

Supplemental Online Content

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eTable 3. Ventilation Outcome *ICD-10-PCS* Codes

eTable 4. Vasopressor Outcome Billing Codes

eTable 5. Primary Composite Outcome by Year

eTable 6. Mortality and Deterioration Models

eTable 7. Individual Elixhauser Comorbidities

eFigure. Propensity Score Distribution

eTable 8. Propensity Score Model

eTable 9. Procalcitonin Subgroup Analysis Model

This supplemental material has been provided by the authors to give readers additional information about their work.

eTable 3. Ventilation outcome ICD-10-PCS procedure codes

Outcome	ICD-10-PCS Procedure Code	ICD-10-PCS Description
NIV	5A09357	Assistance with Respiratory Ventilation, Less than 24 Consecutive Hours, Continuous Positive Airway Pressure
NIV	5A09457	Assistance with Respiratory Ventilation, 24-96 Consecutive Hours, Continuous Positive Airway Pressure
NIV	5A09557	Assistance with Respiratory Ventilation, Greater than 96 Consecutive Hours, Continuous Positive Airway Pressure
IMV	0BH18EZ	Insertion of Endotracheal Airway into Trachea, Via Natural or Artificial Opening Endoscopic
IMV	0BH17EZ	Insertion of Endotracheal Airway into Trachea, Via Natural or Artificial Opening
IMV	5A1935Z	Respiratory Ventilation, Less than 24 Consecutive Hours
IMV	5A1945Z	Respiratory Ventilation, 24-96 Consecutive Hours
IMV	5A1955Z	Respiratory Ventilation, Greater than 96 Consecutive Hours

NIV: Non-invasive ventilation; IMV: Invasive mechanical ventilation

eTable 4. Vasopressor outcome billing codes

Medication	Billing Code Description
Dopamine	DOPAMINE IVPB 200MG 250ML
Dopamine	DOPAMINE IVPB 400MG 250ML
Dopamine	DOPAMINE IVPB 400MG 500ML
Dopamine	DOPAMINE IVPB 800MG 250ML
Dopamine	DOPAMINE IVPB 800MG 500ML
Dopamine	DOPAMINE IVPB 1600MG 500ML
Epinephrine	EPINEPHRINE 4MG/250ML
Epinephrine	EPINEPHRINE 8MG/250ML
Norepinephrine	NOREPINEPHRINE 4MG/250ML
Norepinephrine	NOREPINEPHRINE 8MG/250ML
Norepinephrine	NOREPINEPHRINE 16MG/250ML
Phenylephrine	PHENYLEPH IVPB 20MG/250ML
Phenylephrine	PHENYLEPH IVPB 30MG/250ML
Phenylephrine	PHENYLEPH IVPB 40MG/250ML
Vasopressin	VASOPRESSIN, PITRESSIN AMP 20U/ML 0.5ML
Vasopressin	VASOPRESSIN, PITRESSIN AMP 20U/ML 1ML
Vasopressin	VASOPRESSIN, PITRESSIN AMP 20U/ML 5ML

eTable 5. Annual outcomes for patients hospitalized with COVID-19 treated with and without community-acquired pneumonia (CAP) antibiotics on day 1 of admission

	All Patients <i>n</i> = 520,405	No Antibiotic Day 1 <i>n</i> = 359,923	CAP Antibiotic Day 1 <i>n</i> = 160,482
Primary Composite Outcome			
2020	28,097 (21.9%)	15,150 (21.1%)	12,947 (22.9%)
2021	43,593 (22.2%)	29,357 (21.9%)	14,236 (23.0%)
2022	21,158 (15.2%)	16,462 (14.9%)	4,696 (16.1%)
2023	6,789 (12.1%)	5,318 (12.2%)	1,471 (11.5%)
In-Hospital Mortality			
2020	7,890 (6.1%)	3,959 (5.5%)	3,931 (6.9%)
2021	10,225 (5.2%)	6,604 (4.9%)	3,621 (5.8%)
2022	3,556 (2.6%)	2,581 (2.3%)	975 (3.4%)
2023	684 (1.2%)	498 (1.1%)	186 (1.5%)
Deterioration			
2020	26,047 (20.3%)	14,007 (19.5%)	12,040 (21.3%)
2021	42,396 (21.6%)	28,531 (21.2%)	13,865 (22.4%)
2022	20,129 (14.5%)	15,702 (14.3%)	4,427 (15.2%)
2023	6,483 (11.5%)	5,086 (11.7%)	1,397 (11.0%)

eTable 6. Model outcomes for CAP antibiotic (*n* = 160,482) vs. no antibiotic treatment (*n* = 359,923) day 1 of admission in patients hospitalized for COVID-19

