

Supplementary Material*

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Supplement. Supplement Tables and Figures

* This supplementary material was provided by the authors to give readers further details on their article. The material was reviewed but not copyedited.

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Supplement to: Anesi GL, et al. Characteristics, outcomes, and trends of patients with COVID-19–related critical illness at a learning health system in the U.S.

TABLES

eTable 1. Characteristics of COVID-19 patients with critical illness by period

Characteristics	Period			
	3/13-3/27	3/28-4/11	4/12-4/26	4/27-5/11
Patients, n	63	165	140	96
Age, median years (IQR)	63 (53-75)	66 (59-74)	65 (54-73)	64 (48-78)
Female sex, n (%)	24 (38.1)	70 (42.4)	60 (42.9)	42 (43.8)
Race, n (%)				
Black	24 (38.1)	90 (54.6)	79 (56.4)	52 (54.2)
White	20 (31.8)	45 (27.3)	29 (20.7)	20 (20.8)
Other ^a	19 (30.2)	30 (18.2)	32 (22.9)	24 (25.0)
Hispanic ethnicity, n (%)	5 (7.9)	15 (9.1)	13 (9.3)	10 (10.4)
Hospital admission source, n (%)				
Emergency department	57 (90.5)	152 (92.1)	123 (87.9)	86 (89.6)
Other institution	5 (7.9)	9 (5.5)	16 (11.4)	8 (8.3)
Outpatient clinic	1 (1.6)	3 (1.8)	1 (0.7)	2 (2.1)
Insurance, n (%)				
Private	28 (44.4)	57 (34.6)	49 (35.0)	25 (26.0)
Medicare	30 (47.6)	85 (51.5)	67 (47.9)	41 (42.7)
Medicaid or no insurance ^b	3 (4.8)	11 (6.7)	15 (10.7)	18 (18.8)
Missing	2 (3.2)	12 (7.3)	9 (6.4)	12 (12.5)
Body mass index at admission, n (%)				
< 18.5	2 (3.2)	3 (1.8)	2 (1.4)	3 (3.1)
18.5-34.9	45 (71.4)	121 (73.3)	101 (72.1)	64 (66.7)
≥ 35	15 (23.8)	35 (21.2)	34 (24.3)	25 (26.0)
Missing	1 (1.6)	6 (3.6)	3 (2.1)	4 (4.2)
Pregnancy, n (%)	1 (1.6)	3 (1.8)	1 (0.7)	2 (2.1)
Charlson Comorbidity Index, n (%) unless otherwise noted				
Median (IQR)	3 (0-5)	3 (1-5)	3 (1-6)	3 (2-6)
Points = 0	18 (28.6)	26 (15.8)	27 (19.3)	10 (10.4)
Points = 1	4 (6.4)	24 (14.6)	10 (7.1)	13 (13.5)
Points ≥ 2	41 (65.1)	115 (69.7)	103 (73.6)	73 (76.0)
Duration from acute care presentation to ICU admission, median hours (IQR)	2.6 (0.6-47.7)	2.6 (0.6-41.0)	2.2 (0-48.7)	1.6 (0.5-19.0)

Supplement to: Anesi GL, et al. Characteristics, outcomes, and trends of patients with COVID-19–related critical illness at a learning health system in the U.S.

Notes: ^a Other race includes Hispanic/Latino Black, Hispanic/Latino White, Asian, East Indian, Pacific Island, other, and unknown. ^b The no insurance population includes patients confirmed to have no insurance and require safety net support, as distinct from missing insurance status. ICU, intensive care unit; IQR, interquartile range.

eTable 2. Acute physiology of patients with COVID-19 critical illness at ICU admission by period

