

## Supplemental material

### Association of in-hospital use of ACE-I/ARB and COVID-19 outcomes in African American population

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**Abbreviations:**

AA, African American

ACE, angiotensin-converting enzyme

ACE1, angiotensin-converting enzyme 1

ACE2, angiotensin-converting enzyme 2

ACE-I, angiotensin-converting enzyme inhibitors

AKI, acute kidney injury

ALT, alanine aminotransferase

ARB, angiotensin receptor blockers

AT1R, angiotensin-II type 1 receptors

BPM, beats per minute

COPD, chronic obstructive pulmonary disease

DBP, diastolic blood pressure

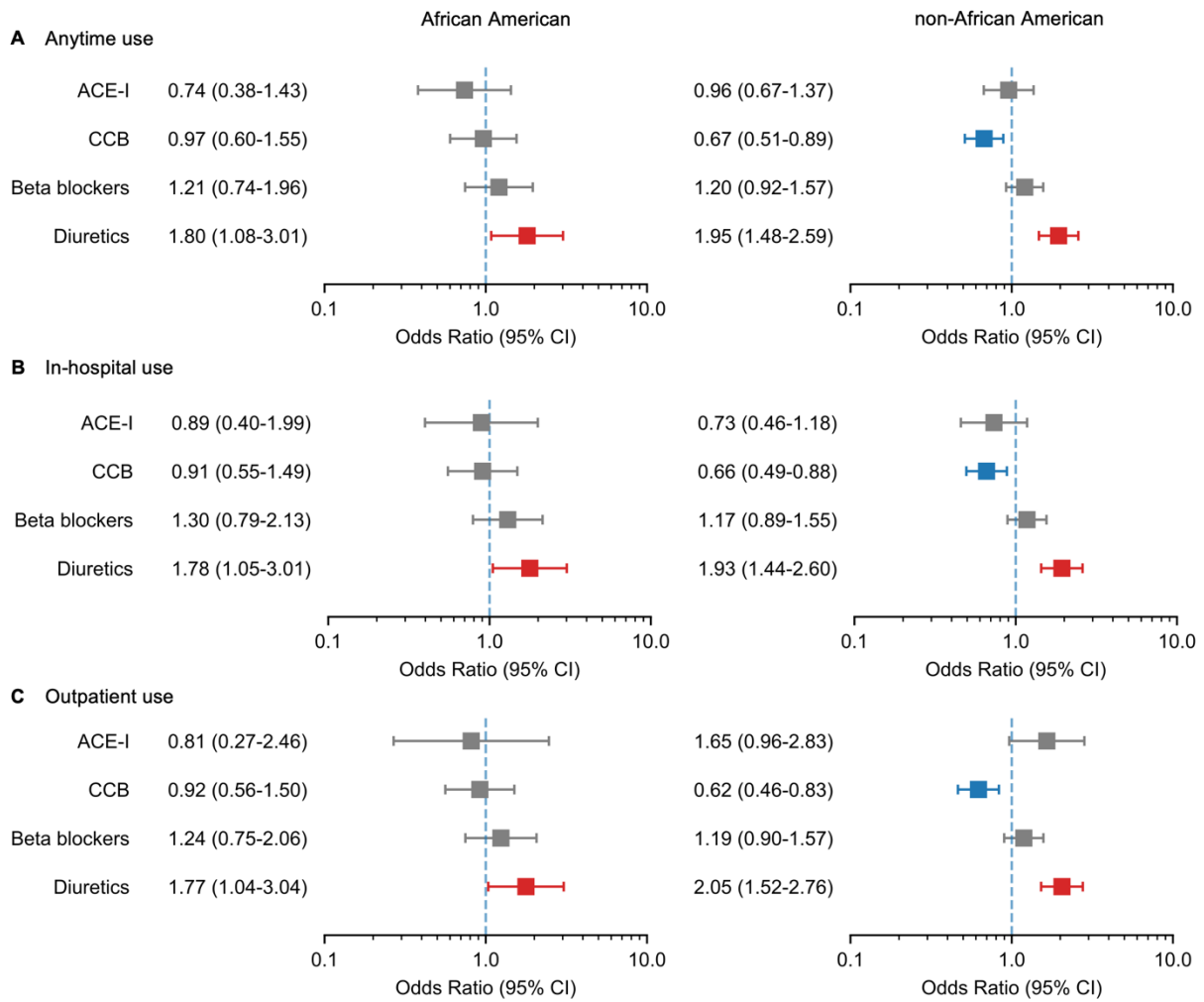
ICU, intensive care unit

IQR, interquartile ranges

RAS, renin-angiotensin system

SBP, systolic blood pressure

SD, standard deviations



**Figure S1. Different ACE-I exposure times and other antihypertensive drugs, and their associations with COVID-19 in-hospital mortality. (A)** Anytime use, AA (N=1,487), non-AA (N=4,223). **(B)** In-hospital use, AA (N=1,413), non-AA (N=4,032). **(C)** Outpatient use. Number of sample, AA (N=1,406), non-AA (N=3,990). ACE-I, angiotensin-converting enzyme inhibitors; CCB, calcium channel blocker.

