% to 75%[19, 22, 24], probably reflecting differences in case mix, illness severity, and patterns of organ support. Such variability highlights that the numerical consequences of adopting SOFA-2 are population dependent.

Importantly, the direction of score change was associated with clinically meaningful differences in outcome. Patients whose SOFA-2 score exceeded their SOFA-1 score had the highest ICU mortality (50.3%), whereas those whose score decreased had the lowest mortality (32%). A broadly similar direction of association has been reported in external validation studies[22]. This finding suggests that score changes with SOFA-2 are not merely a numerical consequence of revised thresholds and may redistribute patients in a manner associated with mortality risk. Conversely, the overall leftward shift in SOFA-2 scores should not be interpreted as indicating systematically lower illness severity. Rather, it reflects recalibration of organ dysfunction to contemporary critical care practice and organ-support strategies. This distinction is relevant when SOFA-2 is used for severity stratification, cohort definition, or comparison with historical SOFA-1 data.

The cardiovascular component contributed particularly to this redistribution. The proportion of patients assigned a cardiovascular score of 2 increased from 0.2% with SOFA-1 to 18.1% with SOFA-2, reflecting replacement of historical dopamine- and dobutamine-based criteria with thresholds based on norepinephrine equivalents. Together with revisions to other organ components, these changes shifted total SOFA-2 scores towards lower values while preserving, and modestly improving, mortality discrimination. This supports the rationale for updating organ dysfunction assessment to reflect contemporary patterns of critical care.

Prognostic performance in older patients with sepsis

SOFA-2 showed higher discrimination than SOFA-1 for ICU, 28-day, and 6-month mortality, although the absolute improvement was modest. The AUCs of SOFA-2 ranged from 0.686 to 0.719, broadly consistent with previous evaluations of SOFA-2 in sepsis populations[22, 25, 26], but lower than those reported in the original development and validation cohorts[19]. This difference is not unexpected. Our cohort had a median age of 90 years, substantial organ-support requirements, and high mortality, representing a population in whom prognosis is likely determined by factors extending beyond acute organ dysfunction alone. This point is particularly relevant in older patients with sepsis. Ageing is accompanied by declining physiological reserve, multimorbidity, frailty, sarcopenia, immunosenescence, and altered responses to acute illness. Consequently, a given degree of acute organ dysfunction may carry different prognostic implications at advanced age. In our cohort, patients aged ≥ 85 years had higher ICU, 28-day, and 6-month mortality than those aged 60–84 years despite similar SOFA scores and comparable use of mechanical ventilation and renal replacement therapy. They also had a greater burden of frailty, nutritional risk, and acute gastrointestinal injury. This apparent dissociation between measured acute organ dysfunction and observed mortality underscores the challenge of prognostication in the oldest-old.

Age-stratified performance of SOFA-2

The age-stratified findings represent an important observation of this study. Among patients aged ≥ 85 years, SOFA-2 consistently showed higher discrimination than SOFA-1 for ICU, 28-day, and 6-month mortality. In contrast, among patients aged 60–84 years, improved discrimination was confined to ICU mortality. The relative advantage of SOFA-2 may therefore be more apparent in the oldest-old, although the mechanisms underlying this observation remain uncertain. Several explanations are plausible. Patients of very advanced age have limited organ reserve and may be more vulnerable to relatively small physiological disturbances. At the same time, pre-existing organ impairment and age-related changes in physiological markers may alter the relationship between conventional thresholds and outcomes. By incorporating contemporary organ-support modalities and recalibrating organ-specific thresholds, SOFA-2 may better characterize acute organ dysfunction in this setting. However, these mechanisms remain speculative and require direct investigation.

Importantly, our findings should not be interpreted as establishing an age-dependent effect of SOFA-2. Although the improvement in AUC with SOFA-2 was numerically greater in patients aged ≥ 85 years for all three outcomes, formal heterogeneity testing did not show statistically significant between-age-group differences in ΔAUC. The differences in ΔAUC were 0.013 for ICU mortality, 0.018 for 28-day mortality, and 0.014 for 6-month mortality, with all 95% confidence intervals crossing zero and all *P* values for heterogeneity > 0.05. The bootstrap sensitivity analysis produced similar confidence intervals. Thus, the more consistent within-group statistical significance observed in the oldest-old should be regarded as a signal of potential heterogeneity rather than evidence that SOFA-2 confers a significantly greater discriminative improvement at age ≥ 85 years. Independent validation with greater power for interaction assessment is warranted.

The moderate discrimination of SOFA-2 in the oldest-old also highlights the limitations of organ dysfunction alone for prognostication in this population. Even among patients aged ≥ 85 years, AUCs remained approximately 0.69–0.73. In our cohort, 72% of patients had severe frailty, 87.6% were at high nutritional risk, and 88% had acute gastrointestinal injury, illustrating the multidimensional vulnerability of this population. Acute organ dysfunction therefore represents only one component of prognosis in the oldest-old. Frailty[27], nutritional reserve, pre-existing functional status, multimorbidity, and age-related biological vulnerability[28] may provide complementary prognostic information. Future studies should determine whether integrating these domains with SOFA-2 improves risk stratification beyond organ dysfunction alone[29].

