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Supplemental information

Performance of crisis standards of care guidelines in a cohort of critically ill COVID-19 patients in the United States

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Supplemental Information

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Study of the Treatment and Outcomes in critically ill Patients with COVID-19

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Table S1. STOP-COVID Investigators and Participating Sites

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Kings County Hospital Center
Lowell General Hospital
Massachusetts General Hospital
MedStar Georgetown University Hospital
Montefiore Medical Center
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Northwestern Memorial Hospital
Promedica Health System
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University of Chicago Medical Center
University of Illinois Hospital and Health Sciences System
University of Kentucky Hospital
University of Michigan Hospital
University of Oklahoma Health Sciences Center
West
Loma Linda University Medical Center
Mayo Clinic, Arizona
Oregon Health and Science University Hospital
Renown Health
Stanford Healthcare
University of California-Davis Medical Center
University of California-Los Angeles Medical Center
University of California-San Diego Medical Center
University of California-San Francisco Medical Center
UCHealth University of Colorado
University Medical Center of Southern Nevada
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Table S2. SOFA ("sSOFA") score calculation.
This study adapted standard SOFA scoring to the data in the clinical registry, as highlighted in Table S2A (grey). Since study sites typically utilized norepinephrine as the first vasopressor, thus the use of one vasopressor was assigned a score of 3, to correspond to the scoring for initiation of norepinephrine in standard SOFA scoring. The dataset allowed scoring of the presence or absence of altered mental status (AMS) but not the Glasgow Coma Score (GCS).

2A. Adapted SOFA scoring

	Adapted SOFA Scoring				
	0	**1**	**2**	**3**	**4**
SOFA Respiratory (PaO_2:FiO_2)	≥400	300-399	200-299	100-199	<100
SOFA Coagulation (Platelets, K/mm^3)	≥150	100-149	50-99	20-49	<20
SOFA Liver (Bilirubin, mg/dl)	<1.2	1.2-1.9	2.0-5.9	6.0-11.9	≥12
SOFA Cardiovascular (#vasopressors/inotropes)	0			1	≥2
SOFA CNS	No AMS	AMS			
SOFA Renal (Creatinine mg/dl)	Cr<1.2	Cr 1.2-1.9	Cr 2-3.4	Cr 3.5-4.9	Cr ≥5 or Acute RRT or ESRD

Abbreviations: SOFA, Sequential Organ Failure Assessment; AMS, Altered Mental Status; CNS: Central Nervous System; RRT, Renal Replacement Therapy; ESRD, End-Stage Renal Disease

2B. Standard SOFA scoring

	Standard SOFA Scoring				
	0	**1**	**2**	**3**	**4**
SOFA Respiratory (PaO_2:FiO_2)	≥400	300-399	200-299	100-199	<100
SOFA Coagulation (Platelets, K/mm^3)	≥150	100-149	50-99	20-49	<20
SOFA Liver (Bilirubin, mg/dl)	<1.2	1.2-1.9	2.0-5.9	6.0-11.9	≥12
SOFA Cardiovascular	MAP>70	MAP<70	dopa<=5 or dobuta	dopa>5, epi<=0.1, or norepi <=0.1	dopa>15, epi>0.1, norepi>0.1
SOFA CNS (Glasgow Coma Score)	15	13-14	10-12	6-9	<6
SOFA Renal (Creatinine mg/dl)	Cr<1.2	Cr 1.2-1.9	Cr 2-3.4	Cr 3.5-4.9	Cr ≥5 or Acute RRT or ESRD

Abbreviations: MAP, Mean Arterial Pressure; Dopa, dopamine; Dobuta, dobutamine; Epi, epinephrine, norepi, norepinephrine

Table S3. Approach to Comorbidity Scoring in Colorado's algorithm
Colorado's algorithm uses the Charlson Comorbidity Index to assign priority points (left). To adapt to the comorbidity data in the STOP-COVID registry, Colorado's comorbidities' scoring was modified (right). Comorbidities are defined in Table S3B.

S3A. Modification of comorbidity scoring in Colorado's algorithm.