**Table S1. Characteristics of COVID-19 patients in ACE-I/ARB and Non-ACE-I/ARB groups for entire population and African American patients**

	Entire Population			African American Patients		
	ACE-I/ARB	Non-ACE-I/ARB	P-value	ACE-I/ARB	Non-ACE-I/ARB	P-value
n	1139	5079		314	1317	
<b>Patient Characteristics</b>						
Age, median [Q1,Q3]	68 [60,78]	60 [43,72]	<0.001	66 [58,75]	59 [43,70]	<0.001
Sex, n (%)			<0.001			0.08
Female	462 (40.6)	2407 (47.4)		150 (47.8)	704 (53.5)	
Male	677 (59.4)	2672 (52.6)		164 (52.2)	613 (46.5)	
Race, n (%)			<0.001			
White	225 (19.8)	1223 (24.1)		NA	NA	
African American	314 (27.6)	1317 (25.9)		NA	NA	
Asian	64 (5.6)	234 (4.6)		NA	NA	
Hispanic	379 (33.3)	1434 (28.2)		NA	NA	
Other	139 (12.2)	708 (13.9)		NA	NA	
Unknown	18 (1.6)	163 (3.2)		NA	NA	
BMI (kg/m <sup>2</sup> ), mean (SD)	29.2 (7.3)	28.7 (7.7)	0.020	30.3 (8.0)	30.2 (8.9)	0.817
Smoking status, n (%)			<0.001			<0.001
Never	575 (50.5)	2798 (55.1)		147 (46.8)	712 (54.1)	
Quit	387 (34.0)	796 (15.7)		119 (37.9)	220 (16.7)	
Yes	64 (5.6)	202 (4.0)		23 (7.3)	80 (6.1)	
Not Asked	113 (9.9)	1283 (25.3)		25 (8.0)	305 (23.2)	
Temperature (F), mean (SD)	98.9 (1.5)	99.0 (1.8)	0.537	98.9 (1.7)	98.8 (1.5)	0.446
Max. temperature (F), mean (SD)	100.8 (1.8)	100.3 (2.0)	<0.001	100.7 (1.8)	100.1 (2.0)	<0.001
O2 saturation (%), median [Q1,Q3]	96.0 [93.0,98.0]	97.0 [94.0,99.0]	<0.001	96.5 [94.0,98.0]	97.0 [95.0,99.0]	<0.001
Min. O2 saturation (%), median [Q1,Q3]	90.0 [82.0,93.0]	92.0 [86.0,97.0]	<0.001	90.5 [84.8,94.0]	93.0 [88.0,98.0]	<0.001
Heart rate (BPM), mean (SD)	93.0 (19.8)	95.7 (19.8)	<0.001	94.8 (18.7)	96.1 (18.4)	0.247
Respiratory rate >25, n (%)	145 (12.7)	593 (11.7)	0.345	34 (10.8)	108 (8.2)	0.170
High BP (SBP>140 or DBP>90), n (%)	491 (43.1)	1588 (31.3)	<0.001	151 (48.1)	482 (36.6)	<0.001
<b>Antihypertensive Medications</b>						
Calcium-channel blockers, n (%)	613 (53.8)	936 (18.4)	<0.001	179 (57.0)	285 (21.6)	<0.001
Beta blockers, n (%)	543 (47.7)	926 (18.2)	<0.001	151 (48.1)	252 (19.1)	<0.001
Diuretics, n (%)	642 (56.4)	959 (18.9)	<0.001	176 (56.1)	246 (18.7)	<0.001
<b>Comorbidities</b>						