Acute physiology assessments	Period			
	3/13-3/27	3/28-4/11	4/12-4/26	4/27-5/11
Patients, n	63	165	140	96
Composite acuity measures				
p _A O ₂ : FIO ₂ ratio, median (IQR) ^a	103 (66-212)	110 (66-204)	100 (65-160)	94 (59-175)
p _A O ₂ : FIO ₂ ratio ≤ 300, n (%) ^a	40 (63.5)	107 (64.9)	76 (54.3)	56 (47.9)
SOFA score, median (IQR) ^b	5 (3-6)	5 (3-7)	4 (2.5-6.5)	4.5 (1-7)
Respiratory SOFA sub-score, median (IQR)	2 (0-4)	3 (0-4)	2 (0.4)	0 (0-3)
Vital signs				
Maximum Glasgow Coma Score < 15, n (%)	15 (32.6)	51 (32.9)	38 (31.7)	35 (38.5)
Temperature ≥ 38.0 °C, n (%)	43 (68.3)	99 (60.0)	76 (54.3)	45 (46.9)
Maximum heart rate, median beats per minute (IQR)	105 (93-124)	115 (99-127)	111 (97-129)	113 (98-129)
Minimum systolic blood pressure, median mmHg (IQR)	87 (81-101)	87 (77-98)	92 (82-106)	96 (83-110)
Minimum mean arterial pressure, median mmHg (IQR)	64 (59-74)	64 (55-71)	67 (60-76)	69 (59-79)
Maximum respiratory rate, median breaths per minute (IQR)	36 (30-40)	35 (30-42)	35 (29-42)	35 (28-42)
Minimum oxygen saturation, median SpO ₂ , % (IQR)	85 (77-90)	86 (77-90)	87 (81-091)	87 (78-92)
FIO ₂ at ICU admission, median % (IQR)	91 (56-100)	91 (60-100)	60 (50-100)	60 (42-100)
Arterial blood gas measurements				
Minimum pH, median (IQR)	7.30 (7.21-7.39)	7.28 (7.22-7.37)	7.33 (7.24-7.40)	7.36 (7.27-7.42)
Minimum p _A O ₂ , median mmHg (IQR)	65 (51-93)	60 (41-85)	59 (41-80)	54 (42-72)
Maximum P _A CO ₂ , median mmHg (IQR)	56 (43-62)	50 (40-61)	45 (38-54)	46 (38-53)
Maximum lactate, median mmol/L (IQR)	1.8 (1.3-2.8)	1.9 (1.3-3.3)	2.1 (1.4-3.1)	2.0 (1.3-3.2)
Blood counts				
White blood cell count, maximum, n (%)				
< 4 × 10 ⁹ /L	7 (11.1)	1 (0.6)	6 (4.3)	3 (3.1)
4-12 × 10 ⁹ /L	36 (57.1)	118 (71.5)	75 (53.6)	65 (67.7)
> 12 × 10 ⁹ /L	19 (30.2)	45 (27.3)	54 (38.6)	28 (29.2)
Minimum absolute lymphocyte count, median cells/L (IQR)	635 (380-830)	700 (400-1000)	600 (400-900)	585 (275-1000)
Minimum hemoglobin, median mmol/L (IQR)	7.1 (6.3-7.9)	7.0 (6.0-7.9)	7.3 (5.8-8.1)	7.0 (5.4-8.2)
Minimum platelet count, median × 10 ⁹ /L (IQR)	175 (129-223)	196 (147-260)	203 (149-276)	204 (144-271)
Chemistries				
Minimum sodium, median mmol/L (IQR)	135 (133-139)	135 (132-139)	135 (132-140)	136 (132-139)
Maximum potassium, median mmol/L (IQR)	4.4 (4.0-4.8)	4.5 (4.1-5.0)	4.6 (4.2-5.3)	4.4 (4.1-4.9)
Maximum blood urea nitrogen (BUN), median mmol/L (IQR)	7.1 (5.0-12.1)	8.9 (6.4-16.4)	10.7 (6.1-17.1)	8.9 (5.7-15.4)
Maximum creatinine, median μmol/L (IQR) [mg/dL (IQR)]	98.2 (70.7-153.0) [1.11 (0.80-1.73)]	117.6 (79.6-213.1) [1.33 (0.90-2.41)]	111.4 (83.1-210.4) [1.26 (0.94-2.38)]	104.3 (70.7-194.5) [1.18 (0.80-2.20)]
Minimum bicarbonate, median mmol/L (IQR)	22 (19-24)	21 (18-24)	21 (19-24)	23 (20-25)
Minimum glucose, median mmol/L (IQR) [mg/dL (IQR)]	6.0 (5.2-7.2) [108 (93-129)]	6.1 (5.1-7.2) [109 (92-129)]	6.0 (5.2-7.6) [108 (93-136)]	5.7 (4.6-7.2) [102 (83-130)]
Maximum anion gap, median mmol/L (IQR)	15 (10-18)	13 (11-17)	13 (11-17)	13 (11-16)
Liver function tests				
Minimum albumin, median g/L (IQR)	30 (28-34)	30 (27-32)	31 (27-34)	30 (26-33)
Maximum aspartate aminotransferase (AST), median units/L (IQR)	44 (31-84)	48 (31-73)	43 (29-70)	38 (27-60)
Maximum alanine aminotransferase (ALT), median units/L (IQR)	27 (19-61)	31 (18-49)	29 (18-55)	26 (17-46)
Maximum total bilirubin, median μmol/L (IQR) [mg/dL (IQR)]	10.3 (6.8-13.7) [0.6 (0.4-0.8)]	12.0 (6.8-17.1) [0.7 (0.4-1.0)]	10.3 (6.8-13.7) [0.6 (0.4-0.8)]	10.3 (6.8-15.4) [0.6 (0.4-0.9)]
Coagulation parameters				
Maximum international normalized ratio (INR), median (IQR)	1.2 (1.2-1.5)	1.2 (1.2-1.5)	1.3 (1.1-1.4)	1.3 (1.2-1.4)
Maximum partial thromboplastin time (PTT), median seconds (IQR)	32.4 (30.4-37.3)	32.9 (29.8-37.9)	34.4 (30.2-42.2)	33.8 (29.7-51.6)
Maximum D-dimer, median nmol/L (IQR)	6.24 (3.23-11.44)	7.94 (5.15-25.68)	9.42 (3.72-26.12)	9.31 (4.82-25.08)
Maximum fibrinogen, median g/L (IQR)	6.1 (4.7-6.5)	5.4 (4.2-6.9)	6.8 (5.3-7.7)	4.4 (3.5-5.9)
Inflammation and injury markers				
Maximum procalcitonin, median ng/mL (IQR)	0.24 (0.15-1.64)	0.40 (0.20-0.90)	0.48 (0.18-2.13)	0.35 (0.17-1.26)
Maximum C-reactive protein, median mg/L (IQR)	51.9 (25.4-98.7)	104.4 (51.4-142.6)	108.1 (82.1-134.6)	97.1 (27.2-125.8)
Maximum ferritin, median μg/L (IQR)	1403 (482-2742)	945 (448-1978)	654 (293-1775)	668 (367-1409)
Maximum troponin-T, median μg/L (IQR)	0.03 (0.02-0.29)	0.05 (0.02-0.19)	0.08 (0.02-0.19)	0.90 (0.03-0.45)
Maximum lactate dehydrogenase (LDH), median μkat/L (IQR)	8.9 (7.4-12.0)	7.3 (5.5-9.5)	6.2 (5.1-9.3)	6.6 (4.8-9.1)
Maximum interleukin 6 (IL-6), median pg/mL (IQR)	15 (7-33)	40 (10-159)	11 (7-15)	21 (11-265)

Notes: Descriptive statistics calculated among non-missing data prior to imputation. Minimum and maximum refer to the most extreme measurements in the 24 hours prior to and after ICU admission. ^a p_AO₂ : FIO₂ ratio calculated based on the P_AO₂ and FIO₂ measurements closest to ICU admission among the full study cohort. ^b SOFA score calculated using worst measurements in the 24 hours prior to and after ICU admission, a conversion of supplemental oxygen in liters per minute to FIO₂, creatinine alone for renal function, binary vasopressor assessment, and assuming 0 for missing sub-scores. ICU, intensive care unit; IQR, interquartile range; SOFA, Sequential Organ Failure Assessment.

eTable 3. Mechanical ventilation over time

Model	Period	OR (95% CI, p-value)	Mechanical ventilation % (95% CI)
Unadjusted	3/13-3/27	Reference	85.7 (77.1-94.4)
	3/28-4/11	0.49 (0.22-1.07, 0.074)	74.5 (67.9-81.2)
	4/12-4/26	0.29 (0.13-0.64, 0.002)*	63.6 (55.6-71.5)
	4/27-5/11	0.20 (0.09-0.44, <0.001)*	54.2 (44.2-64.1)
Adjusted for P _A O ₂ :FiO ₂	3/13-3/27	Reference	95.6 (89.7-101.6)
	3/28-4/11	0.52 (0.11-2.45, 0.41)	91.9 (87.0-96.7)
	4/12-4/26	0.22 (0.05-1.01, 0.052)*	82.8 (74.-90.7)
	4/27-5/11	0.14 (0.03-0.66, 0.013)*	75.5 (64.0-87.1)