Colorado's scoring of comorbidities (Charlson Comorbidity Index)		**Modification of comorbidities' scoring for this study**	
Comorbidity	**Points**	**Comorbidity**	**Points**
Age		Age	
<50	0	<50	0
50-59	1	50-59	1
60-69	2	60-69	2
70-79	3	70-79	3
>=80	4	>=80	4
Chronic Heart Failure	2	Chronic Heart Failure	2
Dementia	2		
Chronic Pulmonary Disease	1	Chronic Pulmonary Disease	1
Connective Tissue Disease	1		
Liver Disease		Liver Disease	2
Mild	2		
Moderate or Severe	4		
Diabetes Mellitus with Chronic Complications	1	Diabetes Mellitus	1
Hemiplegia	2		
Renal Disease	1	Renal Disease	1
Metastatic Solid Tumor	6		
Any active malignancy including leukemia/lymphoma	2	Any active malignancy including leukemia/lymphoma	2
AIDS	4		

Table S3B. Definitions of the comorbidities in the modified Colorado Algorithm.

Modified Charlson Comorbidities Measures	Coexisting Condition per STOP-COVID Study	Definition of Coexisting Condition
Chronic Heart Failure	Congestive heart failure	Per chart review; heart failure with preserved versus reduced ejection fraction
Chronic Pulmonary Disease	Chronic obstructive pulmonary disease	Per chart review
	Asthma	Per chart review
Chronic Liver Disease	Chronic liver disease	Cirrhosis, alcohol-related liver disease, nonalcoholic fatty liver disease, autoimmune hepatitis, hepatitis B or hepatitis C, primary biliary cirrhosis, or other
Diabetes Mellitus	Diabetes mellitus	Per chart review; insulin versus non-insulin dependent
Renal Disease	Chronic kidney disease	Baseline eGFR <60 ml/min/1.73m^2 on at least two consecutive values at least 12 weeks apart prior to hospital admission. If not available, defined as per chart review
	End stage renal disease	Per chart review; on hemodialysis or peritoneal dialysis
Any active malignancy including leukemia/lymphoma	Cancer	Per chart review; active malignancy (other than non-melanoma skin cancer) treated in the past year. Defined as cancer of the lung, breast, colorectal, prostate, gastric, pancreatic, melanoma, ovarian, brain, or other

Table S4. CSC algorithm performance in groups of two or five patients by race

In sub-cohorts of White or Black patients, the New York (NY) (SOFA score grouping only), modified Colorado (CO) (SOFA score groupings with comorbidities scoring) and a hypothetical algorithm of raw SOFA scores without grouping were examined in simulation of 1,000 random groups of two or five patients. Algorithms' "decisions" in selecting a "winning" patient or requiring a lottery tie-breaker were assessed. **Column A.** Percent of decisions that did not require tie-breakers (i.e., two or more patients not tied for the "best" (lowest) priority score). **Column B.** Among the decisions not requiring tie-breakers, percent of decisions in which the algorithm selected a patient with a better outcome (i.e., survival). **Column C**. Percent of correct selections (i.e., selecting a surviving patient) across all decisions (i.e., all decisions regardless whether selected by priority score or tie-breaking lottery).

S4A. CSC algorithm performance in groups of two by race[a].