Asthma, n (%)	95 (8.3)	189 (3.7)	<0.001	29 (9.2)	61 (4.6)	0.002
COPD, n (%)	65 (5.7)	121 (2.4)	<0.001	29 (9.2)	36 (2.7)	<0.001
Hypertension, n (%)	690 (60.6)	928 (18.3)	<0.001	205 (65.3)	261 (19.8)	<0.001
Obstructive Sleep Apnea, n (%)	57 (5.0)	49 (1.0)	<0.001	20 (6.4)	17 (1.3)	<0.001
Obesity, n (%)	170 (14.9)	266 (5.2)	<0.001	62 (19.7)	83 (6.3)	<0.001
Diabetes, n (%)	457 (40.1)	575 (11.3)	<0.001	141 (44.9)	156 (11.8)	<0.001
Chronic Kidney Disease, n (%)	217 (19.1)	322 (6.3)	<0.001	78 (24.8)	110 (8.4)	<0.001
HIV, n (%)	23 (2.0)	61 (1.2)	0.043	13 (4.1)	22 (1.7)	0.013
Cancer, n (%)	135 (11.9)	299 (5.9)	<0.001	50 (15.9)	65 (4.9)	<0.001
Coronary Artery Disease, n (%)	273 (24.0)	291 (5.7)	<0.001	58 (18.5)	59 (4.5)	<0.001
Atrial Fibrillation, n (%)	134 (11.8)	168 (3.3)	<0.001	33 (10.5)	32 (2.4)	<0.001
Heart Failure, n (%)	186 (16.3)	153 (3.0)	<0.001	53 (16.9)	48 (3.6)	<0.001
Chronic Viral Hepatitis, n (%)	17 (1.5)	37 (0.7)	0.020	11 (3.5)	13 (1.0)	0.003
Liver Disease, n (%)	36 (3.2)	80 (1.6)	0.001	12 (3.8)	11 (0.8)	<0.001
Acute Kidney Injury, n (%)	99 (8.7)	241 (4.7)	<0.001	31 (9.9)	77 (5.8)	0.014
<b>Labs</b>						
WBC (K/uL), median [Q1,Q3]	7.2 [5.4,10.4]	7.6 [5.6,10.7]	0.012	6.6 [5.0,9.4]	7.5 [5.4,10.2]	0.002
CREATININE > 1.2, n (%)	514 (45.1)	1347 (26.5)	<0.001	171 (54.5)	432 (32.8)	<0.001
ANION GAP (mEq/L), mean (SD)	13.1 (4.2)	12.9 (4.3)	0.166	13.5 (5.3)	13.4 (4.8)	0.832
POTASSIUM (mmol/L), mean (SD)	4.4 (0.8)	4.4 (0.8)	0.004	4.5 (0.9)	4.4 (0.9)	0.115
ALT (U/L), median [Q1,Q3]	27.0 [17.0,45.5]	30.0 [19.0,52.0]	<0.001	22.0 [15.0,38.0]	27.0 [17.0,46.0]	0.001
<b>Hospital Conditions</b>						
ICU, n (%)	236 (20.7)	749 (14.7)	<0.001	55 (17.5)	167 (12.7)	0.031
Days after infection, median [Q1,Q3]	5.7 [2.5,9.7]	3.6 [0.6,8.0]	<0.001	5.7 [2.6,9.7]	3.5 [0.6,7.9]	<0.001
Hospital status, n (%)			<0.001			<0.001
Still Hospitalized	131 (11.5)	377 (7.4)		45 (14.3)	99 (7.5)	
Deceased	287 (25.2)	1039 (20.5)		61 (19.4)	239 (18.1)	
Discharged	721 (63.3)	3663 (72.1)		208 (66.2)	979 (74.3)	

Abbreviations: BPM, beats per minute; SBP, systolic blood pressure; DBP, diastolic blood pressure; ACE-I, angiotensin-converting enzyme inhibitors; ARBs, angiotensin receptor blockers; COPD, chronic obstructive pulmonary disease; ALT, alanine aminotransferase.

**Table S2. Characteristics of COVID-19 patients in African American and non-African American population**

	<b>African American</b>	<b>Non-African American</b>	<b>P-Value</b>
<b>n</b>	1631	4584	
<b>Antihypertensive Medications</b>			
ACE-I/ARB, n (%)	314 (19.3)	825 (18.0)	0.277
ACE-I, n (%)	161 (9.9)	444 (9.7)	0.866
ARB, n (%)	171 (10.5)	426 (9.3)	0.176
Calcium-channel blockers, n (%)	464 (28.4)	1085 (23.7)	<0.001
Beta blockers, n (%)	403 (24.7)	1066 (23.3)	0.249
Diuretics, n (%)	422 (25.9)	1179 (25.7)	0.929
<b>Patient Characteristics</b>			
Age, median [Q1,Q3]	61 [47,72]	62 [46,75]	0.012
Sex, n (%)			<0.001
Female	854 (52.4)	2015 (44.0)	
Male	777 (47.6)	2569 (56.0)	
BMI (kg/m <sup>2</sup> ), mean (SD)	30.2 (8.7)	28.3 (7.1)	<0.001
Smoking status, n (%)			<0.001
Never	859 (52.7)	2514 (54.8)	
Not Asked	330 (20.2)	1063 (23.2)	
Quit	339 (20.8)	844 (18.4)	
Yes	103 (6.3)	163 (3.6)	
Temperature (F), mean (SD)	98.9 (1.6)	99.0 (1.8)	0.02
Max. temperature (F), mean (SD)	100.2 (2.0)	100.5 (2.0)	<0.001
O <sub>2</sub> saturation (%), median [Q1,Q3]	97.0 [95.0,99.0]	96.0 [93.0,98.0]	<0.001
Min. O <sub>2</sub> saturation (%), median [Q1,Q3]	92.0 [87.0,97.0]	91.0 [84.0,96.0]	<0.001
Heart rate (BPM), mean (SD)	95.9 (18.4)	95.0 (20.2)	0.116
Respiratory rate >25, n (%)	142 (8.7)	596 (13.0)	<0.001
High BP (SBP>140 or DBP>90), n (%)	633 (38.8)	1446 (31.5)	<0.001
<b>Comorbidities</b>			
Asthma, n (%)	90 (5.5)	194 (4.2)	0.039
COPD, n (%)	65 (4.0)	121 (2.6)	0.008
Hypertension, n (%)	466 (28.6)	1152 (25.1)	0.007
Obstructive Sleep Apnea, n (%)	37 (2.3)	69 (1.5)	0.053
Obesity, n (%)	145 (8.9)	291 (6.3)	0.001
Diabetes, n (%)	297 (18.2)	735 (16.0)	0.047
Chronic Kidney Disease, n (%)	188 (11.5)	351 (7.7)	<0.001
HIV, n (%)	35 (2.1)	49 (1.1)	0.002
Cancer, n (%)	115 (7.1)	319 (7.0)	0.945
Coronary Artery Disease, n (%)	117 (7.2)	447 (9.8)	0.002
Atrial Fibrillation, n (%)	65 (4.0)	237 (5.2)	0.065
Heart Failure, n (%)	101 (6.2)	238 (5.2)	0.143
Chronic Viral Hepatitis, n (%)	24 (1.5)	30 (0.7)	0.004
Liver Disease, n (%)	23 (1.4)	93 (2.0)	0.139
Acute Kidney Injury, n (%)	108 (6.6)	232 (5.1)	0.021
<b>Labs</b>			
WBC (K/uL), median [Q1,Q3]	7.3 [5.3,10.0]	7.7 [5.6,10.8]	0.001
Creatinine > 1.2, n (%)	603 (37.0)	1258 (27.4)	<0.001
Anion Gap (mEq/L), mean (SD)	13.4 (4.9)	12.8 (4.0)	<0.001