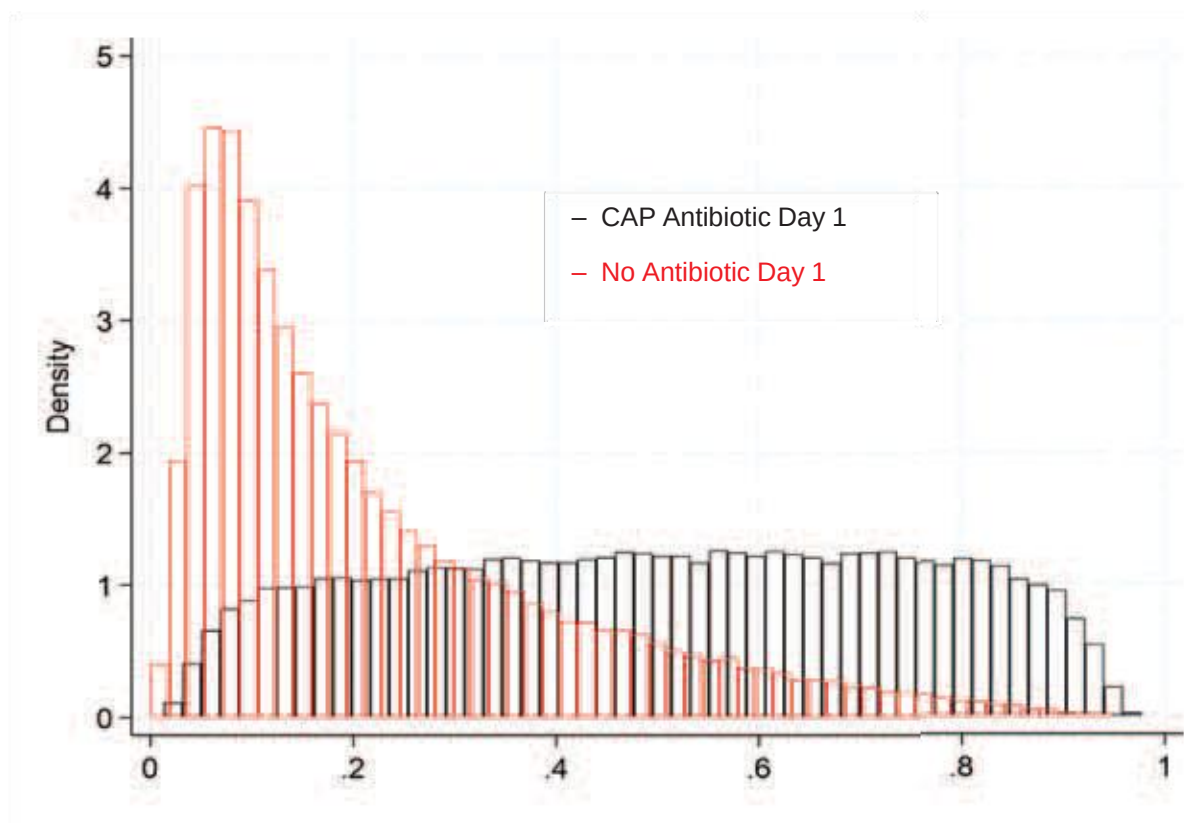
	Odds Ratio (95% CI)	P value
In-Hospital Mortality		
Unadjusted	1.59 (1.54, 1.63)	<0.001
Adjusted for covariates	1.17 (1.12, 1.21)	<0.001
Adjusted for covariates and propensity score	0.95 (0.76, 1.20)	0.67
Propensity score matched	1.09 (1.05, 1.13)	<0.001
SMRW	1.21 (1.16, 1.25)	<0.001
IPTW	1.17 (1.13, 1.21)	<0.001
Deterioration		
Unadjusted	1.31 (1.29, 1.34)	<0.001
Adjusted for covariates	1.07 (1.05, 1.09)	<0.001
Adjusted for covariates and propensity score	1.72 (1.48, 2.00)	<0.001
Propensity score matched	1.03 (1.01, 1.05)	0.006
SMRW	1.10 (1.08, 1.12)	<0.001
IPTW	1.03 (1.02, 1.05)	<0.001