Notes: * $p < 0.05$. CI, confidence interval; OR, odds ratio.

eTable 4. All-cause 28-day in-hospital mortality over time

Model	Period	OR (95% CI, p-value)	Mortality % (95% CI)
Unadjusted	3/13-3/27	Reference	46.0 (33.7-58.3)
	3/28-4/11	0.64 (0.35-1.15, 0.132)	35.2 (27.9-42.4)
	4/12-4/26	0.41 (0.22-0.76, 0.005)*	25.7 (18.5-33.0)
	4/27-5/11	0.25 (0.12-0.52, <0.001)*	17.7 (10.1-24.3)
Core Adjusted ^a	3/13-3/27	Reference	43.5 (31.3-53.8)
	3/28-4/11	0.57 (0.28-1.15, 0.119)	32.2 (26.0-38.6)
	4/12-4/26	0.47 (0.23-0.97, 0.042)*	28.9 (21.9-35.8)
	4/27-5/11	0.24 (0.10-0.57, 0.001)*	19.2 (11.6-26.7)
Expanded Adjusted ^b	3/13-3/27	Reference	45.3 (28.9-61.7)
	3/28-4/11	0.66 (0.24-1.80, 0.42)	37.9 (29.9-45.8)
	4/12-4/26	0.60 (0.21-1.77, 0.36)	36.3 (26.6-45.9)
	4/27-5/11	0.29 (0.09-0.99, 0.047)*	24.7 (13.3-36.1)

Notes: * $p < 0.05$. ^a Adjusted for age, Charlson Comorbidity Index, SOFA score, and hospital. ^b Additionally adjusted for body mass index, Glasgow Coma Score, oxygen saturation, respiratory rate, platelet count, and $P_{aO_2}:FiO_2$ ratio. CI, confidence interval; OR, odds ratio; SOFA, Sequential Organ Failure Assessment.

eTable 5. All-cause 28-day in-hospital mortality among patients requiring mechanical ventilation over time

Model	Period	OR (95% CI, p-value)	Mortality % (95% CI)
Unadjusted	3/13-3/27	Reference	52.9 (38.5-65.2)
	3/28-4/11	0.61 (0.32-1.17, 0.139)	39.8 (31.2-48.5)
	4/12-4/26	0.43 (0.21-0.86, 0.016)*	31.5 (21.8-41.1)
	4/27-5/11	0.31 (0.14-0.71, 0.005)*	25.0 (13.2-36.8)
Core Adjusted ^a	3/13-3/27	Reference	43.5 (31.3-53.8)
	3/28-4/11	0.53 (0.25-1.12, 0.096)	32.2 (26.0-38.6)
	4/12-4/26	0.47 (0.21-1.03, 0.060)	28.9 (21.9-35.8)
	4/27-5/11	0.29 (0.11-0.76, 0.012)*	19.2 (11.6-26.7)
Expanded Adjusted ^b	3/13-3/27	Reference	46.5 (29.6-63.4)
	3/28-4/11	0.64 (0.23-1.76, 0.38)	38.2 (29.8-46.6)
	4/12-4/26	0.59 (0.19-1.79, 0.35)	36.8 (25.9-47.8)
	4/27-5/11	0.21 (0.05-0.78, 0.021)*	20.5 (8.2-32.8)

Notes: * $p < 0.05$. ^a Adjusted for age, Charlson Comorbidity Index, SOFA score, and hospital. ^b Additionally adjusted for body mass index, Glasgow Coma Score, oxygen saturation, respiratory rate, platelet count, and $P_{AO_2}:FiO_2$ ratio. CI, confidence interval; OR, odds ratio; SOFA, Sequential Organ Failure Assessment.

eTable 6. All-cause 28-day in-hospital mortality over time adjusted for COVID-19 patient occupancy of pre-COVID-19 ICU and ward bed capacity

Model	Period	OR (95% CI, p-value)	Mortality % (95% CI)
Core Adjusted ^a	3/13-3/27	Reference	50.2 (38.1-62.4)
	3/28-4/11	0.38 (0.19-0.78, 0.008)*	31.5 (25.0-38.0)
	4/12-4/26	0.29 (0.13-0.66, 0.003)*	27.0 (20.0-34.3)
	4/27-5/11	0.17 (0.07-0.40, <0.001)*	18.6 (11.1-26.2)

Notes: * $p < 0.05$. ^a Adjusted for age, Charlson Comorbidity Index, SOFA score, and COVID-19 patient occupancy of pre-COVID-19 ICU and ward bed capacity. CI, confidence interval; OR, odds ratio; SOFA, Sequential Organ Failure Assessment.

eTable 7. All-cause death at any time over time

Model	Period	OR (95% CI, p-value)	Mortality % (95% CI)
Unadjusted	3/13-3/27	Reference	47.6 (35.3-60.0)
	3/28-4/11	0.77 (0.43-1.38, 0.38)	41.2 (33.7-48.7)
	4/12-4/26	0.63 (0.35-1.15, 0.133)	35.4 (28.5-44.4)
	4/27-5/11	0.41 (0.21-0.80, 0.009)*	27.1 (18.2-36.0)
Core Adjusted ^a	3/13-3/27	Reference	44.2 (33.2-55.3)
	3/28-4/11	0.73 (0.36-1.49, 0.39)	38.6 (32.2-45.0)
	4/12-4/26	0.75 (0.36-1.56, 0.44)	39.1 (32.0-46.1)
	4/27-5/11	0.42 (0.18-0.94, 0.036*)	29.0 (20.6-37.5)
Expanded Adjusted ^b	3/13-3/27	Reference	51.1 (34.6-67.6)
	3/28-4/11	0.61 (0.21-1.73, 0.35)	42.3 (34.5-50.1)
	4/12-4/26	0.66 (0.22-2.02, 0.47)	43.9 (34.3-53.4)
	4/27-5/11	0.40 (0.12-1.34, 0.137)	35.1 (22.6-47.5)

Notes: * $p < 0.05$. ^a Adjusted for age, Charlson Comorbidity Index, SOFA score, and hospital. ^b Additionally adjusted for body mass index, Glasgow Coma Score, oxygen saturation, respiratory rate, platelet count, and $P_{aO_2}:FiO_2$ ratio. CI, confidence interval; OR, odds ratio; SOFA, Sequential Organ Failure Assessment.