Potassium (mmol/L), mean (SD)	4.4 (0.9)	4.4 (0.8)	0.023
ALT (U/L), median [Q1,Q3]	25.0 [17.0,45.0]	30.0 [19.0,53.0]	<0.001
<b>Hospital Conditions</b>			
ICU, n (%)	222 (13.6)	763 (16.6)	0.004
Days after infection, median [Q1,Q3]	3.8 [0.6,8.5]	3.8 [0.7,8.6]	0.407
Hospital status, n (%)			0.003
Censored	144 (8.8)	364 (7.9)	
Deceased	300 (18.4)	1026 (22.4)	
Discharged	1187 (72.8)	3194 (69.7)	

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; BPM, beats per minute; SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; ALT, alanine aminotransferase.

**Table S3. Adjusted odds ratios for COVID-19 in-hospital mortality in different race groups associated with ACE-I/ARB and other covariates**

	All Races (N=5,710)		African American (N=1,487)		Non-African American (N=4,223)	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
<b>Antihypertensive Medications</b>						
ACE-I/ARB	0.655 (0.505-0.850)	0.001	0.440 (0.249-0.779)	0.005	0.748 (0.553-1.012)	0.060
Calcium-channel blockers	0.784 (0.620-0.992)	0.043	1.029 (0.638-1.662)	0.905	0.695 (0.527-0.916)	0.010
Beta blockers	1.212 (0.964-1.522)	0.100	1.219 (0.748-1.986)	0.427	1.226 (0.940-1.600)	0.133
Diuretics	2.077 (1.621-2.664)	<0.001	2.063 (1.218-3.494)	0.007	2.054 (1.543-2.735)	<0.001
<b>Patient Characteristics</b>						
Age	1.082 (1.071-1.093)	<0.001	1.092 (1.069-1.116)	<0.001	1.083 (1.070-1.095)	<0.001
Male	1.071 (0.855-1.342)	0.550	1.234 (0.759-2.006)	0.397	1.051 (0.809-1.366)	0.708
Race: African American	0.685 (0.507-0.925)	0.013	N/A	N/A	N/A	N/A
Race: Asian	0.720 (0.415-1.247)	0.241	N/A	N/A	N/A	N/A
Race: Hispanic	0.793 (0.593-1.061)	0.118	N/A	N/A	N/A	N/A
Race: Other	0.708 (0.497-1.008)	0.056	N/A	N/A	N/A	N/A
Race: Unknown	0.677 (0.349-1.315)	0.249	N/A	N/A	N/A	N/A
Smoking Status: Not Asked	1.161 (0.864-1.557)	0.322	1.259 (0.674-2.351)	0.470	1.037 (0.736-1.459)	0.836
Smoking Status: Quit	1.122 (0.861-1.462)	0.397	1.059 (0.597-1.876)	0.846	1.119 (0.822-1.520)	0.476
Smoking Status: Yes	1.531 (0.902-2.599)	0.114	3.504 (1.398-8.785)	0.007	0.798 (0.393-1.618)	0.532
BMI	1.008 (0.993-1.023)	0.301	1.015 (0.986-1.045)	0.306	1.006 (0.987-1.024)	0.544
Temperature	0.974 (0.923-1.028)	0.342	0.924 (0.791-1.080)	0.321	0.984 (0.928-1.044)	0.597
Max. Temperature	1.218 (1.139-1.302)	<0.001	1.186 (1.025-1.373)	0.021	1.237 (1.146-1.338)	<0.001
O2 Saturation	0.999 (0.982-1.017)	0.919	0.985 (0.947-1.025)	0.472	1.007 (0.987-1.027)	0.506
Min. O2 Saturation	0.936 (0.927-0.945)	<0.001	0.948 (0.933-0.964)	<0.001	0.930 (0.919-0.941)	<0.001
Heart Rate	1.004 (0.998-1.010)	0.167	1.000 (0.988-1.013)	0.943	1.004 (0.998-1.011)	0.213
Respiratory Rate > 25	1.411 (1.053-1.887)	0.021	1.579 (0.788-3.165)	0.197	1.395 (1.003-1.941)	0.048
High BP (SBP>140 or DBP>90)	0.881 (0.705-1.100)	0.263	0.842 (0.528-1.344)	0.472	0.887 (0.683-1.153)	0.369
<b>Comorbidities</b>						
Asthma	0.501 (0.296-0.850)	0.010	0.374 (0.121-1.161)	0.089	0.523 (0.280-0.976)	0.042
COPD	1.359 (0.824-2.241)	0.229	1.094 (0.415-2.889)	0.856	1.462 (0.793-2.697)	0.223
Hypertension	0.901 (0.688-1.179)	0.447	0.671 (0.366-1.231)	0.197	0.999 (0.734-1.361)	0.997
Obstructive Sleep Apnea	1.611 (0.779-3.333)	0.199	0.795 (0.187-3.370)	0.755	1.980 (0.841-4.660)	0.118