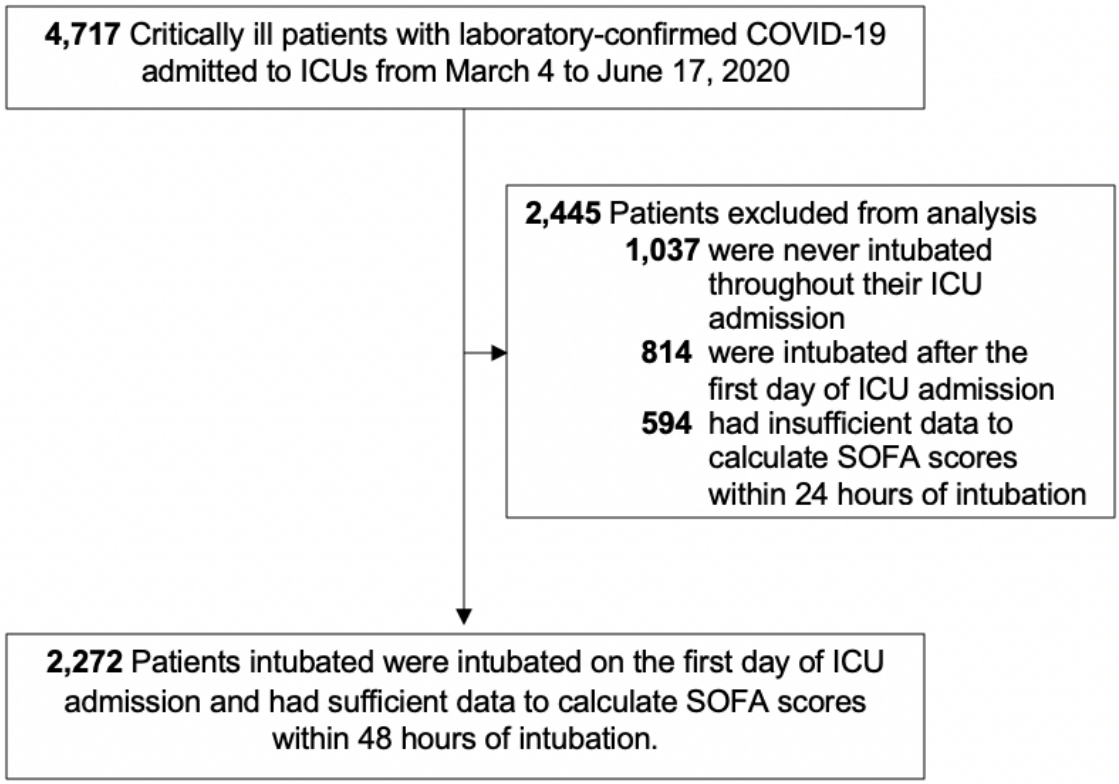
	A. Percent decision not needing lottery tie breaker	95% CI	**B.** Percent correct among decision not requiring lottery	95% CI	**C.** Overall perfor-mance: percent correct decision	95% CI		**A.** Percent decision not needing lottery tie-breaker	95% CI	**B.** Percent correct among decision not requiring lottery	95% CI	**C.** Overall perfor-mance: percent correct decision	95% CI
White: Groups of Two							**Black: Groups of Two**						
New York*	49	44-54	73	68-78	61	57-65	New York	56	51-60	68	63-73	60	56-64
Colorado	76	73-81	74	70-78	68	52-61	Colorado	76	73-80	65	61-70	61	57-65
Raw Sofa	88	85-91	66	62-70	64	60-68	Raw Sofa	89	86-92	62	57-66	61	57-65
Algorithm + Age Tie-Breaker							*Algorithm + Age Tie-Breaker*						
New York + Age	89	87-92	71	67-75	69	65-73	New York + Age	90	87-92	66	62-69	64	61-69
Colorado + Age*	93	90-95	71	67-75	70	66-73	Colorado + Age	94	92-96	63	58-68	62	58-66
Raw Sofa + Age	98*	96-99	66	63-71	65	61-70	Raw Sofa + Age	98	96-99	62	57-66	62	59-66

S4B. CSC algorithm performance in groups of five by race[a].

	A. Percent decision not needing lottery tie-breaker	95% CI	**B.** Percent correct among decision not requiring lottery	95% CI	**C.** Overall perfor-mance: percent correct decision	95% CI
White Groups of Five						
New York*	6	5-7	64*	51-75	61	58-64
Colorado	58	56-61	74	70-77	71	69-74
Raw Sofa	78	76-81	66	63-69	65	62-69
Algorithm - Age as Tie-Breaker						
New York + Age	68	64-70	72	69-75	71	69-73
Colorado + Age*	83	81-86	73	70-76	73	69-75
Raw Sofa + Age	94	93-96	67	64-70	67	64-70

	A. Percent decision not needing lottery tie-breaker	95% CI	**B.** Percent correct among decision not requiring lottery	95% CI	**C.** Overall perfor-mance: percent correct decision	95% CI
Black Groups of Five						
New York	12	10-14	63*	51-71	60	57-63
Colorado	58	55-61	66	63-70	63	60-65
Raw Sofa	81	78-83	60	57-63	60	57-63
Algorithm + Age as Tie-Breaker						
New York + Age	73	71-76	69	64-72	67	64-70
Colorado + Age	85	83-87	64	61-67	63	60-65
Raw Sofa + Age	95	94-96	62	58-64	61	58-64

Figure S1. Study Cohort



Abbreviations: ICU, Intensive Care Unit; SOFA, Sequential Organ Failure Assessment

Figure S2. Sensitivity analysis for the association of priority scores or categories with 28-day mortality.