CAP: Community-acquired pneumonia; SMRW: Standardized mortality ratio weighting; IPTW: Inverse probability treatment weighting

eTable 7. Elixhauser comorbidities of patients hospitalized with COVID-19 by CAP antibiotic exposure

	All Cohort				Matched Cohort		
	All Patients	No Antibiotic Day 1	CAP Antibiotic Day 1	ASD	No Antibiotic Day 1	CAP Antibiotic Day 1	ASD
	<i>n</i> = 520,405	<i>n</i> = 359,923	<i>n</i> = 160,482		<i>n</i> = 113,506	<i>n</i> = 113,506	
Comorbidities							
Cerebrovascular disease	3.2%	3.6%	2.5%	6.2%	2.9%	2.9%	0.1%
Chronic pulmonary disease	17.5%	18.0%	16.3%	4.5%	17.3%	17.2%	0.4%
Coagulopathy	6.9%	6.9%	7.1%	0.9%	7.2%	7.2%	0.1%
Dementia	9.8%	10.2%	9.0%	4.2%	10.1%	9.9%	0.8%
Depression	11.2%	11.8%	9.8%	6.5%	10.7%	10.6%	0.3%
Diabetes with chronic complications	22.3%	22.1%	22.7%	1.5%	22.8%	22.8%	0.0%
Diabetes without chronic complications	12.8%	12.6%	13.4%	2.3%	13.0%	13.1%	0.1%
Drug abuse	2.3%	2.6%	1.6%	6.9%	1.8%	1.8%	0.2%
Heart failure	12.4%	13.1%	10.9%	6.7%	12.1%	11.9%	0.4%
Hypertension, complicated	24.6%	25.7%	22.2%	8.2%	24.2%	24.1%	0.3%
Hypertension, uncomplicated	40.8%	40.3%	41.9%	3.2%	41.2%	41.3%	0.1%
Hypothyroidism	14.2%	14.5%	13.5%	2.8%	14.2%	14.1%	0.4%
Liver disease, mild	3.9%	3.8%	4.1%	1.4%	4.0%	4.0%	0.2%
Liver disease, moderate to severe	0.6%	0.6%	0.7%	0.3%	0.7%	0.7%	0.2%
Metastatic cancer	1.1%	1.2%	0.9%	3.5%	1.1%	1.0%	0.5%
Neurological disorders affecting movement	2.3%	2.3%	2.2%	1.2%	2.3%	2.3%	0.1%
Obesity	24.1%	23.1%	26.2%	7.1%	24.8%	25.0%	0.3%
Other neurological disorders	6.6%	6.7%	6.5%	1.1%	7.2%	7.0%	0.7%
Other thyroid disorders	1.5%	1.6%	1.3%	2.7%	1.4%	1.3%	0.2%
Paralysis	2.7%	2.9%	2.1%	5.4%	2.4%	2.4%	0.4%
Peptic ulcer disease with bleeding	0.4%	0.4%	0.3%	1.4%	0.4%	0.3%	0.5%
Peripheral vascular disease	4.1%	4.3%	3.4%	4.7%	3.8%	3.8%	0.3%
Psychoses	3.2%	3.5%	2.6%	5.1%	3.0%	2.9%	0.2%
Pulmonary circulation disease	2.3%	2.4%	2.0%	2.3%	2.2%	2.2%	0.0%
Renal failure, moderate	10.6%	10.7%	10.4%	0.8%	10.9%	10.9%	0.1%
Renal failure, severe	5.5%	6.0%	4.3%	7.5%	4.9%	4.9%	0.1%
Seizures and epilepsy	2.6%	2.7%	2.3%	2.7%	2.6%	2.5%	0.4%
Solid tumor without metastasis, in situ	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.2%
Solid tumor without metastasis, malignant	1.8%	1.9%	1.6%	1.7%	1.8%	1.8%	0.3%
Valvular disease	4.7%	5.1%	3.8%	6.1%	4.3%	4.3%	0.1%
Weight Loss	4.2%	4.4%	4.0%	1.9%	4.4%	4.2%	0.7%