Longer-term prognostic value

Our findings also extend the evaluation of SOFA-2 beyond short-term mortality. Six-month mortality was 58% in the overall cohort, highlighting the sustained vulnerability of older patients after sepsis. SOFA-2 showed higher discrimination than SOFA-1 for 6-month mortality overall and among patients aged ≥ 85 years, whereas no significant difference was observed in the 60–84-year group.

Of note, the absolute discrimination of SOFA-2 for 6-month mortality was similar between age groups, whereas the performance of SOFA-1 was lower in the oldest-old. Thus, the observed advantage of SOFA-

2 in patients aged ≥ 85 years may reflect preservation of discrimination at advanced age rather than a marked increase in the absolute predictive ability of SOFA-2 itself. This distinction is clinically relevant and avoids overinterpreting relatively small differences in AUC. Although acute organ dysfunction appears to retain prognostic information beyond the ICU stay, longer-term outcomes in older adults are influenced by multiple post-acute and baseline factors[30]. SOFA-2 should therefore be regarded as an acute organ dysfunction score with longer-term prognostic associations rather than as a comprehensive model for long-term outcome prediction.

Clinical implications and future directions

Our results have several implications. First, SOFA-2 appears to provide modestly improved risk discrimination in older patients with sepsis while substantially changing the distribution of severity scores. Direct numerical equivalence between SOFA-1 and SOFA-2 should therefore not be assumed, particularly when historical thresholds are used for clinical research, benchmarking, or trial eligibility. Second, the more consistent improvement observed among patients aged ≥ 85 years supports further age-specific validation of SOFA-2 in contemporary ICU populations. Third, the moderate discrimination of both scores reinforces the need to move beyond organ dysfunction alone when assessing prognosis in very old patients.

Dynamic assessment may offer one way to improve prognostication. Previous studies suggest that the relative performance of SOFA-2 changes over the course of critical illness and that trajectories of organ dysfunction provide information beyond a single baseline measurement[22, 31]. This may be particularly relevant in older patients, in whom limited physiological reserve could make the direction and persistence of organ dysfunction more informative than its initial severity alone. Future studies should therefore evaluate whether longitudinal SOFA-2 trajectories, combined with measures of frailty, nutritional status, and functional reserve, provide more clinically meaningful risk stratification in the oldest-old.

Strengths and limitations

A major strength of this study is its focus on older patients with sepsis, with substantial representation of patients aged ≥ 85 years, a rapidly growing but underrepresented population in critical care research. We evaluated both short- and longer-term outcomes and examined the consequences of the SOFA-2 update at the levels of score distribution, score discordance, and discrimination. Age-stratified analyses further allowed us to explore potential heterogeneity across the older age spectrum.

Several limitations should be acknowledged. First, the single-centre retrospective design may limit generalisability and is susceptible to residual confounding and measurement bias. Second, excluding patients in whom life-sustaining treatment was withdrawn may have introduced selection bias, particularly in the oldest-old, because treatment-limitation decisions may be related to frailty, comorbidity, goals of care, and prognosis. The number and characteristics of such excluded patients should therefore be considered when interpreting generalisability. Third, the 60–84-year subgroup was smaller than the ≥ 85-year subgroup, potentially limiting power to detect small differences in

discrimination. Fourth, although SOFA-2 statistically outperformed SOFA-1 for several outcomes, the absolute improvements in AUC were modest and should not be equated with a major improvement in individual-level prediction. Fifth, although formal heterogeneity testing was performed, the confidence intervals for between-age-group differences in ΔAUC included zero, and the smaller 60–84-year subgroup may have limited power to detect modest effect modification by age. Sixth, SOFA-2 assesses acute organ dysfunction but does not incorporate frailty, functional status, multimorbidity, or nutritional reserve, which are major determinants of outcome in older adults. Finally, our analysis was based on SOFA scores obtained at ICU admission; whether dynamic SOFA-2 assessment provides greater prognostic value in older patients requires further study and external validation.

Conclusions

SOFA-2 modestly improved mortality discrimination over SOFA-1 in older patients with sepsis while substantially changing the distribution of organ dysfunction scores. The improvement was statistically significant across ICU, 28-day, and 6-month mortality in patients aged ≥ 85 years, but was limited to ICU mortality in those aged 60–84 years. Although the improvements in AUC were numerically greater in the oldest-old across all three outcomes, formal heterogeneity testing did not demonstrate statistically significant differences in ΔAUC between age groups. These findings suggest, but do not establish, potential age-related heterogeneity in the prognostic performance of SOFA-2 and support further age-specific validation, particularly in the oldest-old.

Declarations

Consent for publication

All authors approved the final manuscript and consent to its publication.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the General Hospital of Southern Theater Command (No. 2026GJJ013), and informed consent was waived.

Declaration of competing interest

The authors declare that they have no competing interests.

Clinical trial number

Not applicable.

