**Online Supplement**

**Pre-intubation SOFA Score as a Predictor of Short-term Mortality in COVID-19: External Validation using EHR from 86 U.S. Healthcare Systems**

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**eMethods** - Adaptation and Implementation of SOFA Score

The standard definition of original SOFA score was based on adding points from 6 different organ system areas according to Table 1 below.

**Table 1. SOFA Score.**

|  |  |
| --- | --- |
| Organ System | **SOFA Score** |
| Neuro | 1 - GCS score 13-142 - GCS score 10-123 - GCS score 6-94 - GCS score <6 |
| Cardiovascular | 1 – MAP (Mean Arterial Pressure) <70 mmHg2 - Dopamine ≤ 5 mcg/kg/min or Dobutamine (any dose)3 - Dopamine > 5 mcg/kg/min or Epinephrine ≤0.1 mcg/kg/min or Norepinephrine ≤0.1 mcg/kg/min4 - Dopamine > 15 mcg/kg/min or Epinephrine >0.1 mcg/kg/min or Norepinephrine >0.1 mcg/kg/min |
| Pulmonary | 1 - PaO2/FiO2 ratio 300-3992 - PaO2/FiO2 ratio 200-2993 - PaO2/FiO2 ratio 100-199 and mechanically ventilated4 - PaO2/FiO2 ratio <100 and mechanically ventilated |
| Renal | 1 - Creatinine 1.2-1.9 2 - Creatinine 2.0 - 3.43 - Creatinine 3.5 - 4.9 or urine output <500 cc/day4 - Creatinine >5.0 or urine output <200 cc/day |
| Hepatic | 1 - Bilirubin 1.2-1.92 - Bilirubin 2.0 - 5.93 - Bilirubin 6.0 - 11.94 - Bilirubin >12.0 |
| Coagulation | 1 - Platelets <1502 - Platelets <1003 - Platelets <504 - Platelets <20 |

We have adapted an EHR SOFA Score suggested previously by Rhee et al. (which is defined according to Table 2.), with a few modifications as described by organ system below.

**Table 2. Adapted EHR SOFA Score.**

|  |  |
| --- | --- |
| Organ System | **Adapted Version** |
| Neuro | 0 - GCS score 151 - GCS score 13-142 - GCS score 10-123 - GCS score 6-94 - GCS score <6 |
| Cardiovascular | 0 - MAP (Mean Arterial Pressure) >= 70 mmHg1 - MAP (Mean Arterial Pressure) <70 mmHg2 - Any dopamine, dobutamine, or phenylephrine 3 - Any norepinephrine or epinephrine 4 - Any two “concurrent” (on the same day) vasopressors (norepinephrine, epinephrine, vasopressin, phenylephrine, or dopamine) |
| Pulmonary | 0 - PaO2/FiO2 ratio >=400, or SaO2/FiO2 ratio >3011 - PaO2/FiO2 ratio 300- <400, or SaO2/FiO2 ratio 221-3012 - PaO2/FiO2 ratio <300 or SaO2/FiO2 ratio <2213 - PaO2/FiO2 ratio 100- <200 (or SaO2/FiO2 ratio 67 -141) and mechanically ventilated4 - PaO2/FiO2 ratio <100 (or SaO2/FiO2 ratio <67) and mechanically ventilated |
| Renal | 0 - Creatinine <1.21 - Creatinine 1.2-<2.0 2 - Creatinine 2.0 – <3.53 - Creatinine 3.5 – <5.0 (disregard urine output)4 - Creatinine >=5.0 (disregard urine output) |
| Hepatic | 0 - Bilirubin < 1.21 - Bilirubin 1.2- <2.02 - Bilirubin 2.0 – <6.03 - Bilirubin 6.0 – <12.04 - Bilirubin >=12.0 |
| Coagulation | 0 - Platelets >=1501 - Platelets 100- <1502 - Platelets 50-<1003 - Platelets 20-<504 - Platelets <20 |

Our adaptation replaces “missing” values in this algorithm with “0” (missing as normal) with some additional qualifiers. The SOFA score is computed as the sum of the scores determined for each of the 6 components. If any of the 6 components results in "Missing value", then the SOFA score for that day is set to "Missing value". Note that the Renal adaptation simply involves disregarding the urine output component (which is not always available in the EHR databases). The Cardiovascular criteria is adapted because exact vasopressor doses are not typically available. The Pulmonary criteria are extended to include SaO2/FiO2 ratios in place of PaO2/FiO2 ratios when the latter are unavailable. Also, note that an explicit score of zero has been defined for each of the components.

**Details of the Implementation**:

In the current study, daily SOFA score was computed using the *worst* scoring criteria for each individual component on each day (i.e., if there is a creatinine of 2 and a creatinine of 5.1 on a given day, that patient should receive 4 points for Renal dysfunction).