Obesity	1.124 (0.733-1.723)	0.592	2.477 (1.083-5.663)	0.032	0.829 (0.490-1.404)	0.485
Diabetes	1.081 (0.814-1.436)	0.591	1.471 (0.803-2.694)	0.212	0.942 (0.677-1.311)	0.724
Chronic Kidney Disease	1.115 (0.780-1.594)	0.548	1.125 (0.571-2.214)	0.734	1.107 (0.718-1.707)	0.643
HIV	1.763 (0.749-4.150)	0.194	1.077 (0.172-6.753)	0.937	2.312 (0.831-6.437)	0.108
Cancer	1.342 (0.951-1.893)	0.094	2.323 (1.138-4.740)	0.021	1.095 (0.728-1.649)	0.661
Coronary Artery Disease	1.070 (0.767-1.492)	0.691	1.788 (0.840-3.804)	0.132	0.927 (0.633-1.357)	0.696
Atrial Fibrillation	0.927 (0.624-1.377)	0.708	1.430 (0.563-3.633)	0.452	0.869 (0.553-1.366)	0.544
Heart Failure	0.971 (0.643-1.467)	0.889	0.607 (0.243-1.517)	0.285	1.046 (0.648-1.687)	0.855
Liver Disease	1.489 (0.772-2.872)	0.235	1.766 (0.355-8.785)	0.487	1.636 (0.800-3.347)	0.178
Acute Kidney Injury	1.078 (0.723-1.606)	0.714	0.589 (0.268-1.292)	0.186	1.499 (0.919-2.450)	0.105
<b>Labs</b>						
WBC	1.018 (0.997-1.040)	0.094	1.015 (0.968-1.064)	0.540	1.019 (0.995-1.045)	0.122
Creatinine > 1.2	1.732 (1.342-2.234)	<0.001	1.744 (1.004-3.028)	0.049	1.699 (1.266-2.280)	<0.001
Anion Gap	1.079 (1.050-1.110)	<0.001	1.052 (1.003-1.104)	0.038	1.104 (1.065-1.146)	<0.001
Potassium	1.174 (1.028-1.339)	0.017	1.117 (0.877-1.425)	0.369	1.204 (1.022-1.418)	0.026
ALT	1.001 (1.000-1.002)	0.184	1.002 (0.999-1.006)	0.172	1.001 (0.999-1.002)	0.449
<b>Hospital Conditions</b>						
ICU	3.881 (2.930-5.140)	<0.001	8.109 (4.336-15.165)	<0.001	3.062 (2.217-4.229)	<0.001
Duration (days)	0.966 (0.950-0.982)	<0.001	0.972 (0.939-1.008)	0.126	0.963 (0.945-0.981)	<0.001

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; ALT, alanine aminotransferase.

**Table S4. Interaction between ACE-I/ARB and African American population from multivariable logistic regression also adjusted by other confounders**

Interaction Terms	Anytime use		In-hospital use		Outpatient use	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
<i>ACE-I/ARB use</i>						
ACE-I/ARB	0.708 (0.528-0.949)	0.021	0.605 (0.420-0.871)	0.007	1.122 (0.726-1.732)	0.605
ACE-I/ARB * AA	0.736 (0.428-1.266)	0.268	0.825 (0.413-1.648)	0.585	0.695 (0.311-1.550)	0.373
AA	0.896 (0.672-1.193)	0.451	0.897 (0.673-1.198)	0.463	0.879 (0.660-1.172)	0.381
<i>ACE-I use</i>						
ACE-I	0.908 (0.640-1.287)	0.588	0.662 (0.414-1.058)	0.085	1.661 (0.983-2.807)	0.058
ACE-I * AA	0.817 (0.413-1.617)	0.562	1.375 (0.572-3.303)	0.476	0.490 (0.168-1.426)	0.191
AA	0.844 (0.648-1.101)	0.212	0.836 (0.640-1.092)	0.188	0.832 (0.638-1.085)	0.176
<i>ARB use</i>						
ARB	0.708 (0.493-1.016)	0.061	0.669 (0.419-1.068)	0.092	0.998 (0.581-1.712)	0.993
ARB * AA	0.797 (0.403-1.577)	0.516	0.488 (0.185-1.292)	0.149	1.299 (0.477-3.540)	0.609
AA	0.854 (0.654-1.114)	0.244	0.863 (0.661-1.126)	0.278	0.842 (0.645-1.099)	0.206