Funding

The work was performed as part of the authors' institutional roles using existing institutional resources. No commercial sponsorship, gifts, equipment, or drugs supported this work.

Author Contribution

Zhongqing Chen, Zhifeng Liu, and Lingling Wang: conception of the study, interpretation, and drafting of the manuscript.Yun Li and Zongfang Ren: data analysis and contribution to the manuscript. Youcheng Zeng, Chenxi Yang, Qian Liang, Yixin Zhang, Man Zhu, and Wang Xu: conduct of study and data curation.Zhenhui Guo: revision of the manuscript and supervision of the study. All authors reviewed the manuscript.

Acknowledgements

The authors would like to thank all patients who contributed data and clinicians who collected the data.

Data availability

The data sets used in the present study are available from the first author and corresponding authors on reasonable request.

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Figures

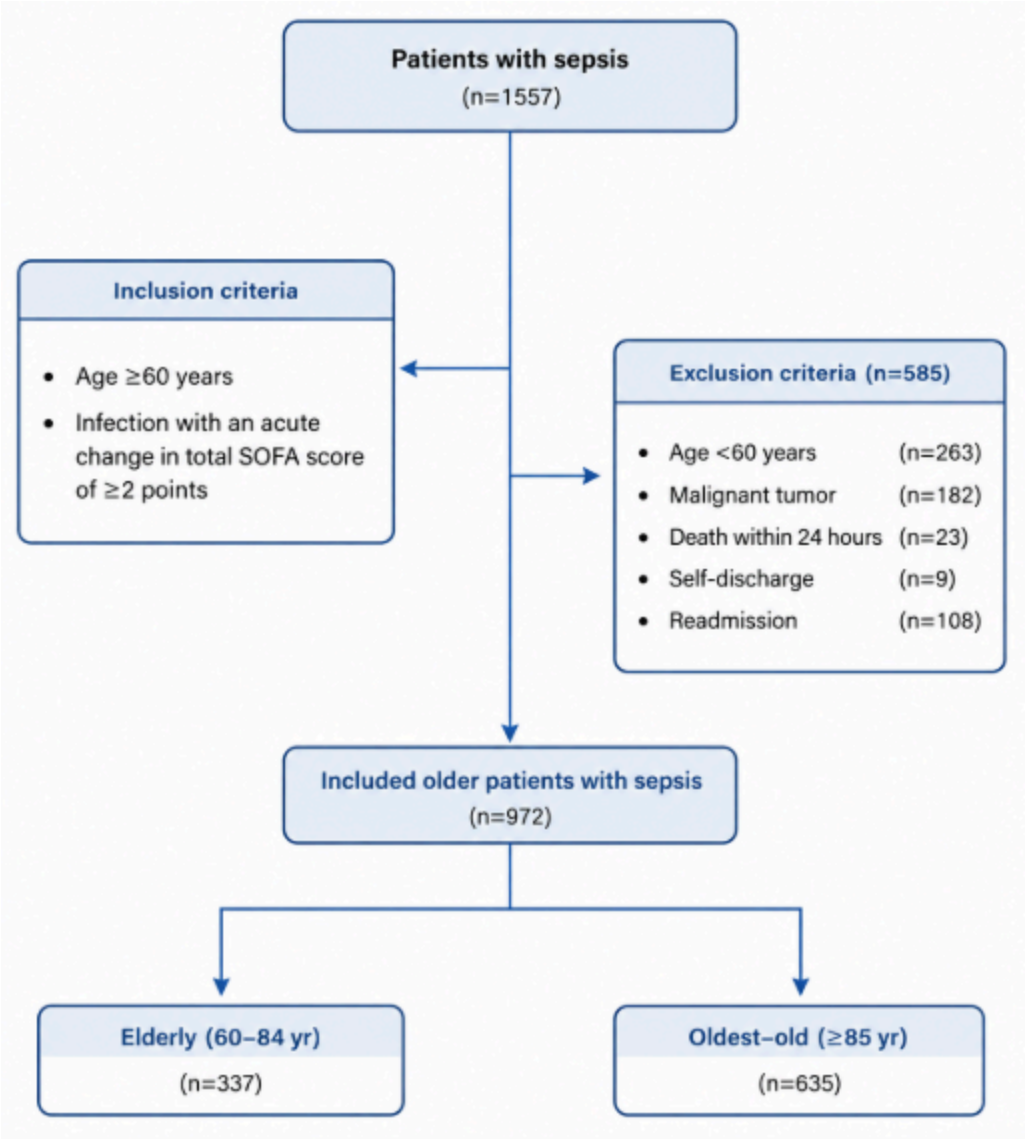


Figure 1

Study flow diagram

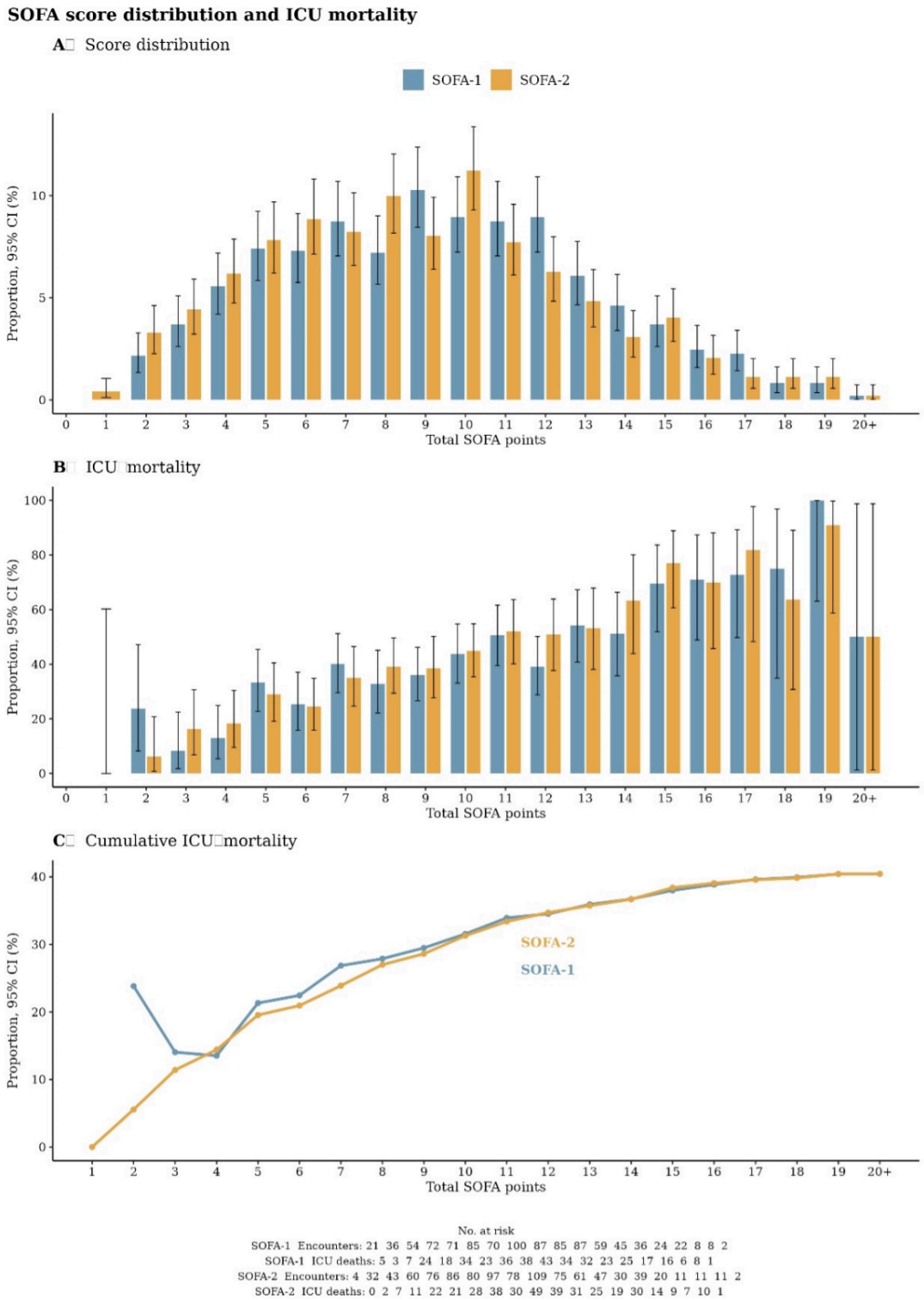


Figure 2

Distribution and ICU mortality for total SOFA-1 and SOFA-2

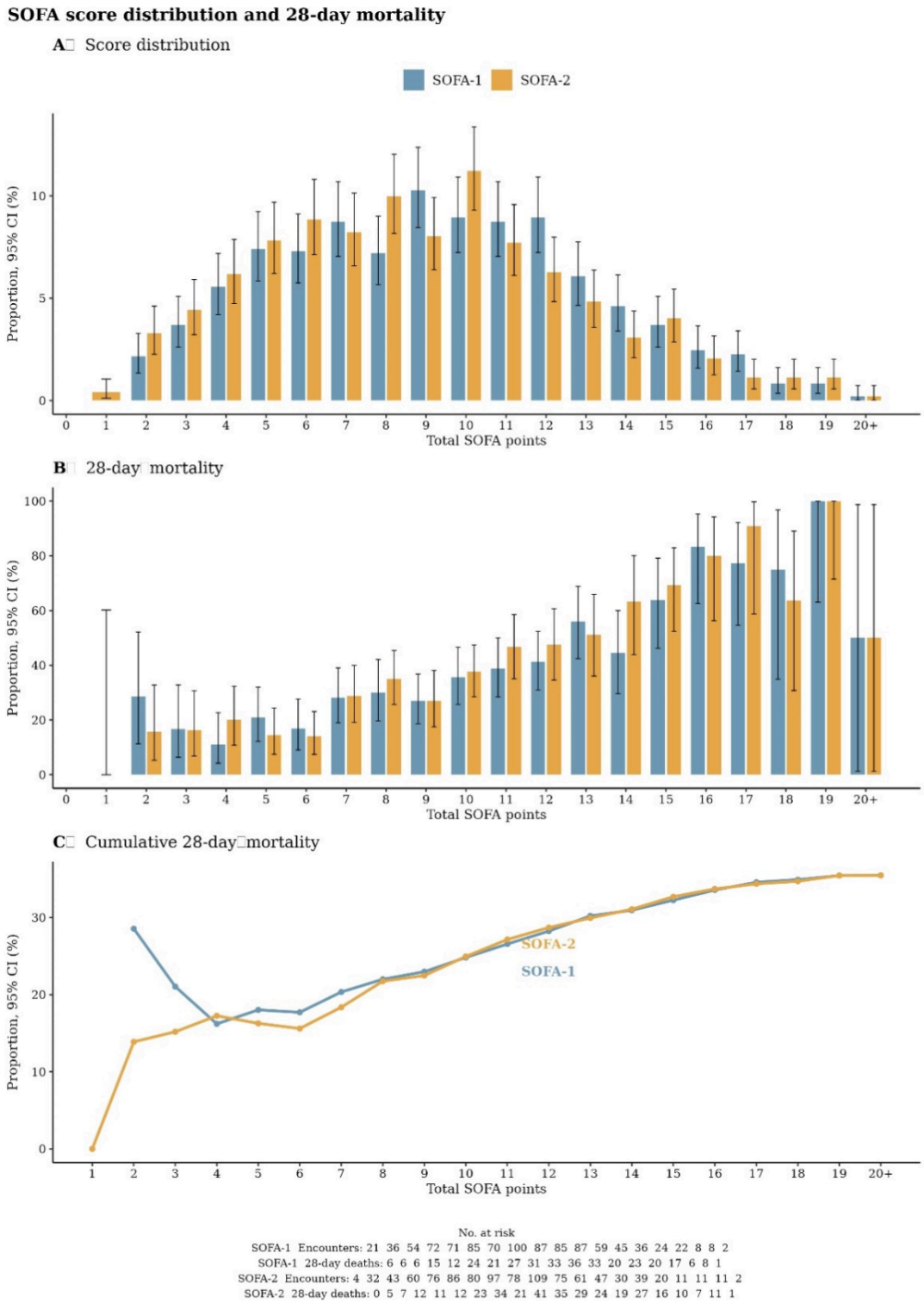


Figure 3

Distribution and day-28 mortality for total SOFA-1 and SOFA-2

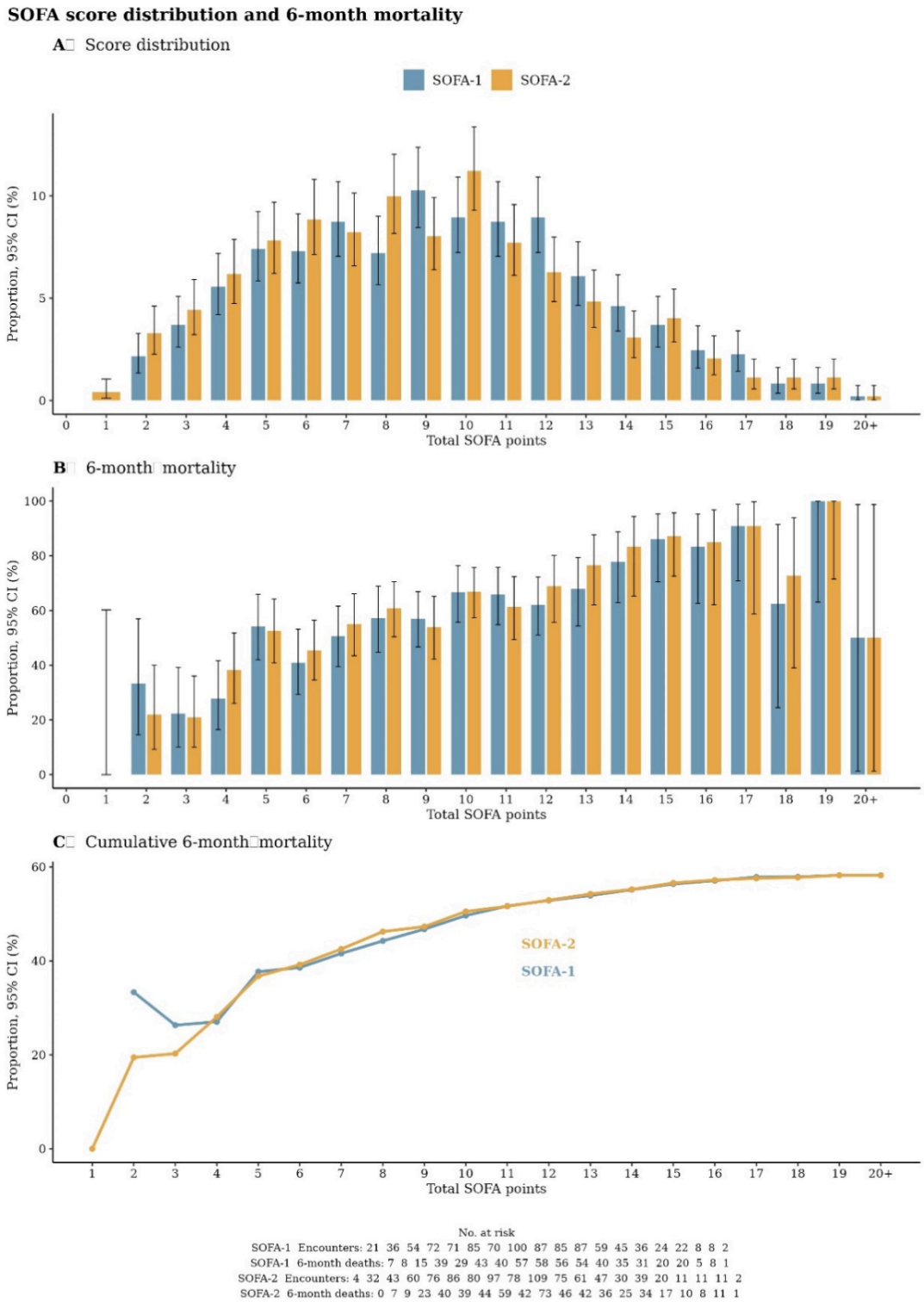