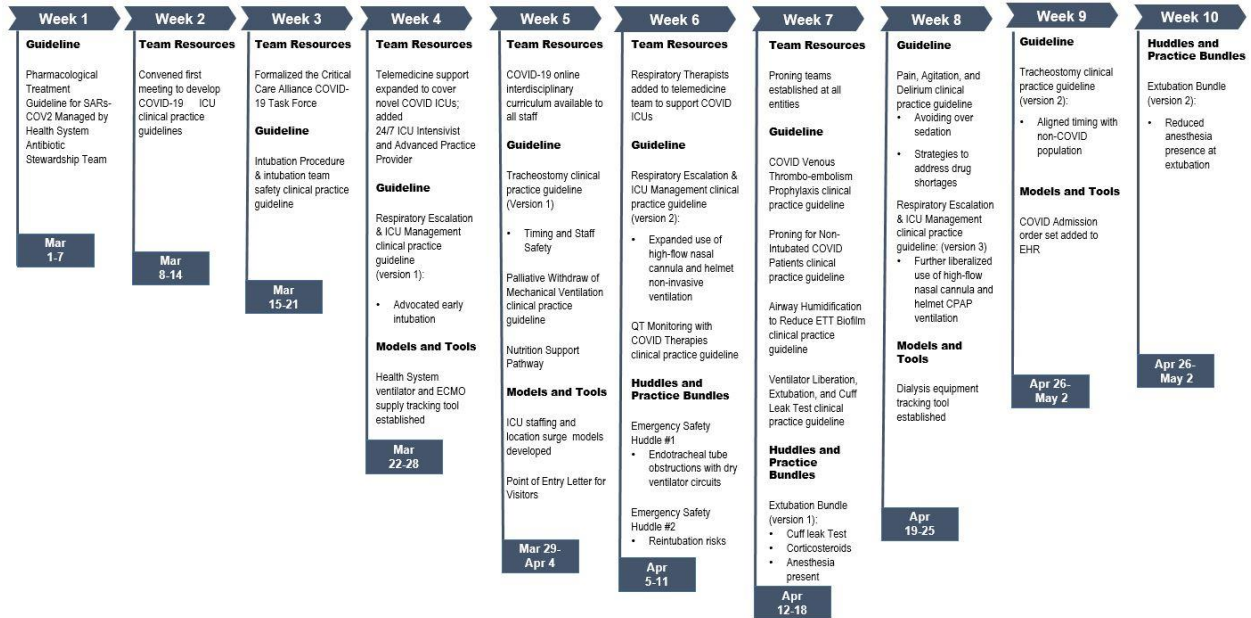
eTable 8. All-cause 28-day in-hospital mortality over time among patients less than or equal to 50 years of age

Model	Period	OR (95% CI, p-value)	Mortality % (95% CI)
Core Adjusted ^a	3/13-3/27	Reference	21.7 (2.2-41.3)
	3/28-4/11	1.93 (0.24-15.70, 0.54)	29.7 (15.5-43.9)
	4/12-4/26	0.07 (0.003-1.35, 0.078)	4.4. (-1.7-10.6)
	4/27-5/11	0.06 (0.002-2.18, 0.127)	4.4. (-2.6-11.4)

Notes: * $p < 0.05$. ^a Adjusted for age, Charlson Comorbidity Index, SOFA score, and COVID-19 patient occupancy of pre-COVID-19 ICU and ward bed capacity. CI, confidence interval; OR, odds ratio; SOFA, Sequential Organ Failure Assessment.