**Renal / Hepatic / Coagulation**

For creatinine, bilirubin, and platelets – we use the worst value per day (highest creatinine, highest bilirubin, lowest platelets). If there are no values available on a day, the closest value within 5 days looking *backward* was used. If there is no value within - 5 days, a value of 0 was assigned for the SOFA points for that component.

**Neuro**

For Glasgow Coma Scale (GCS), some encounters will have a score and some will not. For those that have a GCS score, we took the lowest value on a given day. That value is carried FORWARD until a new value is present on another day. If there are no other values during the hospitalization, that value is carried forward until the end of the encounter. If the first GCS score occurs later in the hospitalization, a 0 is assigned to GCS score for each day leading up to that day (i.e., it does not carry backwards). For encounters with no GCS scores, we assign 0 for each day.

**Cardiovascular**

For mean arterial pressure, this can either be directly given, or it may need to be calculated using the formula: Mean Arterial Pressure = (Systolic Blood Pressure + 2 x Diastolic Blood Pressure)/3. Note that the dosage criteria in the standard SOFA definition have been replaced by criteria that refer to which/how many vasopressor medications were administered on a given day.

**Pulmonary**

Mechanical ventilation is determined by presence of one of the relevant ICD-10 Procedure codes or presence of a LOINC code with description containing the word 'ventilator'.

Calculating PaO2/FiO2 ratios can be challenging since patients may not have both values available simultaneously. The following rules are utilized in order of precedence to derive the P/F ratio on a given day:

1. Simultaneous PaO2 and FiO2 on a given day: If PaO2 and FiO2 are measured simultaneously, compute their ratio as 'PF derived'. If a value for the Horowitz index is given, take that value as 'PF direct'. Combine 'PF derived' and 'PF direct' measurements on a given day and take the minimum value as the P/F ratio for that day.
2. Non-simultaneous PaO2 and FiO2 on a given day: If Rule 1 fails for a given day (there are no simultaneous PaO2 and FiO2 measurements and no Horowitz ratio), use the lowest PaO2 value and the lowest FiO2 value for that day and take the quotient as the P/F ratio.
3. Simultaneous SaO2 and FiO2 on a given day: If Rule 2 fails, use SaO2 and FiO2 values measured simultaneously and take the minimum value of the resulting ratio on the day (and use the Pulmonary criteria specified for SaO2/FiO2).
4. Non-simultaneous SaO2 and FiO2 on a given day: If Rule 3 fails, use the lowest SaO2 value and the lowest FiO2 value for that day and take the quotient as the SaO2/FiO2 ratio (and use the Pulmonary criteria specified for SaO2/FiO2).
5. Apply imputation rules: If the above rules 1-4 fail, employ the following imputation rules:
	* On a non-ventilation day:
		1. When the patient has a PaO2 or SaO2, but no FiO2:
			+ Use the closest FiO2 value from up to 5 days prior (during non-ventilation days)
			+ If none available, use 21% as default FiO2 value
		2. When the patient doesn’t have a PaO2 or SaO2 value:
			+ Assign 0 as the P/F ratio
	* On a ventilation day :
		1. When the patient has a PaO2 or SaO2, but no FiO2:
			+ Within the ventilation episode, use the closest FiO2 value from up to 5 days prior
			+ If none available, use 35% as default FiO2 value
		2. When the patient doesn’t have a PaO2 or SaO2 value:
			+ Within the ventilation episode, use the closest P/F ratio from up to 5 days prior
			+ If none available, assign 0 as the P/F ratio

**eMethods** - STROBE Statement—checklist of items that should be included in reports of observational studies

|  |  |  |
| --- | --- | --- |
|  | Item No | Recommendation |
| **Title and abstract** | 1 | (*a*) Indicate the study’s design with a commonly used term in the title or the abstract |
| (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| Introduction |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses |
| Methods |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| (*b*)*Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8\* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | Describe any efforts to address potential sources of bias |
| Study size | 10 | Explain how the study size was arrived at |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding |
| (*b*) Describe any methods used to examine subgroups and interactions |
| (*c*) Explain how missing data were addressed |
| (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed*Case-control study*—If applicable, explain how matching of cases and controls was addressed*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| (*e*) Describe any sensitivity analyses |

Continued on next page

|  |
| --- |
| Results |
| Participants | 13\* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| (b) Give reasons for non-participation at each stage |
| (c) Consider use of a flow diagram |
| Descriptive data | 14\* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| (b) Indicate number of participants with missing data for each variable of interest |
| (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15\* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| *Case-control study—*Report numbers in each exposure category, or summary measures of exposure |
| *Cross-sectional study—*Report numbers of outcome events or summary measures |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| (*b*) Report category boundaries when continuous variables were categorized |
| (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| Discussion |
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |
| Other information |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