ASD: Absolute standardized difference; CAP: Community-acquired pneumonia



eFigure 1. Propensity score distribution for patients hospitalized with COVID-19 treated with and without community-acquired pneumonia (CAP) antibiotics on day 1 of admission

eTable 8. Propensity score model to predict receipt of community-acquired pneumonia antibiotic on day 1 of admission

Variable	Odds Ratio (95% CI)	p
(Intercept)	0.4 (0.34, 0.49)	<0.001
Age		
18-20	0.66 (0.59, 0.73)	<0.001
21-30	0.71 (0.67, 0.75)	<0.001
31-40	0.76 (0.73, 0.80)	<0.001
41-50	0.78 (0.75, 0.82)	<0.001
51-60	0.81 (0.78, 0.84)	<0.001
61-70	0.82 (0.80, 0.85)	<0.001
71-88	0.88 (0.85, 0.90)	<0.001
89+	Ref	Ref
Gender		
Male	0.99 (0.98, 1.00)	0.16
Female	Ref	Ref
Race/Ethnicity		
Black	1.01 (0.99, 1.03)	0.30
Hispanic	1.11 (1.08, 1.14)	<0.001
Other	1.06 (1.03, 1.09)	<0.001
White	Ref	Ref
Insurance		
Medicaid	1.03 (1.01, 1.05)	0.25
Private	1.04 (1.00, 1.07)	0.02
Uninsured/Other/Unknown	0.98 (0.96, 1.01)	0.02
Medicare	Ref	Ref
Comorbidities		
Cerebrovascular disease	0.88 (0.84, 0.93)	<0.001
Chronic pulmonary disease	0.96 (0.95, 0.98)	<0.001
Coagulopathy	1.07 (1.02, 1.12)	0.003
Dementia	0.93 (0.91, 0.96)	<0.001
Depression	0.92 (0.90, 0.95)	<0.001
Diabetes with chronic complications	1.01 (0.99, 1.03)	0.17
Diabetes without chronic complications	0.99 (0.97, 1.01)	0.50
Drug abuse	0.85 (0.81, 0.90)	<0.001
Heart failure	0.99 (0.96, 1.02)	0.41
Hypertension, complicated	0.92 (0.89, 0.94)	<0.001
Hypertension, uncomplicated	0.95 (0.94, 0.97)	<0.001
Hypothyroidism	0.96 (0.94, 0.98)	<0.001
Liver disease, mild	1.06 (1.02, 1.10)	0.002
Liver disease, moderate to severe	1.59 (1.45, 1.74)	<0.001
Metastatic cancer	0.93 (0.87, 1.00)	0.04
Neurological disorders affecting movement	1.00 (0.95, 1.04)	0.84
Obesity	1.01 (1.00, 1.03)	0.12
Other neurological disorders	0.95 (0.91, 0.99)	0.02
Other thyroid disorders	0.90 (0.84, 0.95)	<0.001

Paralysis	0.96 (0.91, 1.02)	0.20
Peptic ulcer disease with bleeding	0.96 (0.85, 1.08)	0.50
Peripheral vascular disease	0.95 (0.92, 0.99)	0.007
Psychoses	0.89 (0.85, 0.92)	<0.001
Pulmonary circulation disease	1.09 (1.04, 1.15)	<0.001
Renal failure, moderate	1.05 (1.02, 1.08)	0.002
Renal failure, severe	0.82 (0.79, 0.85)	<0.001
Seizures and epilepsy	0.94 (0.90, 0.98)	0.006
Solid tumor without metastasis, in situ	0.64 (0.36, 1.15)	0.14
Solid tumor without metastasis, malignant	1.04 (0.99, 1.10)	0.13
Valvular disease	0.93 (0.90, 0.97)	<0.001
Weight Loss	1.16 (1.12, 1.20)	<0.001
Organ Failure		
Acidosis	1.12 (1.09, 1.16)	<0.001
Cardiovascular shock	0.91 (0.88, 0.93)	<0.001
Hematological	0.96 (0.92, 1.01)	0.09
Hepatic	0.90 (0.83, 0.99)	0.02
Neurologic	1.10 (1.06, 1.14)	<0.001
Renal	1.07 (1.05, 1.09)	<0.001
Respiratory	1.20 (1.15, 1.25)	<0.001
Early Treatment		
Blood culture	4.19 (4.12, 4.26)	<0.001
Lactate	1.26 (1.24, 1.28)	<0.001
Monoclonal antibodies	0.83 (0.77, 0.89)	<0.001
Procalcitonin	1.68 (1.65, 1.71)	<0.001
Remdesivir	1.22 (1.20, 1.24)	<0.001
Systemic steroid	1.81 (1.78, 1.85)	<0.001
Venous Thromboembolism Present on Admission		
Deep vein thrombosis	0.95 (0.88, 1.01)	0.1
Pulmonary embolism	1.09 (1.04, 1.15)	<0.001
Admission Quarter		
2020-Q3	0.57 (0.55, 0.60)	<0.001
2020-Q4	0.44 (0.43, 0.46)	<0.001
2021-Q1	0.35 (0.34, 0.36)	<0.001
2021-Q2	0.31 (0.30, 0.33)	<0.001
2021-Q3	0.29 (0.28, 0.30)	<0.001
2021-Q4	0.25 (0.24, 0.26)	<0.001
2022-Q1	0.24 (0.23, 0.25)	<0.001
2022-Q2	0.21 (0.20, 0.22)	<0.001
2022-Q3	0.21 (0.20, 0.22)	<0.001
2022-Q4	0.26 (0.25, 0.27)	<0.001
2023-Q1	0.27 (0.25, 0.28)	<0.001
2023-Q2	0.30 (0.28, 0.32)	<0.001
2023-Q3	0.27 (0.26, 0.29)	<0.001
2023-Q4	0.27 (0.26, 0.29)	<0.001