**Note:** among patients of anytime use, the odds ratio of in-hospital death in AA population who received ACE-I/ARB compared to non-AA population who also received ACE-I/ARB is calculated as  $0.736 \times 0.896 = 0.659$ ; among patients of in-hospital use, the odds ratio of in hospital-death in AA population who received ARB compared to non-AA population who also received ARB is calculated as  $0.488 \times 0.863 = 0.421$

**Table S5. Adjusted odds ratios of secondary outcomes for African American COVID-19 patients associated with ACE-I/ARB and other covariates**

	ICU (N=1,487)		AKI (N=1,487)	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
<b>Antihypertensive Medications</b>				
ACE-I/ARB	0.709 (0.419-1.198)	0.198	1.306 (0.721-2.364)	0.379
Calcium-channel blockers	0.953 (0.599-1.514)	0.838	1.043 (0.617-1.762)	0.876
Beta blockers	1.986 (1.253-3.146)	0.003	1.671 (0.989-2.824)	0.055
Diuretics	4.728 (2.918-7.660)	<0.001	0.590 (0.325-1.071)	0.083
<b>Patient Characteristics</b>				
Age	0.985 (0.969-1.002)	0.082	0.994 (0.974-1.015)	0.563
Male	1.102 (0.692-1.755)	0.682	0.954 (0.557-1.631)	0.862
Smoking Status: Not Asked	2.437 (1.362-4.360)	0.003	1.173 (0.597-2.307)	0.644
Smoking Status: Quit	1.020 (0.582-1.787)	0.946	0.763 (0.402-1.448)	0.407
Smoking Status: Yes	2.595 (1.127-5.976)	0.025	0.776 (0.261-2.313)	0.649
BMI	1.034 (1.008-1.060)	0.011	0.988 (0.956-1.020)	0.455
Temperature	0.755 (0.655-0.872)	<0.001	0.910 (0.759-1.090)	0.307
Max. Temperature	1.510 (1.310-1.740)	<0.001	0.857 (0.716-1.026)	0.093
O2 Saturation	0.996 (0.963-1.029)	0.793	0.976 (0.941-1.013)	0.206
Min. O2 Saturation	0.970 (0.960-0.981)	<0.001	0.999 (0.984-1.014)	0.877
Heart Rate	1.009 (0.997-1.021)	0.163	1.001 (0.988-1.014)	0.939
Respiratory Rate > 25	2.138 (1.156-3.954)	0.015	1.070 (0.518-2.211)	0.855
High BP (SBP>140 or DBP>90)	0.891 (0.567-1.399)	0.615	0.735 (0.431-1.253)	0.257
<b>Comorbidities</b>				
Asthma	0.891 (0.352-2.257)	0.808	3.210 (1.212-8.499)	0.019
COPD	0.557 (0.201-1.544)	0.261	1.517 (0.400-5.742)	0.540
Hypertension	0.873 (0.488-1.563)	0.649	1.675 (0.867-3.237)	0.125
Obstructive Sleep Apnea	2.457 (0.848-7.121)	0.098	0.211 (0.022-1.986)	0.174
Obesity	0.468 (0.214-1.025)	0.058	1.491 (0.611-3.641)	0.380
Diabetes	1.513 (0.873-2.622)	0.140	0.644 (0.345-1.200)	0.166
Chronic Kidney Disease	0.371 (0.179-0.770)	0.008	0.858 (0.443-1.663)	0.650
HIV	1.963 (0.537-7.173)	0.308	0.918 (0.217-3.879)	0.907
Cancer	1.054 (0.494-2.249)	0.891	0.801 (0.307-2.089)	0.650
Coronary Artery Disease	1.733 (0.808-3.713)	0.158	0.511 (0.199-1.315)	0.164
Atrial Fibrillation	0.628 (0.229-1.723)	0.367	1.558 (0.580-4.183)	0.379
Heart Failure	1.486 (0.650-3.399)	0.348	0.449 (0.150-1.346)	0.153
Liver Disease	0.291 (0.043-1.983)	0.207	1.907 (0.352-10.332)	0.454
<b>Labs</b>				
WBC	1.034 (0.991-1.078)	0.119	1.034 (0.983-1.088)	0.192
Creatinine > 1.2	0.685 (0.414-1.133)	0.141	38.538 (11.297-131.468)	<0.001
Anion Gap	1.044 (0.999-1.091)	0.053	1.045 (1.001-1.091)	0.044
Potassium	1.132 (0.881-1.455)	0.334	1.059 (0.831-1.351)	0.642
ALT	0.999 (0.996-1.002)	0.573	1.004 (1.000-1.007)	0.044
<b>Hospital Conditions</b>				
Duration (days)	1.053 (1.019-1.087)	0.002	1.007 (0.967-1.049)	0.723

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; ALT, alanine aminotransferase.