**eMethods:**

Link to statistical code <https://github.com/wangj2727/EHR_SOFA>

**eMethods:**

**Evaluation of US State Adopted CSC Guidelines**

To understand the extent of integration of SOFA in real world policy and guidelines on ventilator allocation during crisis standards, we performed a cross-sectional analysis of state-adopted CSC guidelines to examine the prevalence of SOFA score utilization and the degree of its representation in current CSC models. One study investigator (M.K.) performed a search, on 3 separate dates between October 1st, 2021 and October 14th, 2021, for state adopted CDC guidelines providing guidance on triage of mechanical ventilation or scarce resources. As described in previous studies, keyword searches of the World Wide Web were performed using the search engine Google using the name of the state and either of the following search terms (PMID: 33270132) “Crisis Standards of Care”, “Crisis Standards of Care Guidelines”, “Crisis Standards of Care COVID-19” and “Crisis Standards of Care Ventilator Allocation”. The first 20 links available on the initial results page were reviewed. State adopted CSC guidelines were identified as those written by or in coordination with the state’s department of public health. CSC guidelines that were revoked or not written in coordination with the state’s department of health (i.e. those written by hospital associations were excluded. Any guidelines that directly mention COVID-19 or were written after March 1st, 2020, were deemed as “COVID-19 specific”. Next, we determined each CSC guideline’s level of reliance on the SOFA score and categorized them as follows:

1. No reliance on SOFA score
2. Low Reliance – The SOFA score is mentioned but not directly involved in the triage of mechanical ventilation or scarce resources.
3. Heavy Reliance – The patient’s SOFA score is either used alone or is a major component (defined as SOFA indicated as holding the greatest weight or SOFA used with one other variable) in assigning patients to priority tiers for the receipt of mechanical ventilation or scarce resources.

**Supplementary Index Table 1a: Logistic regression output for prediction of death among ventilated patients**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Variable** | **AUC (95% CI) using Derivation Cohort****(N=10085)** | **AUC (95% CI) using Validation Cohort****(N=5037)** | **Logistic Regression****Odds ratio (95% CI)c**  |
| SOFAa  | SOFA | 0.66 (0.65,0.67) | 0.66 (0.64,0.67) | 1.39 (1.35, 1.42) |
|  |
| Respiratory | Respiratory | 0.57 (0.56,0.58) | 0.58 (0.57,0.59) | 1.42 (1.35, 1.49) |
| Renal | Renal | 0.52 (0.52,0.53) | 0.51 (0.51,0.52) | 1.67 (1.49, 1.88) |
| Coagulation | Coagulation | 0.55 (0.54,0.55) | 0.54 (0.53,0.55) | 1.61 (1.49, 1.74) |