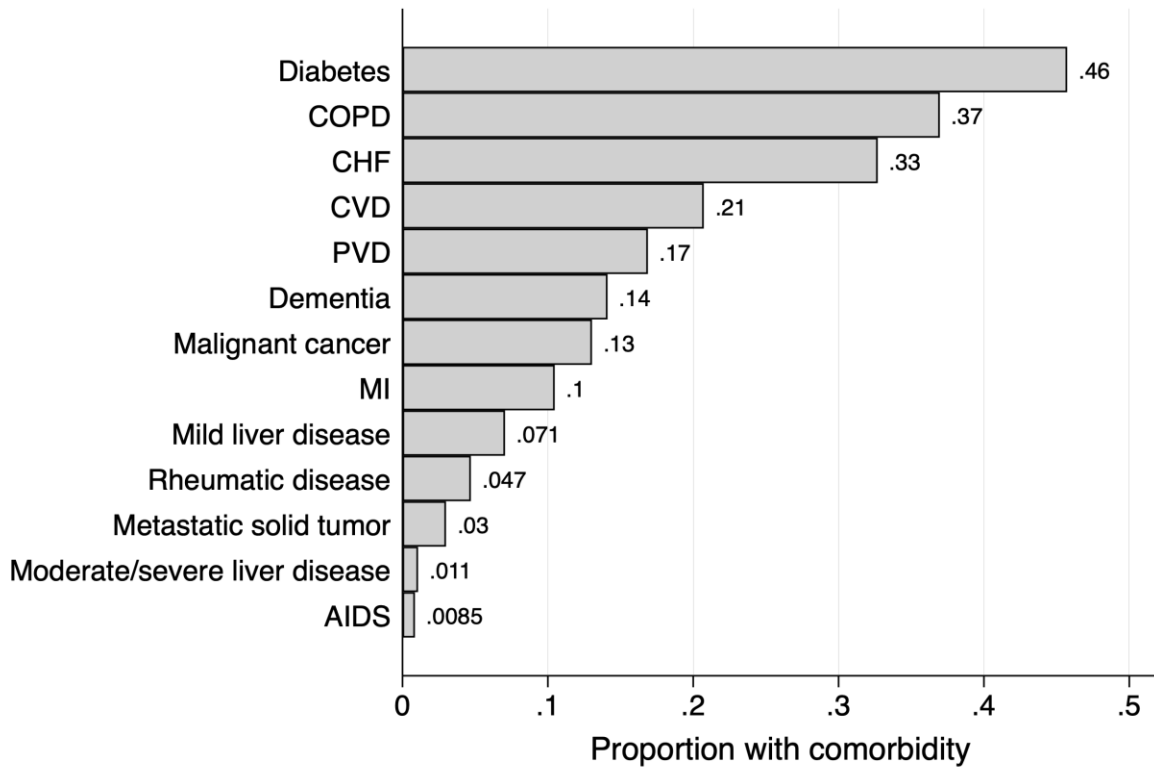
FIGURES

eFigure 1. Penn Medicine Critical Care Alliance COVID-19 Task Force Timeline

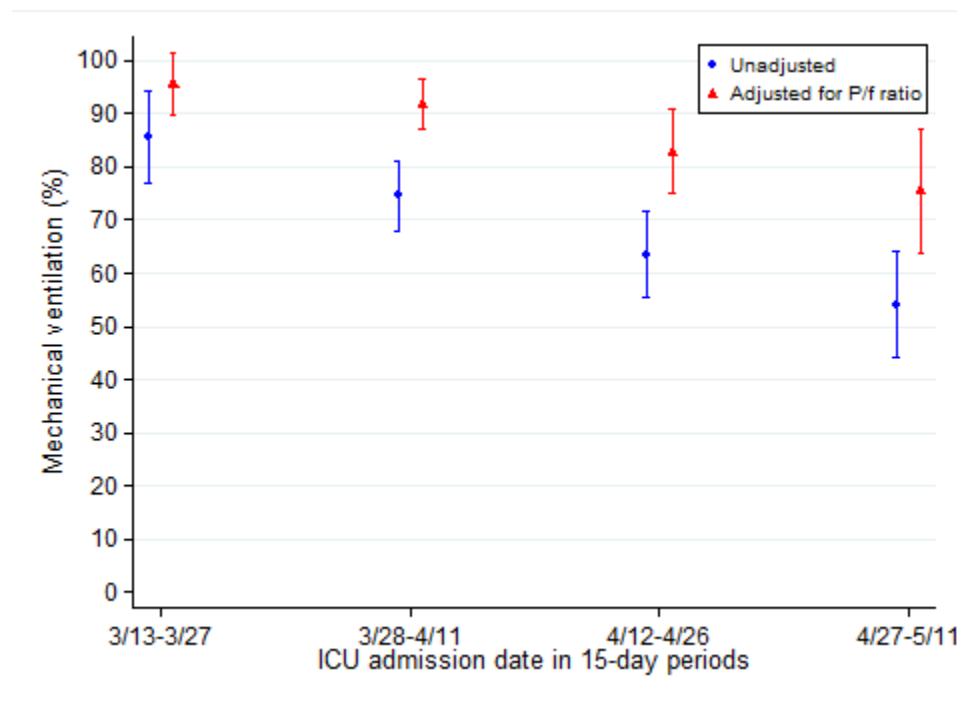


eFigure 2. Charlson Comorbidity Index diagnosis proportions

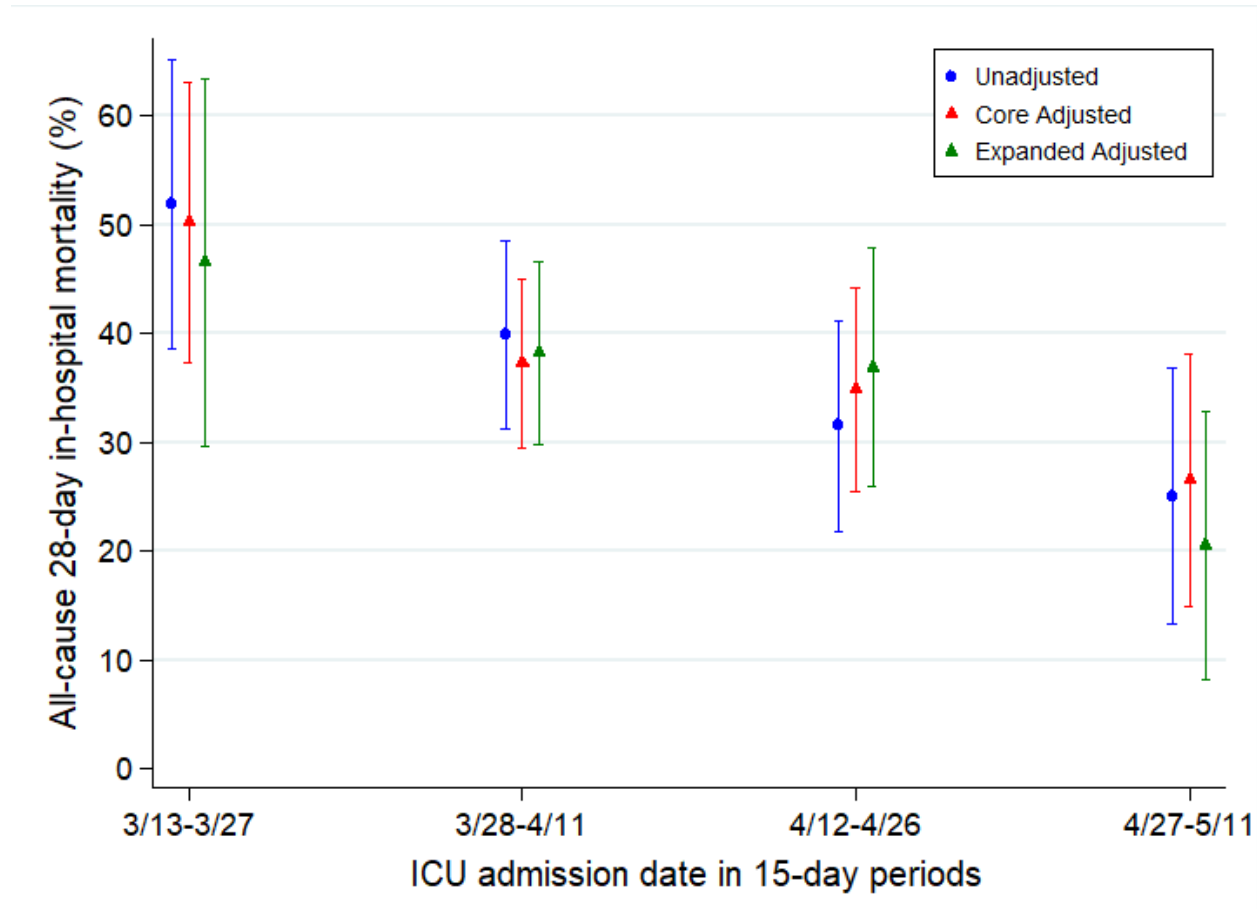
Notes: AIDS, acquired immunodeficiency syndrome; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; MI, myocardial infarction; PVD, peripheral vascular disease.