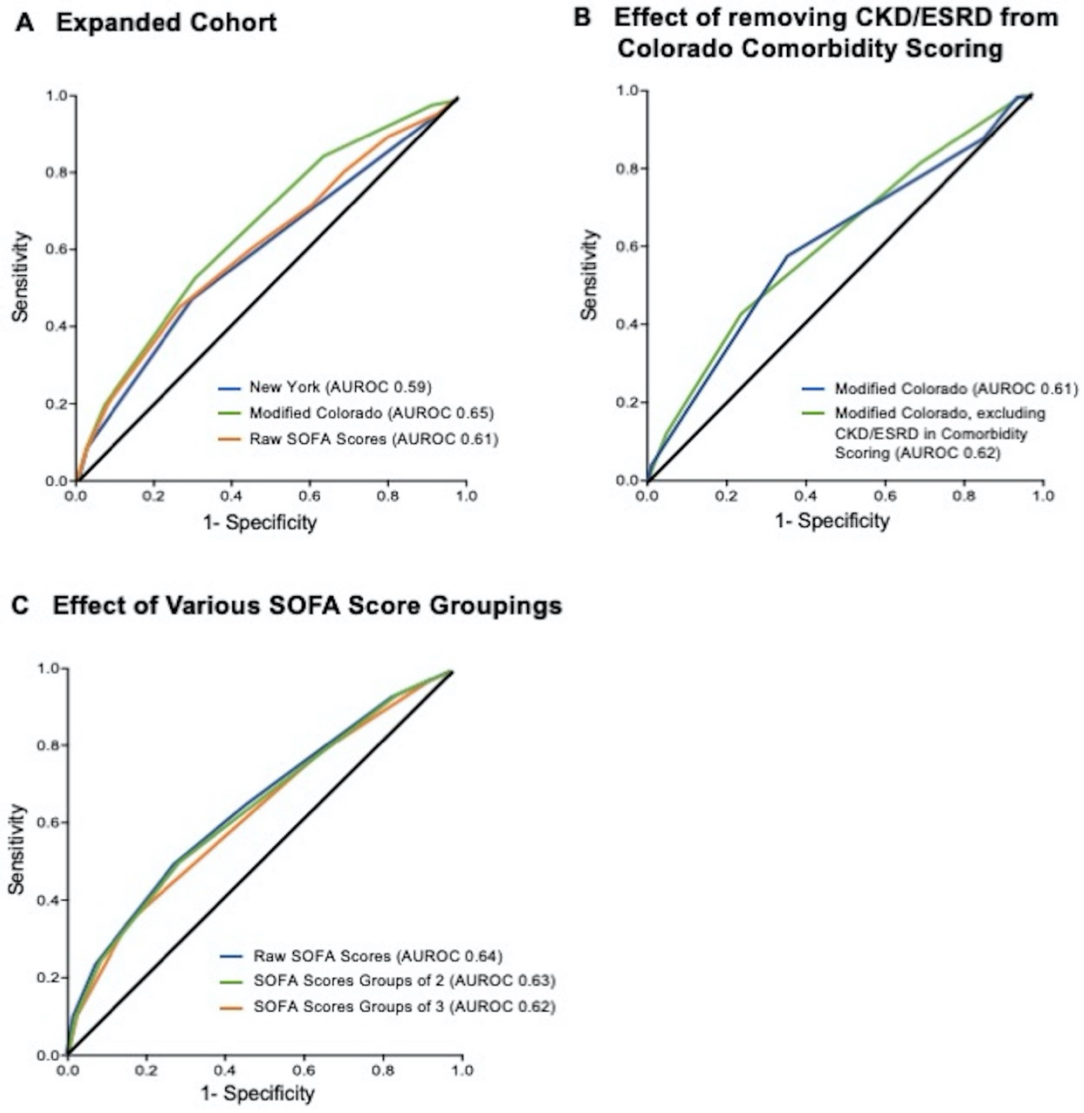


Figure S2. A-C: AUROC curves for discrimination of 28-day mortality by priority scores are shown for the following sensitivity analyses: **A.** The cohort was expanded to a total of 2,866 patients, which includes the 594 patients that were excluded due insufficient data to calculate SOFA scores in the original analysis (Figure S1) and the 2,272 patient included in the original analysis. The three algorithms (New York, Colorado, Raw SOFA Scores) were applied to the expanded cohort. **B.** In the modified Colorado algorithm, CKD/ESRD could be "counted double," by contributing to both the SOFA scoring and the comorbidities scoring. The modified Colorado algorithm was compared to a version excluding CKD/ESRD from comorbidity scoring. **C.** Hypothetical algorithms of grouping SOFA scores in ranges of two or groupings in ranges of three were applied to the study cohort to generate priority points. The hypothetical algorithm of raw (ungrouped SOFA scores) was compared to the groupings of SOFA scores in ranges of 2 and ranges of 3.