| Neurologic | Neurologic | 0.56 (0.56,0.57) | 0.57 (0.56,0.58) | 1.8 (1.67, 1.95) |
| Liver | Liver | 0.59 (0.58,0.6) | 0.58 (0.57,0.6) | 1.44 (1.38, 1.51) |
| Cardiovascular | Cardiovascular | 0.52 (0.52,0.53) | 0.52 (0.51,0.53) | 1.21 (1.13, 1.29) |
|  |
| SOFA categoriesb | >=6 & <9 | 0.55 (0.54,0.55) | 0.54 (0.54,0.55) | 3.42 (2.89, 4.06) |
| >=9 and <12 | 4.73 (3, 7.82) |
| >=12 | 5.89 (1.96, 25.32) |
|  |
| Six sofa components | Pulmonary  | 0.67 (0.66,0.68) | 0.67 (0.65,0.68) | 1.52 (1.44, 1.6) |
| Renal  | 1.47 (1.3, 1.67) |
| Heme | 1.45 (1.34, 1.58) |
| Neuro | 1.65 (1.53, 1.79) |
| Liver  | 1.39 (1.33, 1.45) |
| Cardio  | 1 (0.93, 1.08) |
|  |
| SOFA + covariatesd | SOFA | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.33 (1.29, 1.36) |
| Age | 1.06 (1.05, 1.06) |
| Gender (M vs. F) | 1.15 (1.05, 1.25) |
| Obesity | 0.92 (0.79, 1.08) |
| Diabetes | 1.18 (1.05, 1.32) |
| Hypertension | 0.84 (0.75, 0.93) |
| Six sofa components+ covariates | Pulmonary  | 0.75 (0.74,0.76) | 0.75 (0.73,0.76) | 1.49 (1.41, 1.58) |
| Renal  | 1.61 (1.42, 1.83) |
| Heme | 1.38 (1.27, 1.51) |
| Neuro | 1.34 (1.24, 1.46) |
| Liver  | 1.32 (1.26, 1.38) |
| Cardio  | 1.03 (0.95, 1.12) |
| Age | 1.06 (1.05, 1.06) |
| Gender (M vs. F) | 1.12 (1.03, 1.23) |
| Obesity | 0.92 (0.79, 1.08) |
| Diabetes | 1.19 (1.06, 1.33) |
| Hypertension | 0.83 (0.74, 0.93) |
|  |
| Age | Age | 0.71 (0.7,0.72) | 0.71 (0.69,0.72) | 1.06 (1.06, 1.06) |
| Age + SOFA Categories | Age | 0.73 (0.72,0.74) | 0.72 (0.71,0.73) | 1.06 (1.05, 1.06) |
| >=6 & <9 | 3.18 (2.67, 3.82) |
| >=9 and <12 | 4.92 (3.05, 8.3) |
| >=12 | 6.66 (2.13, 29.31) |
| Age + SOFA | Age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| SOFA | 1.33 (1.3, 1.36) |
| Age + elixhauser score | Age | 0.71 (0.7,0.72) | 0.71 (0.69,0.72) | 1.06 (1.05, 1.06) |
| elixhauser score | 1.03 (1.01, 1.06) |
|  |
| SOFA + elixhauser score | SOFA | 0.66 (0.65,0.67) | 0.66 (0.65,0.68) | 1.38 (1.35, 1.42) |
| elixhauser score | 1.04 (1.01, 1.07) |
| Categories SOFA + elixhauser score | >=6 & <9 | 0.57 (0.56,0.58) | 0.56 (0.55,0.58) | 3.33 (2.82, 3.96) |
| >=9 and <12 | 4.59 (2.91, 7.59) |
| >=12 | 5.75 (1.91, 24.76) |
| elixhauser score | 1.06 (1.03, 1.09) |
|  |
| SOFA + Age + elixhauser score | Age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| elixhauser score | 1 (0.97, 1.03) |
| SOFA | 1.33 (1.3, 1.36) |
| Pulmonary + Renal +Heme+ Neuro + Liver + Cardio + Age + elixhauser score | Renal  | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.62 (1.43, 1.84) |
| Pulmonary | 1.49 (1.41, 1.58) |
| Heme | 1.39 (1.27, 1.51) |
| Neuro | 1.35 (1.24, 1.46) |
| Liver  | 1.32 (1.26, 1.39) |
| Cardio  | 1.03 (0.95, 1.11) |
| Age | 1.06 (1.05, 1.06) |
| elixhauser score | 1 (0.98, 1.03) |