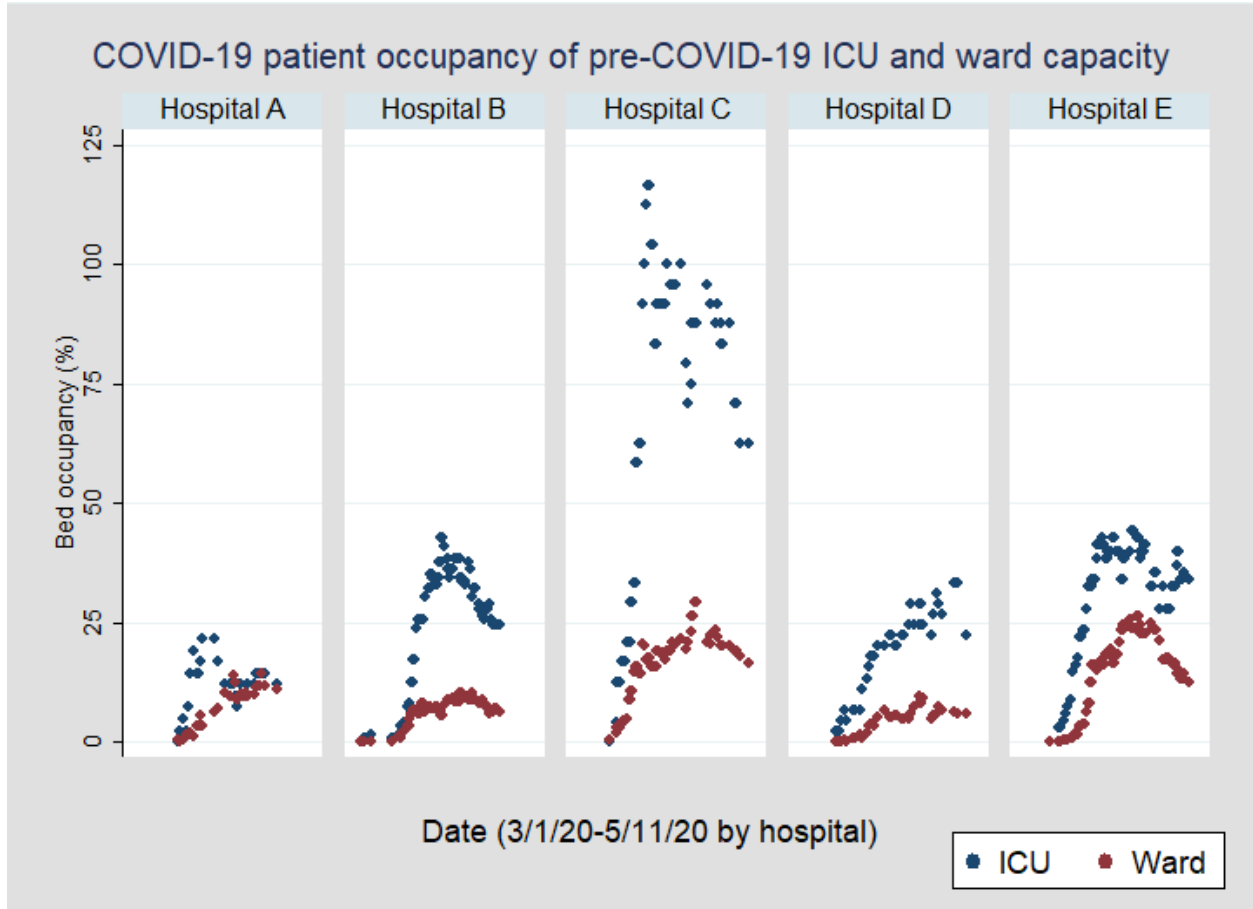
eFigure 3. Mechanical ventilation over time



eFigure 4. All-cause 28-day in-hospital mortality among patients requiring mechanical ventilation over time