**Table S6. ACE-I/ARB in-hospital use: adjusted odds ratios for COVID-19 in-hospital mortality in different race groups**

	All Races (N=5,240)		African American (N=1,356)		Non-African American (N=3,884)	
	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
<b>Antihypertensive Medications</b>						
ACE-I/ARB	0.575 (0.419-0.791)	0.001	0.378 (0.188-0.760)	0.006	0.652 (0.449-0.946)	0.024
Calcium-channel blockers	0.745 (0.577-0.964)	0.025	0.919 (0.549-1.540)	0.75	0.678 (0.501-0.919)	0.012
Beta blockers	1.218 (0.951-1.560)	0.118	1.229 (0.728-2.071)	0.44	1.265 (0.946-1.690)	0.113
Diuretics	1.908 (1.456-2.497)	<0.001	1.775 (1.007-3.130)	0.047	1.887 (1.379-2.581)	<0.001
<b>Patient Characteristics</b>						
Age	1.082 (1.071-1.094)	<0.001	1.094 (1.069-1.120)	<0.001	1.082 (1.069-1.096)	<0.001
Male	0.944 (0.740-1.203)	0.639	1.178 (0.698-1.990)	0.539	0.908 (0.684-1.206)	0.505
Race: African American	0.755 (0.548-1.040)	0.085	N/A	N/A	N/A	N/A
Race: Asian	0.835 (0.463-1.508)	0.551	N/A	N/A	N/A	N/A
Race: Hispanic	0.839 (0.614-1.148)	0.273	N/A	N/A	N/A	N/A
Race: Other	0.753 (0.516-1.097)	0.14	N/A	N/A	N/A	N/A
Race: Unknown	0.740 (0.375-1.459)	0.385	N/A	N/A	N/A	N/A
Smoking Status: Not Asked	1.203 (0.888-1.631)	0.233	1.420 (0.746-2.705)	0.286	1.067 (0.749-1.520)	0.718
Smoking Status: Quit	1.201 (0.898-1.608)	0.218	1.335 (0.715-2.494)	0.365	1.135 (0.808-1.595)	0.463
Smoking Status: Yes	1.624 (0.924-2.852)	0.092	3.963 (1.514-10.360)	0.005	0.757 (0.351-1.631)	0.476
BMI	1.008 (0.992-1.024)	0.329	1.015 (0.984-1.046)	0.352	1.009 (0.989-1.028)	0.394
Temperature	0.983 (0.929-1.040)	0.548	0.946 (0.803-1.117)	0.518	0.988 (0.929-1.051)	0.709
Max. Temperature	1.235 (1.150-1.326)	<0.001	1.206 (1.034-1.406)	0.017	1.255 (1.155-1.363)	<0.001
O2 Saturation	0.992 (0.973-1.011)	0.409	0.987 (0.946-1.028)	0.533	0.997 (0.975-1.019)	0.784
Min. O2 Saturation	0.937 (0.927-0.946)	<0.001	0.950 (0.934-0.966)	<0.001	0.931 (0.919-0.943)	<0.001
Heart Rate	1.003 (0.997-1.010)	0.284	0.998 (0.985-1.012)	0.818	1.004 (0.996-1.011)	0.325
Respiratory Rate > 25	1.339 (0.977-1.833)	0.069	1.336 (0.619-2.883)	0.461	1.339 (0.941-1.904)	0.105
High BP (SBP>140 or DBP>90)	0.873 (0.687-1.108)	0.265	0.787 (0.477-1.298)	0.348	0.868 (0.654-1.150)	0.325
<b>Comorbidities</b>						
Asthma	0.548 (0.304-0.989)	0.046	0.222 (0.051-0.965)	0.045	0.650 (0.330-1.281)	0.213
COPD	1.575 (0.893-2.779)	0.117	1.793 (0.586-5.490)	0.307	1.610 (0.804-3.222)	0.179
Hypertension	0.903 (0.672-1.213)	0.497	0.734 (0.386-1.398)	0.347	0.975 (0.692-1.373)	0.886
Obstructive Sleep Apnea	1.465 (0.590-3.644)	0.411	0.647 (0.122-3.428)	0.609	1.958 (0.654-5.859)	0.23
Obesity	0.863 (0.525-1.419)	0.563	2.411 (0.944-6.160)	0.066	0.553 (0.294-1.039)	0.066
Diabetes	1.043 (0.757-1.436)	0.799	1.188 (0.602-2.344)	0.619	0.949 (0.652-1.381)	0.785