aSOFA and all components are the scores recorded within the 24 hours prior to the start of ventilation.

bVariable SOFA category is created based on SOFA variable with the cutoffs of:<6, >=6 & <9, >=9 and <12, and >=12. In the logistic regression model, sofa <6 is served as the reference group.

cOutcome variable has two levels: deceased and discharged, where discharged is served as the reference level.

dCovariates include age, gender, obesity, hypertension, and diabetes.

Supplementary Index Table 1b: **change in SOFA score from admission to intubation (24 hours prior to intubation) with mortality and at admission with mortality**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **AUC (95% CI) using Derivation Cohort** | **AUC (95% CI) using Validation Cohort** | **Logistic Regression****Odds ratio (95% CI)**  |
| sofa at admission | 0.62 (0.61,0.63) | 0.61 (0.60,0.63) | 1.27 (1.25, 1.30) |
| sofa change from admission to intubation | 0.53 (0.52,0.54) | 0.54 (0.52,0.55) | 1.10 (1.08, 1.13) |

## Supplementary Index Table 2a: Logistic regression model output excluding patients with end stage renal disease

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Variable** | **AUC (95% CI) Derivation Cohort****(N=9799)** | **AUC (95% CI)** **Validation Cohort****(N=4879)** | **Logistic Regression****Odds ratio (95%CI)c**  |
| SOFAa  | SOFA | 0.66 (0.65,0.67) | 0.66 (0.64,0.67) | 1.41 (1.37, 1.45) |
| SOFA categoriesb | >=6 & <9 | 0.54 (0.54,0.55) | 0.54 (0.53,0.54) | 3.57 (2.96, 4.34) |
| >=9 and <12 | 4.61 (2.82, 7.96) |
| >=12 | 17.71 (3.61, 319.7) |
| Age | age | 0.71 (0.7,0.72) | 0.71 (0.7,0.73) | 1.06 (1.05, 1.06) |
| Age + SOFA Categories | age | 0.73 (0.72,0.74) | 0.72 (0.71,0.74) | 1.06 (1.05, 1.06) |
| >=6 & <9 | 3.2 (2.62, 3.92) |
| >=9 and <12 | 4.7 (2.8, 8.3) |
| >=12 | 21.29 (4.19, 388.98) |
| Age + SOFA | age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| SOFA | 1.34 (1.3, 1.38) |
| SOFA + Age + Covariatesd | SOFA | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.33 (1.3, 1.37) |
| age | 1.06 (1.05, 1.06) |
| Gender (M vs. F) | 1.15 (1.05, 1.25) |
| Obesity | 0.92 (0.79, 1.08) |
| Diabetes | 1.18 (1.05, 1.33) |
| Hypertension | 0.82 (0.74, 0.92) |
| SOFA + Age + elixhauser score | age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| elixhauser score | 1 (0.97, 1.02) |
| SOFA | 1.34 (1.3, 1.38) |
| SOFA + elixhauser score | SOFA | 0.66 (0.65,0.67) | 0.66 (0.65,0.68) | 1.41 (1.37, 1.44) |
| elixhauser score | 1.04 (1.02, 1.07) |
| Categories SOFA + elixhauser score | >=6 & <9 | 0.56 (0.55,0.57) | 0.56 (0.54,0.57) | 3.53 (2.93, 4.29) |
| >=9 and <12 | 4.55 (2.78, 7.85) |
| >=12 | 17.45 (3.56, 315.21) |
| elixhauser score | 1.06 (1.03, 1.09) |

## Supplementary Index Table 2b: Logistic regression model output excluding patients with chronic kidney disease and end stage renal disease

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Variable** | **AUC (95% CI) Derivation Cohort****(N=9648)** | **AUC (95% CI)** **Validation Cohort****(N=4792)** | **Logistic Regression****Odds ratio (95%CI)c**  |
| SOFAa  | SOFA | 0.66 (0.65,0.67) | 0.66 (0.64,0.67) | 1.41 (1.37, 1.45) |
| SOFA categoriesb | >=6 & <9 | 0.54 (0.53,0.54) | 0.54 (0.53,0.54) | 3.48 (2.88, 4.24) |
| >=9 and <12 | 4.77 (2.88, 8.37) |
| >=12 | 17.79 (3.63, 321.16) |
| Age | age | 0.71 (0.7,0.72) | 0.71 (0.7,0.73) | 1.06 (1.06, 1.06) |
| Age + SOFA Categories | age | 0.73 (0.72,0.74) | 0.72 (0.71,0.73) | 1.06 (1.06, 1.06) |
| >=6 & <9 | 3.1 (2.53, 3.81) |
| >=9 and <12 | 4.88 (2.87, 8.76) |
| >=12 | 21.29 (4.19, 389.17) |
| Age + SOFA | age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| SOFA | 1.34 (1.3, 1.38) |
| SOFA + Age + Covariatesd | SOFA | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.33 (1.3, 1.37) |
| age | 1.06 (1.05, 1.06) |
| Gender (M vs. F) | 1.14 (1.04, 1.24) |
| Obesity | 0.93 (0.79, 1.09) |
| Diabetes | 1.17 (1.04, 1.31) |
| Hypertension | 0.84 (0.75, 0.94) |
| SOFA + Age + elixhauser score | age | 0.75 (0.74,0.76) | 0.74 (0.73,0.76) | 1.06 (1.05, 1.06) |
| elixhauser score | 1 (0.97, 1.03) |
| SOFA | 1.34 (1.3, 1.38) |
| SOFA + elixhauser score | SOFA | 0.66 (0.65,0.67) | 0.66 (0.64,0.67) | 1.41 (1.37, 1.45) |
| elixhauser score | 1.05 (1.02, 1.07) |
| SOFA Categories + elixhauser score | >=6 & <9 | 0.56 (0.55,0.57) | 0.55 (0.54,0.57) | 3.45 (2.86, 4.2) |
| >=9 and <12 | 4.71 (2.84, 8.26) |
| >=12 | 17.49 (3.57, 315.83) |
| elixhauser score | 1.06 (1.03, 1.09) |