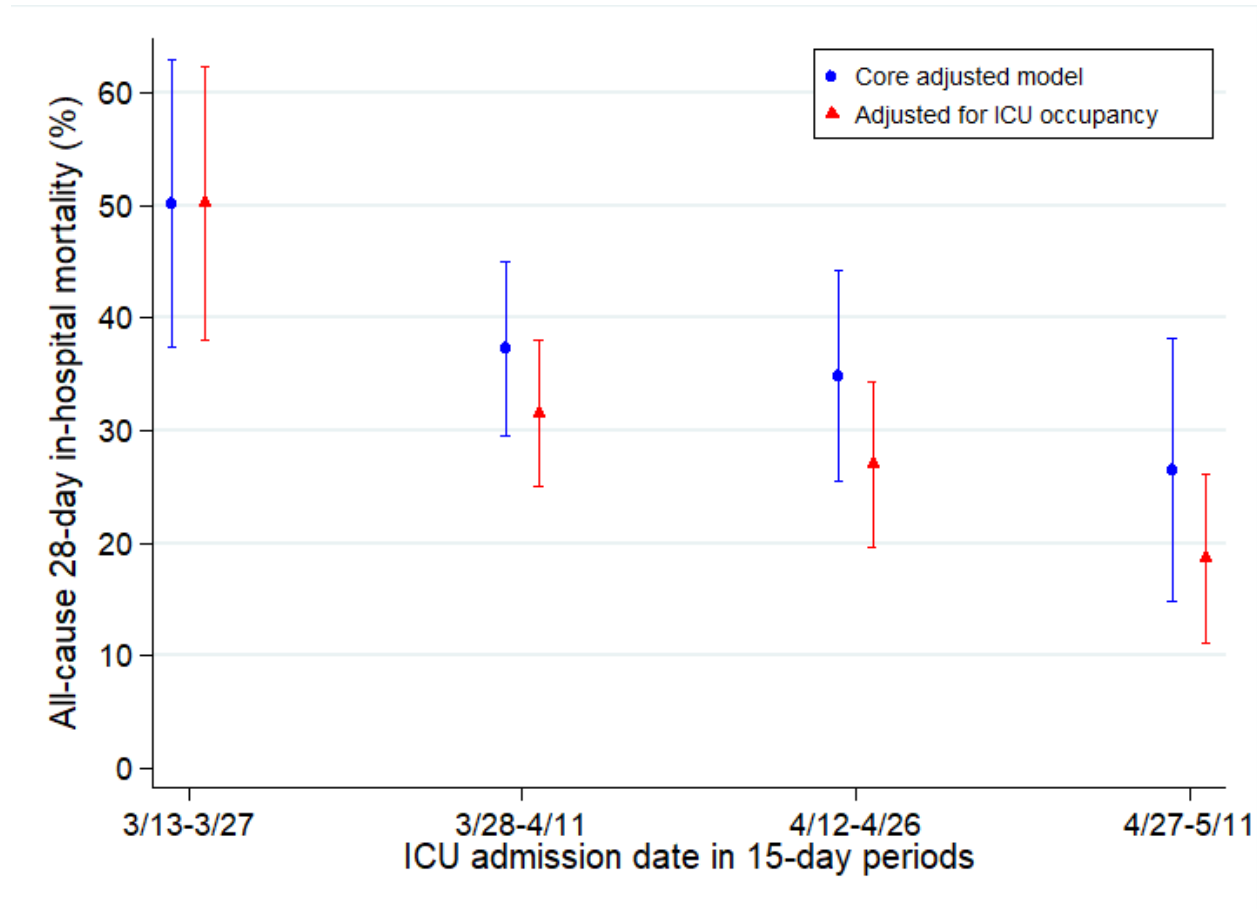


eFigure 5. COVID-19 patient occupancy of pre-COVID-19 ICU and ward bed capacity

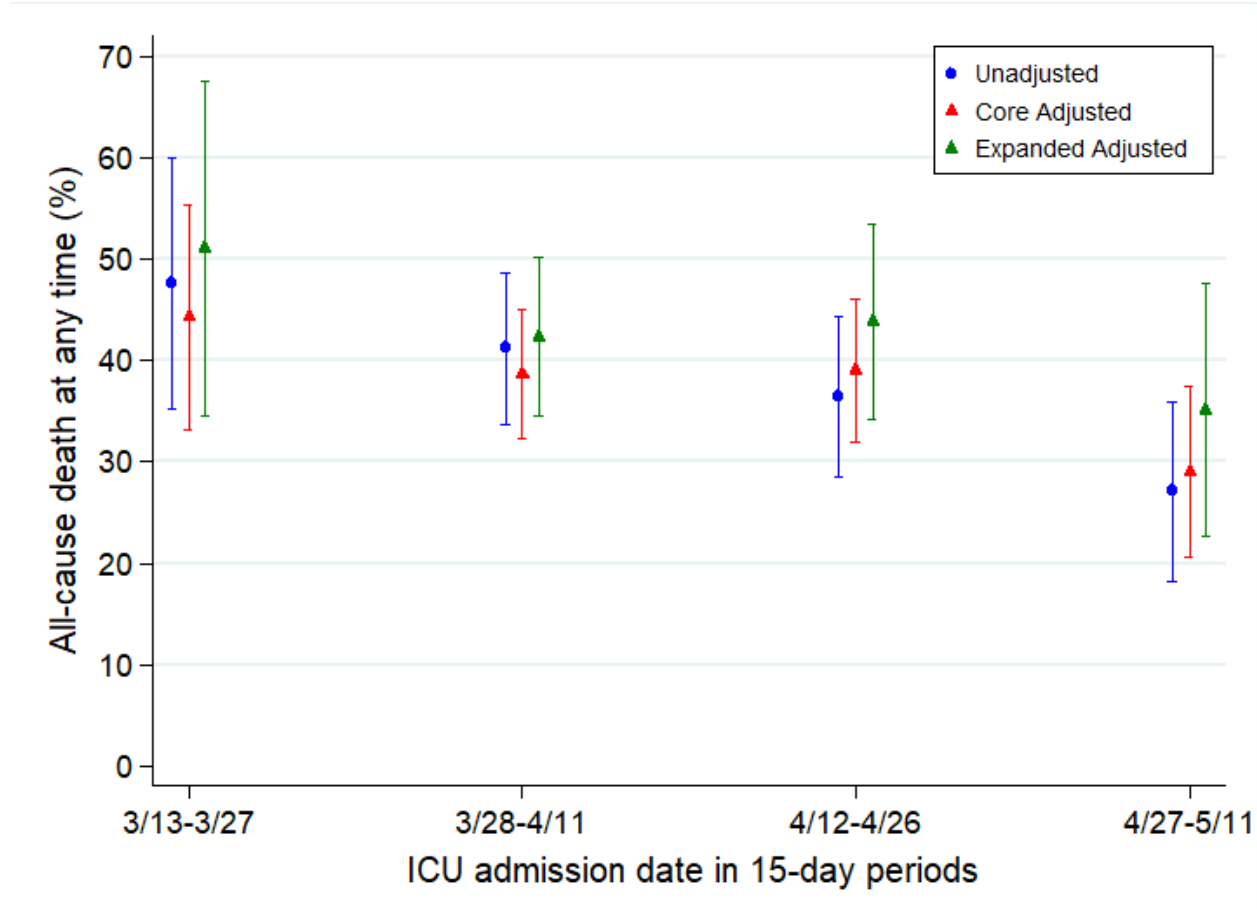


Notes: Bed occupancy is calculated as a percentage of the pre-COVID bed capacity occupied by COVID-19 patients stratified by ICU vs ward and by hospital over time by calendar day.

eFigure 6. All-cause 28-day in-hospital mortality over time adjusted for COVID-19 patient occupancy of pre-COVID-19 ICU and ward bed capacity