2020-Q2	Ref	Ref
Hospital Bed Size		
<200	1.25 (1.05, 1.48)	0.01
200-399	1.12 (0.95, 1.32)	0.18
399+	Ref	Ref
Hospital Census Region		
Midwest	0.72 (0.61, 0.85)	<0.001
Northeast	0.59 (0.49, 0.72)	<0.001
South	1.08 (0.93, 1.27)	0.31
West	Ref	Ref
Hospital Rurality		
Rural	1.16 (1.02, 1.33)	0.03
Urban	Ref	Ref
Teaching Hospital		
No	1.23 (1.07, 1.42)	0.003
Yes	Ref	Ref

eTable 9. Logistic regression model to predict primary composite outcome (deterioration or in-hospital mortality) among subgroup of patients hospitalized for COVID-19 with procalcitonin (PCT) lab result

Variable		OR (95% CI)	p
(Intercept)		0.2 (0.11, 0.38)	<0.001
CAP Antibiotic Day 1		1.08 (1, 1.17)	0.06
PCT 2: 0.25 ng/mL		1.49 (1.34, 1.66)	<0.001
CAP Antibiotic Day 1 * PCT 2: 0.25 ng/mL		0.97 (0.84, 1.12)	0.70
Age			
	18-20	0.48 (0.26, 0.9)	0.02
	21-30	0.57 (0.45, 0.73)	<0.001
	31-40	0.68 (0.56, 0.83)	<0.001
	41-50	0.76 (0.64, 0.91)	0.002
	51-60	0.83 (0.71, 0.99)	0.03
	61-70	0.88 (0.76, 1.03)	0.12
	71-88	0.88 (0.76, 1.01)	0.07
	89+	Ref	Ref
Gender			
	Male	1.18 (1.1, 1.25)	<0.001
	Female	Ref	Ref
Race/Ethnicity			
	Black	0.81 (0.73, 0.89)	<0.001
	Hispanic	1.08 (0.97, 1.2)	0.18
	Other	1.09 (0.98, 1.23)	0.13
	White	Ref	Ref
Insurance			
	Private	1.16 (1.06, 1.26)	<0.001
	Uninsured/Other/Unknown	1.05 (0.93, 1.18)	0.45
	Medicaid/Medicare	Ref	Ref
Comorbidities			
	Cerebrovascular disease	1.2 (0.86, 1.66)	0.28
	Chronic pulmonary disease	1.08 (1, 1.17)	0.06
	Coagulopathy	0.95 (0.79, 1.14)	0.60
	Dementia	0.86 (0.76, 0.98)	0.02
	Depression	1.12 (1.02, 1.23)	0.02
	Diabetes with chronic complications	1.29 (1.2, 1.4)	<0.001
	Diabetes without chronic complications	0.93 (0.85, 1.03)	0.18
	Drug abuse	0.86 (0.67, 1.11)	0.25
	Heart failure	1.8 (1.6, 2.03)	<0.001
	Hypertension, complicated	0.83 (0.74, 0.95)	0.005
	Hypertension, uncomplicated	1.05 (0.97, 1.14)	0.20
	Hypothyroidism	1.03 (0.95, 1.13)	0.46
	Liver disease, mild	1.22 (1.05, 1.43)	0.01
	Liver disease, moderate to severe	0.85 (0.53, 1.38)	0.51
	Metastatic cancer	1.2 (0.86, 1.66)	0.28
	Neurological disorders affecting movement	1.26 (1.02, 1.55)	0.03
	Obesity	1.88 (1.75, 2.02)	<0.001