## Supplementary Index Table 3a: Logistic Regression model excluding patients with SOFA scores imputed as zero

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Variable** | **AUC (95% CI) Derivation Cohort****(N=5910)** | **AUC (95% CI)** **Validation Cohort****(N=2979)** | **Logistic Regression****Odds ratio (95%CI)c**  |
| SOFAa  | SOFA | 0.67 (0.65,0.68) | 0.66 (0.64,0.68) | 1.4 (1.36, 1.45) |
| SOFA categoriesb | >=6 & <9 | 0.56 (0.55,0.56) | 0.55 (0.54,0.56) | 3.33 (2.72, 4.1) |
| >=9 and <12 | 4.57 (2.73, 8.15) |
| >=12 | 4.67 (1.52, 20.29) |
| Age | age | 0.71 (0.69,0.72) | 0.71 (0.69,0.73) | 1.06 (1.05, 1.06) |
| Age + SOFA Categories | age | 0.73 (0.71,0.74) | 0.72 (0.7,0.74) | 1.06 (1.05, 1.06) |
| >=6 & <9 | 3.1 (2.51, 3.86) |
| >=9 and <12 | 4.99 (2.9, 9.11) |
| >=12 | 5.63 (1.76, 25.06) |
| Age + SOFA | age | 0.75 (0.73,0.76) | 0.74 (0.72,0.76) | 1.06 (1.05, 1.06) |
|  | SOFA | 1.35 (1.3, 1.39) |
| SOFA + Age + Covariatesd | SOFA | 0.75 (0.74,0.76) | 0.74 (0.72,0.76) | 1.34 (1.3, 1.39) |
| age | 1.06 (1.05, 1.06) |
| Gender (M vs. F) | 1.13 (1.01, 1.27) |
| Obesity | 0.83 (0.67, 1.02) |
| Diabetes | 1.21 (1.04, 1.4) |
| Hypertension | 0.9 (0.78, 1.04) |
| SOFA + age + elixhauser score | age | 0.75 (0.73,0.76) | 0.74 (0.72,0.76) | 1.06 (1.05, 1.06) |
| elixhauser score | 1 (0.97, 1.04) |
| SOFA | 1.34 (1.3, 1.39) |
| SOFA + elixhauser score | SOFA | 0.67 (0.65,0.68) | 0.67 (0.65,0.69) | 1.4 (1.36, 1.45) |
| elixhauser score | 1.04 (1, 1.07) |
| Categories SOFA + elixhauser score | >=6 & <9 | 0.57 (0.56,0.59) | 0.57 (0.55,0.59) | 3.27 (2.67, 4.02) |
| >=9 and <12 | 4.46 (2.66, 7.95) |
| >=12 | 4.6 (1.5, 20) |
| elixhauser score | 1.05 (1.02, 1.09) |

## Supplementary Index Table 3b: Tree Based model excluding patients with SOFA scores imputed as zero

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **AUC (95% CI) using Derivation Cohort****(N=5910)**  | **AUC (95% CI) using Validation Cohort** **(N=2979)**  | **Variable selected by Tree models** |
| SOFA  | 0.644 (0.631,0.657) | 0.636 (0.618,0.654) | SOFA |
| SOFA categoriesb | 0.5 | 0.5 | None |
| Age | 0.696 (0.683,0.709) | 0.694 (0.676,0.712) | Age |
| Age + SOFA Categories | 0.696 (0.683,0.709) | 0.694 (0.676,0.712) | Age |
| Age + SOFA | 0.697 (0.684,0.71) | 0.692 (0.674,0.71) | Age, SOFA |
| SOFA + Age + Covariatesd | 0.697 (0.684,0.71) | 0.692 (0.674,0.71) | Age, SOFA |
| SOFA + Age + elixhauser score | 0.697 (0.684,0.71) | 0.692 (0.674,0.71) | Age, SOFA |
| SOFA + elixhauser score | 0.644 (0.631,0.657) | 0.636 (0.618,0.654) | SOFA |
| SOFA categories + elixhauser score | 0.524 (0.512,0.537) | 0.519 (0.501,0.536) | elixhauser score |

aSOFA and all components are the scores recorded within the 24 hours prior to the start of ventilation.

bVariable SOFA category is created based on SOFA variable with the cutoffs of:<6, >=6 & <9, >=9 and <12, and >=12. In the logistic regression model, sofa <6 is served as the reference group.

cOutcome variable has two levels: deceased and discharged, where discharged is served as the reference level.

dCovariates include age, gender, obesity, hypertension, and diabetes.