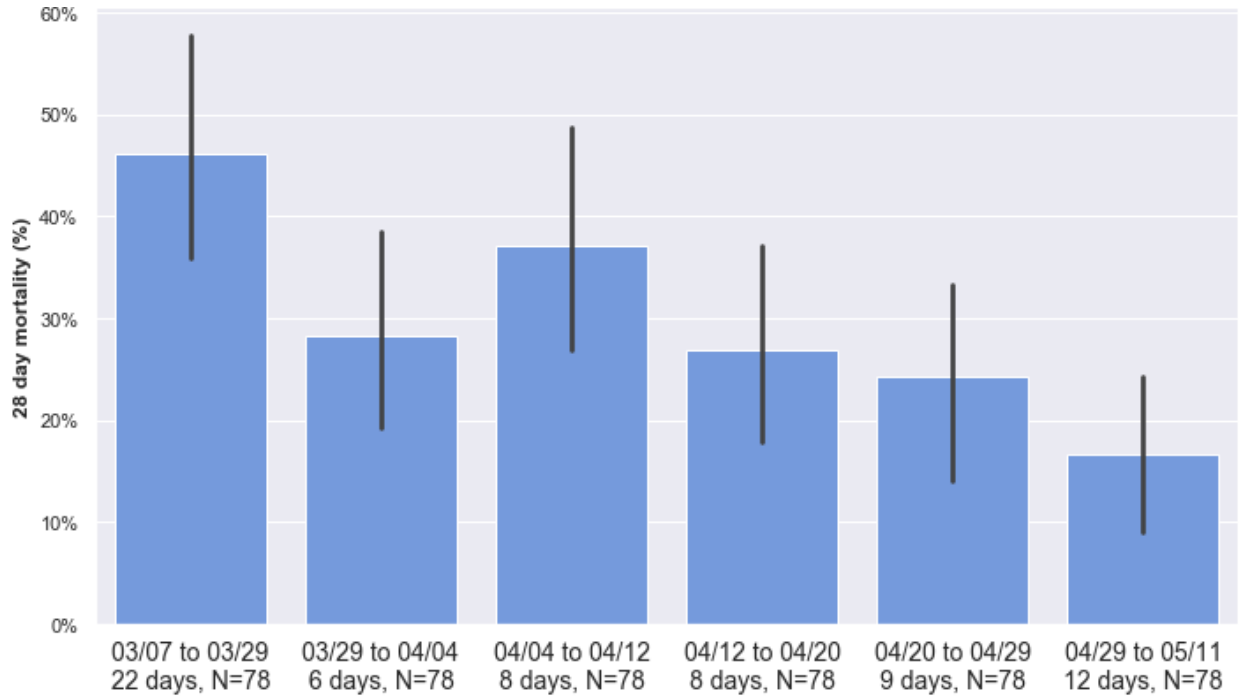


eFigure 7. All-cause death at any time over time

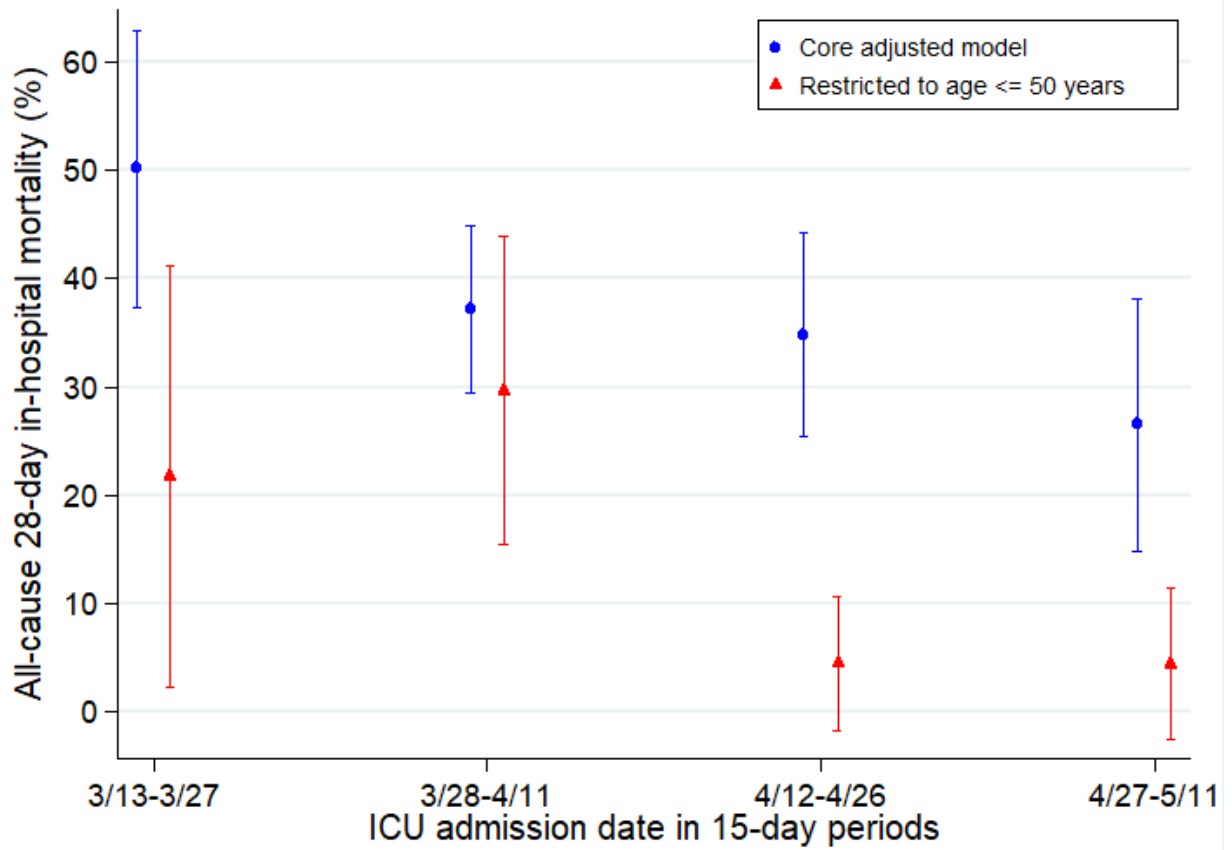


eFigure 8. All-cause 28-day in-hospital mortality over cumulative COVID-19 patient volume

All-cause 28-day in-hospital mortality decreased over cumulative COVID-19 patient volume in equal increments of 78 consecutive ICU admissions across the study period.



eFigure 9. All-cause 28-day in-hospital mortality over time among patients less than or equal to 50 years of age



eFigure 10. Age and in-hospital mortality

Notes: Red subtotals report deaths by age category.