Figure S3. Performance of CSC algorithms according to race or ethnicity

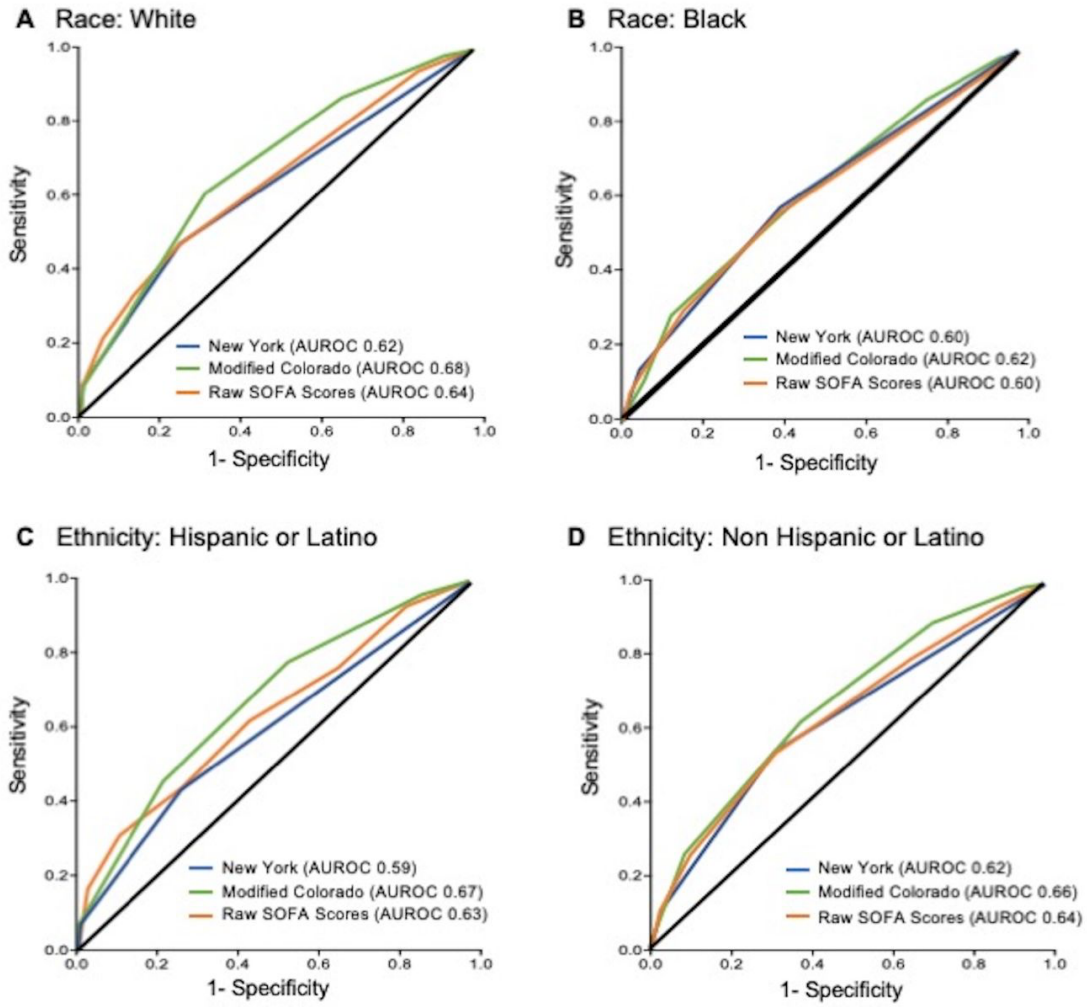


Figure S3. The state CSC or hypothetical raw SOFA score algorithms were applied to sub-cohorts defined by race or ethnicity to generate priority scores. The accuracy of priority scores in predicting 28-day mortality after ICU admission and intubation were assessed by AUROC curve. There were no statistically significant differences in AUROC for each algorithm across race or ethnicity ($p>0.05$).