**Supplementary Index Table 4: Logistic Regression model excluding patients who had an ICD-10 code for Operating Room (OR) or other procedural indications on the same day as intubation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Variable** | **AUC (95% CI) Derivation Cohort****(N=9640)** | **AUC (95% CI)** **Validation Cohort****(N=4833)** | **Logistic Regression****Odds ratio (95%CI)c**  |
| SOFAa  | SOFA | 0.658 (0.647,0.668) | 0.657 (0.642,0.671) | 1.392 (1.357, 1.428) |
| SOFA categoriesb | >=6 & <9 | 0.548 (0.542,0.553) | 0.542 (0.534,0.55) | 3.448 (2.906, 4.11) |
| >=9 and <12 | 4.998 (3.075, 8.593) |
| >=12 | 5.355 (1.766, 23.134) |
| Age | age | 0.712 (0.702,0.722) | 0.711 (0.696,0.725)  | 1.059 (1.056, 1.063) |
| Age + SOFA Categories | age | 0.728 (0.718,0.738) | 0.723 (0.708,0.737) | 1.059 (1.055, 1.063) |
| >=6 & <9 | 3.228 (2.693, 3.887) |
| >=9 and <12 | 5.288 (3.171, 9.296) |
| >=12 | 5.991 (1.89, 26.583) |
| Age + SOFA | age | 0.748 (0.738,0.758) | 0.743 (0.729,0.757) | 1.056 (1.052, 1.06) |
| SOFA | 1.056 (1.052, 1.06) |
| SOFA + Age + Covariatesd | SOFA | 0.749 (0.74,0.759) | 0.744 (0.73,0.758) | 1.331 (1.296, 1.367) |
| age | 1.057 (1.053, 1.06) |
| Gender (M vs. F) | 1.143 (1.044, 1.252) |
| Obesity | 0.902 (0.77, 1.057) |
| Diabetes | 1.159 (1.032, 1.303) |
| Hypertension | 0.825 (0.738, 0.922) |
| SOFA + age + elixhauser score | age | 0.748 (0.738,0.758) | 0.743 (0.729,0.757) | 1.056 (1.052, 1.06) |
| elixhauser score | 1.056 (1.052, 1.06) |
| SOFA | 0.743 (0.729,0.757) |
| SOFA + elixhauser score | SOFA | 0.66 (0.649,0.671) | 0.661 (0.646,0.676) | 1.388 (1.353, 1.424) |
| elixhauser score | 1.031 (1.005, 1.058) |
| Categories SOFA + elixhauser score | >=6 & <9 | 0.564 (0.553,0.575) | 0.561 (0.546,0.577) | 3.375 (2.843, 4.025) |
| >=9 and <12 | 4.892 (3.008, 8.413) |
| >=12 | 5.302 (1.747, 22.911) |
| elixhauser score | 1.049 (1.023, 1.076) |

## Supplementary Index Table 5a: Tree model output

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **AUC (95% CI) using Derivation Cohort****(N=10085)** | **AUC (95% CI) using Validation Cohort****(N=5037)** | **Variable selected by Tree models** |
| SOFA  | 0.654 (0.644,0.665) | 0.655 (0.64,0.67) | SOFA |
| SOFA categoriesb | 0.5 | 0.5 | None |
| Age | 0.705 (0.695,0.715) | 0.701 (0.687,0.715) | Age |
| Age + SOFA Categories | 0.705 (0.695,0.715) | 0.701 (0.687,0.715) | Age |
| Age + SOFA | 0.72 (0.71,0.73) | 0.713 (0.698,0.727) | Age, SOFA |
| SOFA + Age + Covariatesd | 0.72 (0.71,0.73) | 0.713 (0.698,0.727) | Age, SOFA |
| SOFA + Age + elixhauser score | 0.72 (0.71,0.73) | 0.713 (0.698,0.727) | Age, SOFA |
| SOFA + elixhauser score | 0.654 (0.644,0.665) | 0.655 (0.64,0.67) | SOFA |
| SOFA categories + elixhauser score | 0.522 (0.513,0.532) | 0.52 (0.506,0.534) | elixhauser score |

## Supplementary Index Table 5b: Tree model output excluding patients with end stage renal disease

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **AUC (95% CI) using Derivation Cohort****(N=9799)**  | **AUC (95% CI) using Validation Cohort****(N=4879)**  | **Variable selected by Tree models** |
| SOFA  | 0.656 (0.646,0.666) | 0.656 (0.641,0.67) | SOFA |
| SOFA categoriesb | 0.5 | 0.5 | None |
| Age | 0.703 (0.693,0.713) | 0.696 (0.682,0.71) | Age |
| Age + SOFA Categories | 0.703 (0.693,0.713) | 0.696 (0.682,0.71) | Age |
| Age + SOFA | 0.719 (0.71,0.729) | 0.713 (0.699,0.727) | Age, SOFA |
| SOFA + Age + Covariatesd | 0.719 (0.71,0.729) | 0.713 (0.699,0.727) | Age, SOFA |
| SOFA + Age + elixhauser score | 0.719 (0.71,0.729) | 0.713 (0.699,0.727) | Age, SOFA |
| SOFA + elixhauser score | 0.656 (0.646,0.666) | 0.656 (0.641,0.67) | SOFA |
| SOFA categories + elixhauser score | 0.527 (0.518,0.537) | 0.524 (0.51,0.538) | elixhauser score |

## Supplementary Index Table 5c: Tree model output model excluding patients with chronic kidney disease and end stage renal disease