Figure 4

Distribution and 6-month mortality for total SOFA-1 and SOFA-2

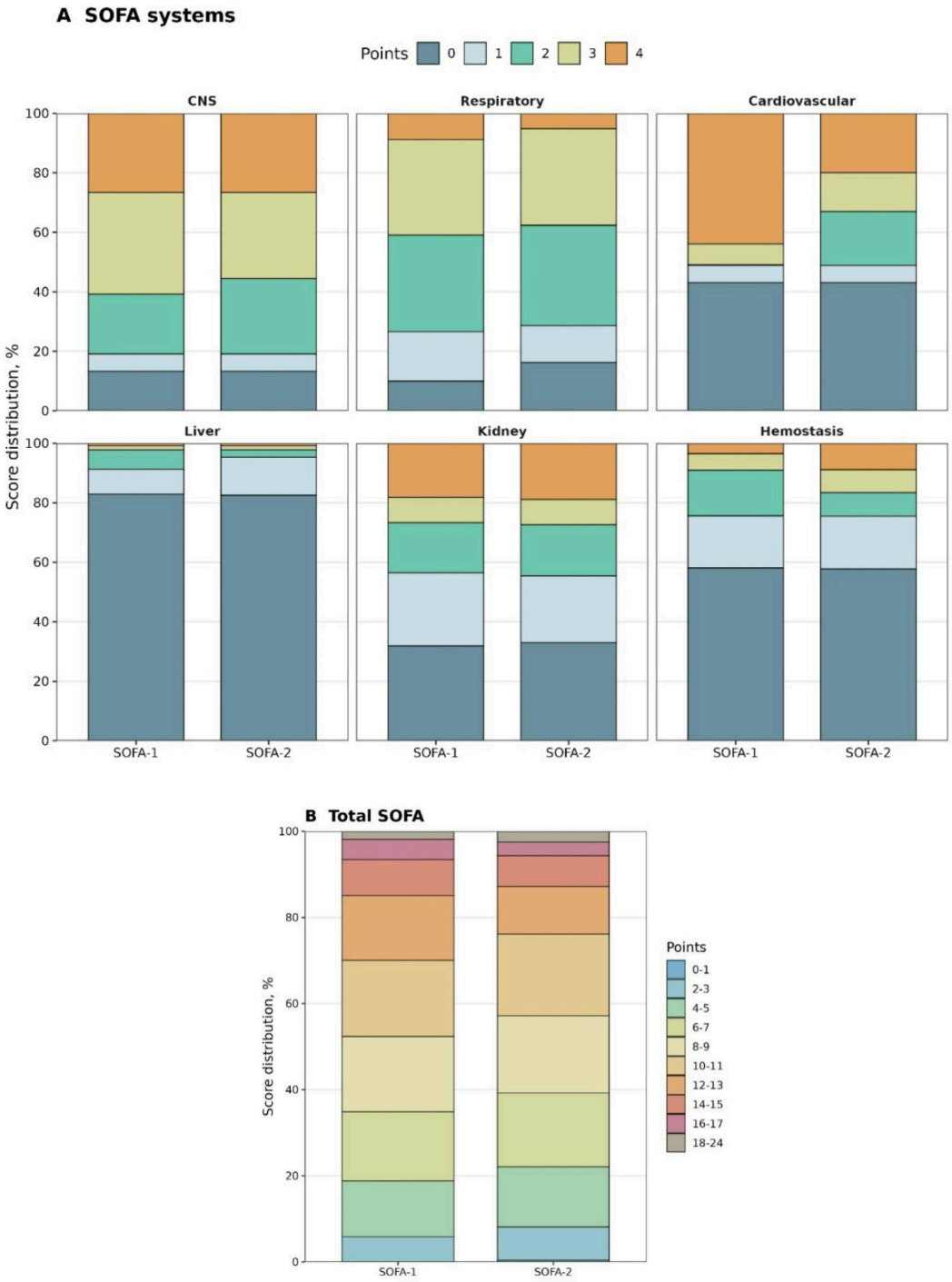


Figure 5

Distribution change from SOFA-1 to SOFA-2 systems and total scores

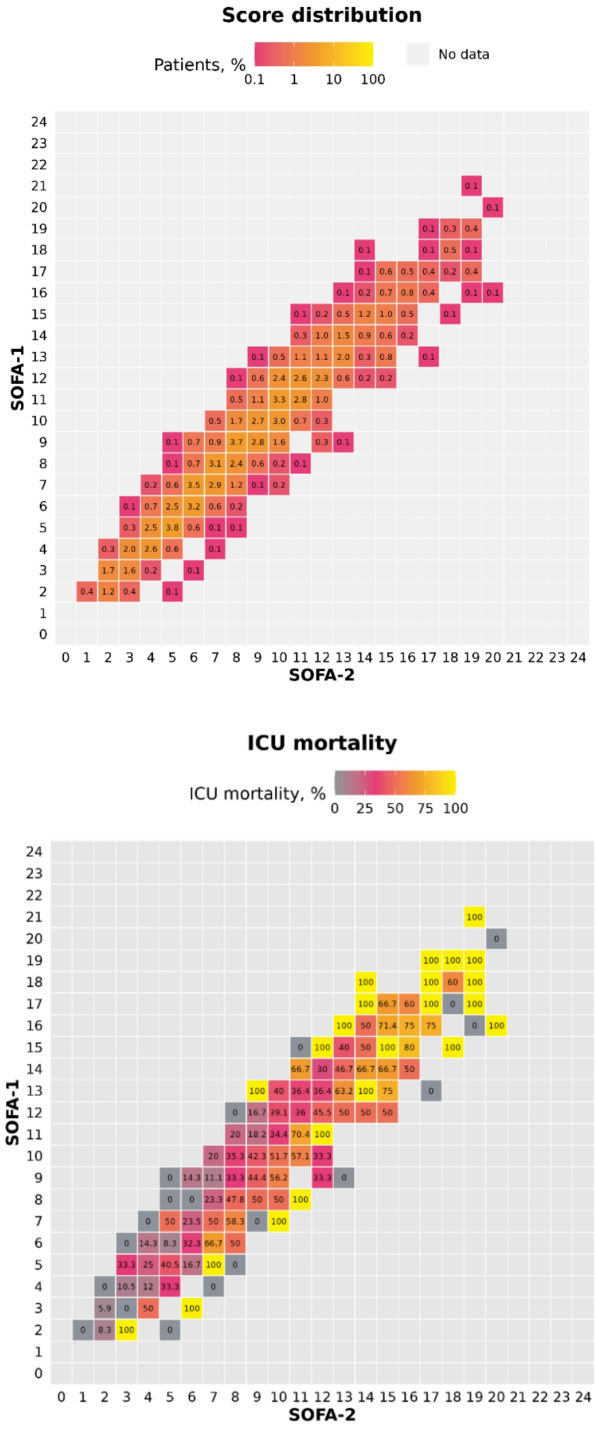


Figure 6

Reclassification for total SOFA-1 and SOFA-2