Organ Failure	Other neurological disorders	0.6 (0.5, 0.73)	<0.001
	Other thyroid disorders	1.13 (0.87, 1.47)	0.37
	Paralysis	1.06 (0.81, 1.4)	0.67
	Peptic ulcer disease with bleeding	1.77 (1.04, 2.98)	0.03
	Peripheral vascular disease	1.2 (1.02, 1.41)	0.03
	Psychoses	1.23 (1.03, 1.47)	0.02
	Pulmonary circulation disease	1.35 (1.09, 1.67)	0.005
	Renal failure, moderate	1.04 (0.92, 1.18)	0.54
	Renal failure, severe	0.84 (0.7, 1)	0.05
	Seizures and epilepsy	1.23 (1.01, 1.5)	0.04
	Solid tumor without metastasis, in situ	1.08 (0.12, 9.64)	0.94
	Solid tumor without metastasis, malignant	1 (0.78, 1.29)	0.97
	Valvular disease	1.28 (1.1, 1.49)	0.002
	Weight Loss	1.83 (1.58, 2.13)	<0.001
Early Treatment	Acidosis	1.77 (1.58, 1.98)	<0.001
	Cardiovascular shock	3.05 (2.74, 3.39)	<0.001
	Hematological	1.64 (1.38, 1.95)	<0.001
	Hepatic	2.94 (1.98, 4.36)	<0.001
	Neurologic	3.3 (2.79, 3.91)	<0.001
	Renal	1.46 (1.34, 1.58)	<0.001
	Respiratory	3.05 (2.74, 3.39)	<0.001
Venous Thromboembolism Present on Admission	Blood culture	1.02 (0.95, 1.1)	0.50
	Lactate	1.02 (0.94, 1.11)	0.60
	Monoclonal antibodies	0.38 (0.26, 0.56)	<0.001
	Remdesivir	1.21 (1.12, 1.3)	<0.001
	Systemic steroid	1.08 (1, 1.17)	0.05
Admission Quarter	Deep vein thrombosis	1.54 (1.19, 2.01)	0.001
	Pulmonary embolism	1.85 (1.53, 2.23)	<0.001
	2020-Q3	0.9 (0.76, 1.07)	0.22
	2020-Q4	0.73 (0.64, 0.84)	<0.001
	2021-Q1	0.67 (0.57, 0.77)	<0.001
	2021-Q2	0.7 (0.58, 0.84)	<0.001
	2021-Q3	0.88 (0.76, 1.02)	0.09
	2021-Q4	0.82 (0.7, 0.96)	0.02
	2022-Q1	0.56 (0.48, 0.66)	<0.001
	2022-Q2	0.25 (0.19, 0.34)	<0.001
	2022-Q3	0.34 (0.27, 0.43)	<0.001
	2022-Q4	0.31 (0.24, 0.4)	<0.001
	2023-Q1	0.24 (0.17, 0.32)	<0.001
	2023-Q2	0.27 (0.17, 0.44)	<0.001
	2023-Q3	0.37 (0.26, 0.51)	<0.001

Hospital Bed Size	2023-Q4	0.25 (0.18, 0.35)	<0.001
	2020-Q2	Ref	Ref
Hospital Census Region	<200	0.79 (0.56, 1.11)	0.18
	200-399	0.95 (0.68, 1.34)	0.79
	399+	Ref	Ref
Hospital Rurality	Midwest	0.64 (0.37, 1.11)	0.11
	Northeast	0.7 (0.39, 1.24)	0.22
	South	0.63 (0.38, 1.06)	0.08
	West	Ref	Ref
Teaching Hospital	Rural	0.89 (0.68, 1.16)	0.40
	Urban	Ref	Ref
	No	0.97 (0.72, 1.29)	0.81
	Yes	Ref	Ref

CAP: Community-acquired pneumonia; PCT: Procalcitonin