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **AUC (95% CI) using Derivation Cohort****(N=9648)**  | **AUC (95% CI) using Validation Cohort****(N=4792)**  | **Variable selected by Tree models** |
| SOFA  | 0.654 (0.643,0.664) | 0.652 (0.637,0.667) | SOFA |
| SOFA categoriesb | 0.5 | 0.5 | None |
| Age | 0.706 (0.696,0.716) | 0.7 (0.685,0.714) | Age |
| Age + SOFA Categories | 0.706 (0.696,0.716) | 0.7 (0.685,0.714) | Age |
| Age + SOFA | 0.726 (0.716,0.736) | 0.716 (0.701,0.73) | Age, SOFA |
| SOFA + Age + Covariatesd | 0.726 (0.716,0.736) | 0.716 (0.701,0.73) | Age, SOFA |
| SOFA + Age + elixhauser score | 0.726 (0.716,0.736) | 0.716 (0.701,0.73) | Age, SOFA |
| SOFA + elixhauser score | 0.654 (0.643,0.664) | 0.652 (0.637,0.667) | SOFA |
| SOFA categories + elixhauser score | 0.516 (0.508,0.524) | 0.509 (0.498,0.52) | elixhauser score |

## Supplementary Index Table 6: Summary of US States with CSC Protocols and Reliance on SOFA

|  |
| --- |
| **Supplementary Table 4:** Summary of US States with CSC Protocols and Reliance on SOFA |
| State | Degree of Reliance  | COVID specific?  | Comments |
| Alabama | N/A | No | No SOFA  |
| Alaska  | Low | Yes | SOFA considered but not instituted heavily in algorithm for triage\* |
| Arizona  | High – Major Criteria | Yes | Categorized SOFA + Points assigned based on clinical judgement of prognosis  |
| California | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| Colorado | High – Major Criteria | Yes | Categorized SOFA (most importance) + Clinician judgement of duration of benefit/need |
| Connecticut | N/A | No | No SOFA |
| Delaware | Low | Yes | SOFA considered but not instituted in algorithm for triage |
| Hawaii | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis based on co-morbidities  |
| Idaho | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis based on co-morbidities |
| Illinois  | N/A | Yes | No SOFA |
| Indiana | High – SOFA Alone | No | Categorized SOFA to assign into tiers |
| Iowa | Low | No | SOFA considered but not instituted in algorithm for triage  |
| Kansas | High – SOFA Alone | No | Categorized SOFA to assign into tiers |
| Kentucky | Low | Yes | SOFA considered but not instituted in algorithm for triage  |
| Louisiana | High – SOFA Alone | No | Categorized SOFA to assign into tiers |
| Maryland | High – Major Criteria | No | Categorized SOFA + Points assigned for severity of co-morbidities + Age  |
| Massachusetts | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis of long-term survival  |
| Michigan | High – Major Criteria | Yes | Categorized SOFA (most importance) + Clinician judgement of duration of benefit/need |
| Minnesota | Low | Yes | SOFA considered but not instituted in algorithm for triage  |
| Montana | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis based on co-morbidities |
| Nebraska | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis of 1 year survival based on comorbidities  |
| Nevada | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| New Hampshire  | N/A | Yes | No SOFA  |
| New Jersey | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| New Mexico | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis of 1 year survival based on comorbidities  |
| New York | High – SOFA Alone | No | Categorized SOFA to assign into tiers |
| North Carolina  | N/A | No | No SOFA |
| Oklahoma | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis based on co-morbidities |
| Pennsylvania | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis based on co-morbidities |
| Rhode Island | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| South Carolina | High – SOFA Alone | No | Categorized SOFA to assign into tiers |
| Tennessee | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| Utah | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| Vermont | High – SOFA Alone | Yes | Categorized SOFA to assign into tiers |
| Virginia | High – Major Criteria | Yes | Categorized SOFA + points assigned for prognosis of 6 month survival based on comorbidities  |
| Washington | Low | Yes | SOFA considered but not instituted in algorithm for triage  |

Supplementary Figure 1 – Density plot illustrating SOFA Score by re-admission

|  |  |
| --- | --- |
| Number Of Admission | Freq |
| 2 | 641 |
| 3 | 64 |
| 4 | 5 |
| 6 | 1 |



The median sofa was 2 for the 1st admission, and it is 2 for the 2nd and 2 for the 3rd admission as well. In order to illustrate the distribution of scores across admissions, we have constructed density plots below stratified by number of admissions. Two-sample t-test and Wilcoxon rank sum test didn’t detect any significant differences in admission SOFA score between the 1st and the 2nd, or between the 1st and the 3rd admission.

## Supplemental Figure 2: Calibration belts