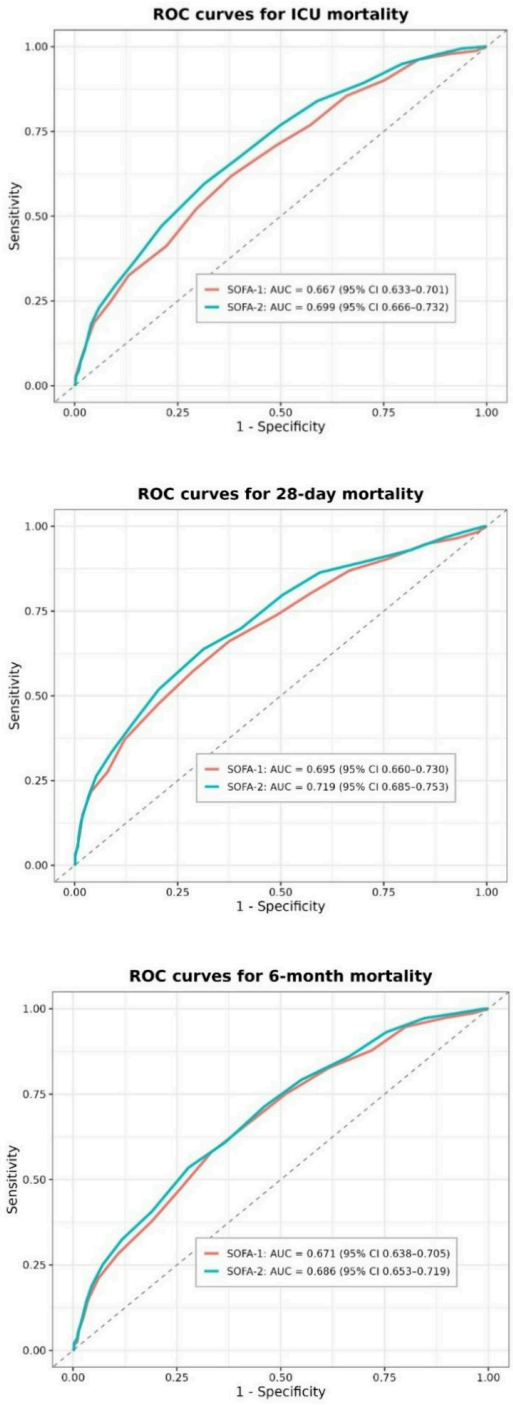


Figure 7

AUCs for ICU mortality, 28-day mortality, and 6-month mortality in all older patients with sepsis

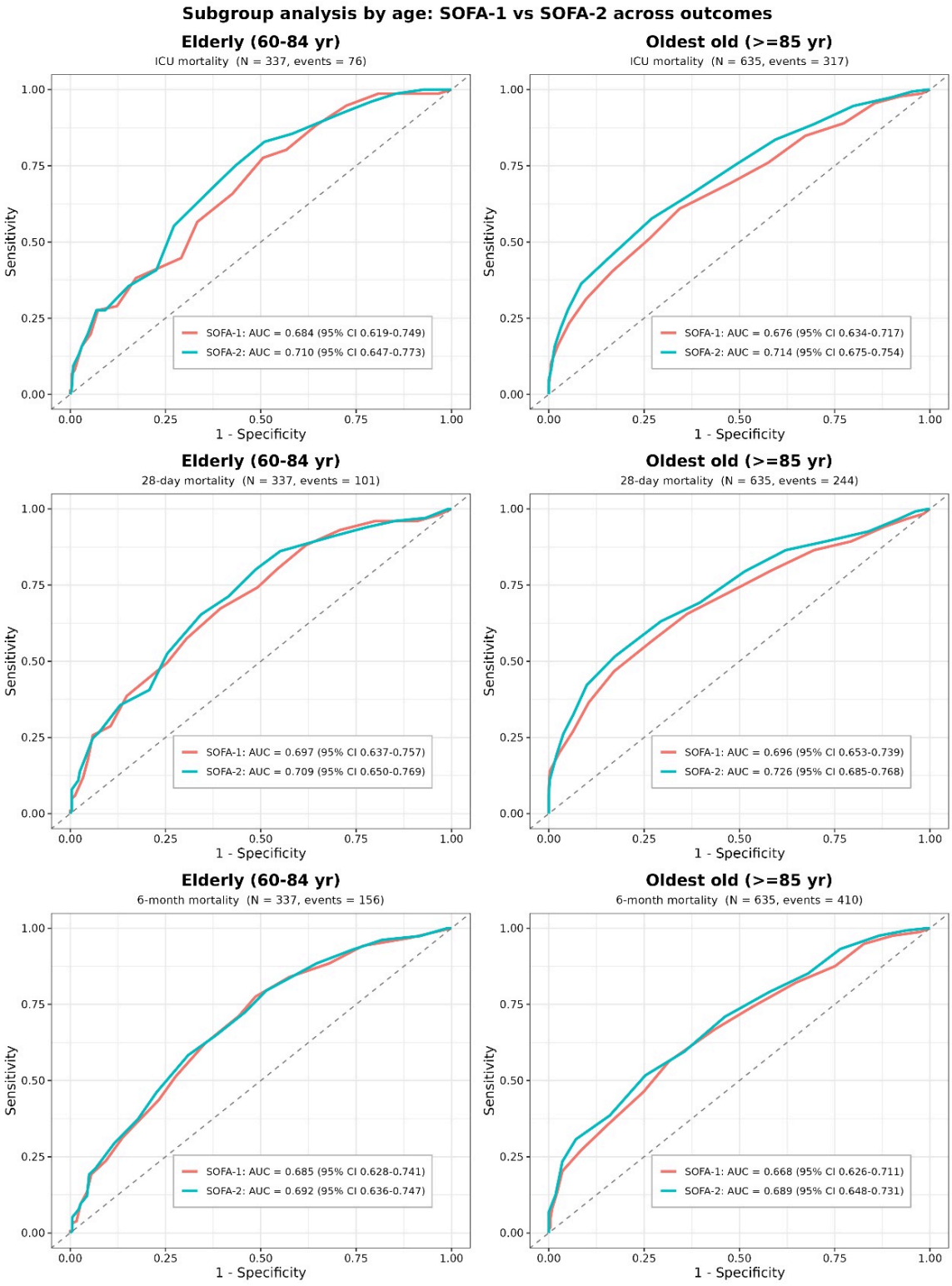


Figure 8

AUCs for ICU mortality, 28-day mortality, and 6-month mortality in elderly (60-84 yr) and oldest-old patients (≥85 yr) with sepsis