Chronic Kidney Disease	1.006 (0.665-1.522)	0.978	0.975 (0.448-2.125)	0.95	1.033 (0.623-1.713)	0.9
HIV	2.460 (0.978-6.178)	0.056	1.354 (0.141-12.975)	0.793	2.729 (0.942-7.901)	0.064
Cancer	1.335 (0.914-1.952)	0.135	2.113 (0.962-4.637)	0.063	1.068 (0.681-1.675)	0.775
Coronary Artery Disease	1.323 (0.902-1.939)	0.151	1.891 (0.774-4.618)	0.162	1.203 (0.779-1.861)	0.404
Atrial Fibrillation	0.874 (0.553-1.381)	0.564	1.112 (0.369-3.353)	0.851	0.860 (0.512-1.445)	0.569
Heart Failure	0.892 (0.537-1.480)	0.659	0.638 (0.219-1.857)	0.409	0.928 (0.511-1.685)	0.806
Liver Disease	1.275 (0.610-2.667)	0.519	2.330 (0.406-13.370)	0.343	1.307 (0.579-2.954)	0.519
Acute Kidney Injury	1.067 (0.672-1.692)	0.783	0.473 (0.194-1.153)	0.099	1.619 (0.909-2.883)	0.102
<b>Labs</b>						
WBC	1.009 (0.985-1.033)	0.468	0.992 (0.942-1.045)	0.765	1.015 (0.988-1.044)	0.279
Creatinine > 1.2	1.659 (1.261-2.181)	<0.001	1.980 (1.099-3.564)	0.023	1.584 (1.155-2.173)	0.004
Anion Gap	1.087 (1.053-1.121)	<0.001	1.060 (1.003-1.121)	0.04	1.102 (1.058-1.147)	<0.001
Potassium	1.177 (1.018-1.361)	0.027	1.053 (0.813-1.363)	0.695	1.236 (1.033-1.480)	0.021
ALT	1.001 (0.999-1.002)	0.358	1.001 (0.998-1.005)	0.397	1.000 (0.999-1.002)	0.585
<b>Hospital Conditions</b>						
ICU	4.255 (3.149-5.749)	<0.001	9.393 (4.802-18.394)	<0.001	3.397 (2.404-4.807)	<0.001
Duration (days)	0.967 (0.950-0.984)	<0.001	0.972 (0.937-1.009)	0.141	0.964 (0.945-0.983)	<0.001

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; ALT, alanine aminotransferase.

**Table S7. Inverse propensity-weighted logistic regression results for COVID-19 in-hospital mortality in different race groups and ACE-I/ARB exposure time**

<b>Drug (Year 2019-2020)</b>	<b>All Races</b>		<b>African American</b>		<b>Non-African American</b>	
	<b>Adjusted OR (95% CI)</b>	<b>p-value</b>	<b>Adjusted OR (95% CI)</b>	<b>p-value</b>	<b>Adjusted OR (95% CI)</b>	<b>p-value</b>
<b>ACE-I/ARB use</b>						
Anytime use	0.673 (0.511-0.886)	0.005	0.381 (0.204-0.712)	0.003	0.765 (0.556-1.052)	0.100
In-hospital use	0.577 (0.418-0.795)	< 0.001	0.307 (0.140-0.672)	0.003	0.653 (0.450-0.948)	0.025
Outpatient use	0.941 (0.626-1.415)	0.770	0.534 (0.224-1.273)	0.157	0.927 (0.567-1.518)	0.764
<b>ACE-I use</b>						
Anytime use	0.951 (0.689-1.313)	0.761	0.684 (0.321-1.458)	0.326	1.016 (0.708-1.456)	0.933
In-hospital use	0.724 (0.489-1.071)	0.106	4.113 (0.409-41.37)	0.230	0.787 (0.496-1.250)	0.311
Outpatient use	1.347 (0.846-2.144)	0.209	0.824 (0.192-3.526)	0.794	1.730 (0.970-3.086)	0.063
<b>ARB use</b>						
Anytime use	0.636 (0.464-0.870)	0.005	0.428 (0.190-0.966)	0.041	0.655 (0.454-0.946)	0.024
In-hospital use	0.514 (0.340-0.775)	0.002	0.144 (0.049-0.428)	< 0.001	0.609 (0.384-0.966)	0.035
Outpatient use	0.761 (0.480-1.209)	0.248	0.637 (0.187-2.166)	0.470	0.594 (0.351-1.005)	0.053

**Table S8. ACE-I/ARB and potential confounding medication categories including detailed medication names**

<b>Medication Category</b>	<b>Medication Names</b>
ACE-I	Benazepril hydrochloride, Captopril, Enalapril maleate, Fosinopril sodium, Lisinopril, Moexipril, Perindopril, Quinapril hydrochloride, Ramipril, Trandolapril
ARB	Azilsartan, Candesartan, Eprosartan mesylate, Irbesartan, losartan potassium, Olmesartan, Telmisartan, Valsartan
Diuretics	Chlorthalidone, Chlorothiazide, Hydrochlorothiazide, Indapamide, Metolazone, Amiloride hydrochloride, Spironolactone, Triamterene, Eplerenone, Furosemide, Bumetanide, Torsemide, Ethacrynic acid
Beta Blockers	Acebutolol, Atenolol, Betaxolol, Bisoprolol fumarate, Carteolol hydrochloride, Metoprolol, Nadolol, Nebivolol, Penbutolol sulfate, Pindolol, Propranolol hydrochloride, Solotol hydrochloride, Timolol maleate
Calcium-channel Blockers	Amlodipine, Bepridil, Diltiazem hydrochloride, Felodipine, Isradipine, Nicardipine, Nifedipine, Nisoldipine, Verapamil hydrochloride

Abbreviations: ACE-I, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers.