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1 **Title:** Covid-19 Testing, Hospital Admission, and Intensive Care Among 2,026,227 United States
2 Veterans Aged 54-75 Years

3
4 **Authors:** Christopher T. Rentsch, Ph.D.^{1,2}, Farah Kidwai-Khan, MS^{1,3*}, Janet P. Tate, Sc.D.^{1,3*},
5 Lesley S. Park, Ph.D.^{4*}, Joseph T. King, Jr., M.D.^{1,5*}, Melissa Skanderson, MSW^{1*}, Ronald G.
6 Hauser, M.D.^{1,6}, Anna Schultze, Ph.D.², Christopher I. Jarvis, Ph.D.², Mark Holodniy, M.D.^{7,8},
7 Vincent Lo Re III, M.D.⁹, Kathleen M. Akgün, M.D.^{1,3}, Kristina Crothers, M.D.¹⁰, Tamar H. Taddei,
8 M.D.^{1,3}, Matthew S. Freiberg, M.D.^{11,12}, and Amy C. Justice, M.D.^{1,3,13}

- 9
10 1. VA Connecticut Healthcare System, US Department of Veterans Affairs, West Haven, CT,
11 US, 06516
12 2. Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical
13 Medicine, London, UK, WC1E 7HT
14 3. Department of Internal Medicine, Yale School of Medicine, New Haven, CT, US, 06520
15 4. Stanford Center for Population Health Sciences, Stanford University School of Medicine,
16 Stanford, CA, US, 94305
17 5. Department of Neurosurgery, Yale School of Medicine, New Haven, CT, US, 06520
18 6. Department of Laboratory Medicine, Yale School of Medicine, New Haven, CT, US,
19 06520
20 7. VA Palo Alto Healthcare System, US Department of Veterans Affairs, Palo Alto, CA, US,
21 94304
22 8. Division of Infectious Diseases and Geographic Medicine, Stanford University School of
23 Medicine, Stanford, CA, US, 94305
24 9. Division of Infectious Diseases, Department of Medicine and Center for Clinical
25 Epidemiology and Biostatistics, Department of Biostatistics, Epidemiology, and
26 Informatics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA,
27 US, 19104
28 10. VA Puget Sound Health Care System and Department of Medicine, University of
29 Washington School of Medicine, Seattle, WA, US, 98104
30 11. Geriatric Research Education and Clinical Center (GRECC), US Department of Veterans
31 Affairs, Tennessee Valley Health Care System, Nashville, TN, US 37212
32 12. Department of Medicine, Vanderbilt University Medical Center, Nashville, TN, US, 37232
33 13. Center for Interdisciplinary Research on AIDS, Yale School of Public Health, New Haven,
34 CT, US, 06511

35
36 *These authors contributed equally

37
38 **Corresponding author:**

39 Amy C. Justice, M.D., Ph.D.
40 Yale School of Medicine
41 VA Connecticut Healthcare System
42 950 Campbell Ave
43 Bldg 35A, Rm 2-209 (11-ACSLG)
44 West Haven, CT 06516

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47

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49

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51

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54 **Key Points**

55 **Question:** What are the demographic and clinical characteristics associated with testing
56 positive for coronavirus 2019 (Covid-19+), and among Covid-19+ subsequent hospitalization
57 and intensive care among Veterans in the United States?

58 **Findings:** In this retrospective cohort study of 2,026,227 Veterans aged 54-75 years and active
59 in care, 585/3,789 (15.4%) tested Covid-19+. Black race was strongly associated with Covid-19+,
60 but not with hospitalization or intensive care. Among Covid-19+, laboratory abnormalities and a
61 summary measure of physiologic injury were strongly associated with hospitalization and
62 intensive care.

63 **Meaning:** Racial differences in testing positive for Covid-19 may be an underestimate of the
64 general population as racial health disparities in the Veterans Affairs Healthcare System tend to
65 be smaller than in the private sector. Risk of hospitalization and intensive care may be better
66 characterized by laboratory measures and vital signs than by comorbid conditions or prior
67 medication exposure.

68 **Abstract**

69 **Importance:** Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection causes
70 coronavirus disease 2019 (Covid-19), an evolving pandemic. Limited data are available
71 characterizing SARS-Cov-2 infection in the United States.

72 **Objective:** To determine associations between demographic and clinical factors and testing
73 positive for coronavirus 2019 (Covid-19+), and among Covid-19+ subsequent hospitalization
74 and intensive care.

75 **Design:** Retrospective cohort study including all patients tested for Covid-19 between February
76 8 and March 30, 2020, inclusive.

77 **Setting:** We extracted electronic health record data from the national Veterans Affairs
78 Healthcare System, the largest integrated healthcare system in the United States.

79 **Participants:** Veterans Birth Cohort comprising 2,026,227 patients born between 1945 and
80 1965 and active in care.

81 **Exposures:** Demographic data, comorbidities, medication history, substance use, vital signs, and
82 laboratory measures. Laboratory tests were analyzed first individually and then grouped into a
83 validated summary measure of physiologic injury (VACS Index).

84 **Main Outcomes and Measures:** We evaluated which factors were associated with Covid-19+
85 among all who tested. Among Covid-19+ we identified factors associated with hospitalization or
86 intensive care. We identified independent associations using multivariable and conditional
87 multivariable logistic regression with multiple imputation of missing values.

88 **Results:** Among Veterans aged 54-75 years, 585/3,789 (15.4%) tested Covid-19+. In adjusted
89 analysis (C -statistic=0.806) black race was associated with Covid-19+ (OR 4.68, 95% CI 3.79-

90 5.78) and the association remained in analyses conditional on site (OR 2.56, 95% CI 1.89-3.46).

91 In adjusted models, laboratory abnormalities (especially fibrosis-4 score [FIB-4] >3.25 OR 8.73,

92 95% CI 4.11-18.56), and VACS Index (per 5-point increase OR 1.62, 95% CI 1.43-1.84) were

93 strongly associated with hospitalization. Associations were similar for intensive care. Although

94 significant in unadjusted analyses, associations with comorbid conditions and medications were

95 substantially reduced and, in most cases, no longer significant after adjustment.

96 **Conclusions and Relevance:** Black race was strongly associated with Covid-19+, but not with

97 hospitalization or intensive care. Among Covid-19+, risk of hospitalization and intensive care

98 may be better characterized by laboratory measures and vital signs than by comorbid

99 conditions or prior medication exposure.

100 **Introduction**

101 Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection causes coronavirus
102 disease 2019 (Covid-19) and is an evolving pandemic. Limited data are available characterizing
103 SARS-Cov-2 infection in the United States. Unadjusted analyses restricted to Covid-19 cases in
104 China,¹⁻⁵ Italy,⁶ and the United States^{7,8} suggest that older age, diabetes, chronic obstructive
105 lung disease (COPD), hypertension, vascular disease, renal disease, and liver disease are
106 associated with more severe disease. Further, while some have speculated that use of
107 angiotensin converting enzyme inhibitor (ACE), angiotensin II receptor blockers (ARB), and
108 nonsteroidal anti-inflammatory drugs (NSAID) may exacerbate disease,^{9,10} no analysis of this
109 question has been published.

110

111 The Department of Veterans Affairs (VA) is the largest integrated healthcare system in the
112 United States. All care is recorded in a national electronic health record with daily uploads into
113 a central data repository. As a result, it is possible to extract data on patients tested for Covid-
114 19, including outpatient and inpatient records, laboratory values, and pharmacy fill/refill data.
115 When a well-characterized longitudinal cohort is supplemented with Covid-19 testing data, it is
116 possible to answer important questions rapidly using validated methods.

117

118 The VA Birth Cohort includes all Veterans born between 1945 and 1965, over 2 million living
119 individuals aged 54-75 years,^{11,12} a demographic at particularly high risk of adverse outcomes
120 from Covid-19.¹⁻⁴ Using unadjusted and adjusted analyses, we consider a wide range of factors

121 either associated with testing positive for Covid-19 and subsequent hospitalization and
122 intensive care in the national VA system as of March 30, 2020.

123

124 **Methods**

125 *Data Source*

126 Using data from the VA national Corporate Data Warehouse on members of the VA Birth
127 Cohort, we identified patients tested for Covid-19 from date of first recorded VA test on
128 February 8, 2020 through March 30, 2020. Available data included demographics, outpatient
129 and inpatient encounters, diagnoses, laboratory results, vital signs, health factors (e.g., smoking
130 and alcohol health behaviors), and pharmacy dispensing records.

131

132 VA Birth Cohort was approved by the Institutional Review Boards of VA Connecticut Healthcare
133 System and Yale University. It has been granted a waiver of informed consent and is Health
134 Insurance Portability and Accountability Act compliant.

135

136 *Data Collection*

137 We selected previously validated cohort characteristics and those that have been evaluated in
138 prior Covid-19 reports.^{1,13} Baseline was defined as the date of specimen collection for the
139 Covid-19 test unless testing occurred during hospitalization, in which case it was date of
140 admission. Demographics included age at baseline, sex, race/ethnicity, and rural/urban
141 residence. Residence was defined using geographic information system coding based upon
142 established criteria.¹⁴

143

144 *Main Study Outcomes*

145 We examined three outcomes: 1) testing positive for SARS-CoV-2 (Covid-19+), 2)
146 hospitalization, and 3) admission to an intensive care unit (ICU). We used VA inpatient bed
147 section codes 12 (medical) and 13 (cardiac) to identify ICU admission.

148

149 *Covid-19 tests*

150 We identified Covid-19 tests conducted in the VA using text searching of laboratory results
151 containing terms consistent with SARS-CoV-2 or Covid-19. If a patient had more than one test
152 and all were negative we selected first negative, otherwise we used date of first positive.
153 Patients for whom results were pending (n=93) or inconclusive (n=33) were excluded. Nearly all
154 tests utilized nasopharyngeal swabs, 1% were from other sources. Testing was performed in VA,
155 state public health and commercial reference laboratories using emergency use authorization
156 approved SARS-CoV-2 assays.

157

158 *Comorbidity*

159 We extracted diagnostic codes for asthma, cancer, COPD, chronic kidney disease, diabetes
160 mellitus, hypertension, liver disease, vascular disease, and alcohol use disorder (definitions
161 provided in **eTable 1**). We used a validated algorithm to capture smoking status derived from
162 health factors.¹⁵

163

164 *Pharmacy Data*

165 We collected pharmacy fills for ACE/ARBs, chemotherapy and immunosuppressive drugs, and
166 prescription NSAIDs and determined which medications were active in the year prior to testing.
167 Exposure windows for NSAIDs ended 14 days prior to baseline to minimize the potential of
168 protopathic bias. Exposure windows for other medications not used to treat Covid-19
169 symptoms ended three days prior to baseline.

170

171 *Vital Signs, Clinical Laboratory Data, and a Summary Measure of Physiologic Injury*

172 Vital signs measured within two days of baseline included body mass index (BMI), oxygen
173 saturation, pulse, systolic blood pressure, and temperature. We chose laboratory findings
174 closest to baseline within a year prior or up to one week after baseline. Measures included
175 alanine aminotransferase, albumin, aspartate aminotransferase, creatinine, estimated
176 glomerular filtration rate,¹⁶ fibrosis-4 score (FIB-4),¹⁷ hemoglobin, platelet count, total white
177 blood cell count, and lymphocyte count. We calculated a validated composite measure of
178 physiologic injury (VACS Index) which includes age, BMI, and all previously mentioned
179 laboratory measures save lymphocyte count^{18,19} (details in **eMethods**).

180

181 *Statistical Analysis*

182 We evaluated characteristics of patients undergoing Covid-19 testing, and among Covid-19+,
183 factors associated with hospital admission and intensive care, using chi-square, Fisher's exact,
184 and Wilcoxon rank-sum tests, as appropriate. For bivariate comparisons, statistical significance
185 reflects complete case analysis. When modeling Covid-19+, we restricted analyses to factors
186 available when initially evaluating a patient (i.e., demographic data, comorbid conditions,

187 medication history, health behaviors, and vital signs). Because age, black race, ACE/ARB use,
188 and NSAID use are of special interest, we included them in all multivariable models. Otherwise,
189 variables significant at $p < 0.05$ in unadjusted analyses were included in the multivariable
190 models. When modeling hospital admission and intensive care, we compared C-statistics for
191 models including individual laboratory values to a model including VACS Index. In *post hoc*
192 analyses we explored the association between black race and Covid-19+ with a multivariable
193 model conditioned on site, among sites having at least five positive tests.

194
195 We report missing data for each variable. We used multiple imputation to impute missing
196 laboratory measures, vital signs, and smoking status. The imputation model included outcomes
197 and all covariates. Estimates from regressions performed on 10 imputed data sets were
198 combined using Rubin's rules.²⁰ Analyses were performed using SAS version 9.4 (SAS Institute
199 Inc., Cary, NC, USA) and Stata version 14.2 (StataCorp, LLC., College Station, TX). We used R
200 version 3.6.3 to map Covid-19 cases in the VA system overall and those captured in the VA Birth
201 Cohort.

202

203 **Results**

204 In the year prior to the Covid-19 outbreak, the VA Birth Cohort included 2,026,277 living
205 individuals: 1,866,256 (92.1%) men and 159,971 (7.9%) women. The cohort includes 1,369,454
206 (67.6%) white, 402,295 (19.9%) black, 106,639 (5.3%) Latinx, and 147,839 (7.3%) other or
207 unknown race/ethnicity. More than a third of the subjects (745,284 or 36.8%) were 70-75 years
208 of age, 23.3% (n=472,732) were 65-69 years old, 20.1% (n=407,900) were 60-64 years old, and

209 19.8% (n=400,311) were 54-59 years old. Of these, 3,789 individuals have been tested for
210 Covid-19 (18.7 per 10,000 persons) since February 8, 2020 through March 30, 2020.

211
212 Testing per 10,000 persons varied by race, sex, age, and residence (p<0.001 for all). Black
213 Veterans were more likely to be tested than white Veterans (28.0 versus 15.6). Women were
214 more likely to be tested than men (23.3 versus 18.3). Testing generally decreased with age (age
215 54-59: 21.5; age 60-64: 22.2; age 65-69: 18.6; and age 70-75: 15.4). Veterans living in urban
216 settings were more likely to be tested than those in rural settings (39.2 vs. 5.8).

217
218 Among those tested, median age was 65.7 years (**Table 1**), 90.2% were male, 29.7% were black,
219 and 81.1% lived in urban settings. Common comorbid conditions were hypertension (65.0%),
220 diabetes mellitus (37.8%), vascular disease (28.9%), COPD (26.2%), and alcohol use disorder
221 (13.9%). Receipt of ACE/ARBs (40.5%) or NSAIDs (30.5%) was common. Among those tested,
222 42.3% were current smokers, 40.8% were obese (BMI >30 kg/m²), 7.7% were febrile (≥100.4°F),
223 13.1% were hypoxic (oxygen saturation ≤93%), and 35.4% were tachycardic (pulse ≥90 beats
224 per minute).

225

226 *Testing Positive vs. Negative for Covid-19*

227 Of the 3,789 patients tested in the VA Birth Cohort, 585 (15.4%, 95% CI 14.3-16.6) were Covid-
228 19+, representing approximately half (585/1244, 47%) of all Covid-19+ patients in the VA as of
229 March 30, 2020 (**Figure 1a** and **eFigure 1**). In unadjusted analyses, factors associated with
230 Covid-19+ (**Table 1**) included male sex, black race, urban residence, chronic kidney disease,

231 diabetes, and hypertension (all $p < 0.003$). Smoking, COPD, and alcohol use disorder were
232 associated with a lower probability of a positive test (all $p < 0.001$). No medication exposure was
233 associated with a positive test. Vital signs associated with Covid-19+ included higher BMI,
234 tachycardia, and higher temperature (all $p < 0.001$). All laboratory values were associated with
235 Covid-19+ (all $p < 0.001$). Composite variables, eGFR and FIB-4, were also strongly associated
236 (both $p < 0.001$).

237

238 In multivariable analyses (**Table 2**, C -statistic=0.806), black race (OR 4.68, 95% CI 3.79-5.78),
239 male sex (OR 3.17, 95% CI 2.03-4.94), urban residence (OR 1.60, 95% CI 1.17-2.20), higher
240 temperature (OR 1.70, 95% CI 1.58-1.84 per 1°F), lower systolic blood pressure (OR 1.44, 95% CI
241 1.16-1.78), and prior use of NSAIDs (OR 1.27, 95% CI 1.02-1.58) were associated with increased
242 likelihood of Covid-19+. Current smoking (OR 0.45, 95% CI 0.35-0.57), alcohol use disorder (OR
243 0.58, 95% CI 0.41-0.83), and COPD (OR 0.67, 95% CI 0.50-0.88) were associated with decreased
244 likelihood of Covid-19+. Results were similar in complete case analysis (**eTable 2**).

245

246 In *post hoc* analyses, we observed that black Veterans were more likely to be tested at sites
247 with higher Covid-19 prevalence (**Figure 1b**). A model conditional on site (**Table 2**) reduced the
248 association with black race (OR 2.56, 95% CI 1.89-3.46) and increased the association with male
249 sex (OR 3.85, 95% CI 2.20-6.74). Associations with other factors were consistent with
250 unconditional estimates.

251

252 *Risk Factors for Hospitalization and Intensive Care*

253 Among 585 Covid-19+ patients, 297 (50.8%, 95% CI 46.6-54.9%) were hospitalized and 122
254 (20.9%, 95% CI 17.6-24.4%) received intensive care. In bivariate analyses, age, chronic kidney
255 disease, COPD, diabetes, hypertension, vascular disease, ACE/ARB exposure, and decreased
256 oxygen saturation, and elevated temperature were associated with hospitalization and
257 intensive care (all $p < 0.05$, **Table 3a and Table 3b**). All laboratory abnormalities investigated
258 were associated with hospitalization and intensive care (all $p < 0.05$). Median VACS Index scores
259 varied substantially between those hospitalized versus not hospitalized (78.7 vs. 66.2, $p < 0.001$)
260 and between those receiving and not receiving intensive care (82.0 vs. 69.4, $p < 0.001$).

261

262 Parallel models, first adjusted for all significant factors identified in bivariate analyses and then
263 substituting VACS Index for all laboratory tests, demonstrated good discrimination for
264 hospitalization (**Table 4**, C-statistics: 0.859, 0.834) and intensive care (C-statistics: 0.876, 0.835).
265 White blood cell count, lymphocyte count, eGFR, albumin and FIB-4 were all independently
266 associated with hospitalization and intensive care (**Table 4**). The most pronounced association
267 was for patients with $FIB-4 > 3.25$ – adjusted OR 8.73 (95% CI 4.11-18.56) for hospitalization and
268 8.40 (95% CI 2.90-24.28) for intensive care – compared to those with $FIB-4 < 1.45$. Of note,
269 associations were stronger for FIB-4 and eGFR than for components of these measures (data
270 not otherwise shown).

271

272 While COPD, diabetes, hypertension, kidney disease, vascular disease and exposure to ACE/ARB
273 exposure were associated with hospitalization and intensive care in unadjusted analyses, they

274 were not significantly associated after adjusting for laboratory abnormalities and vital signs
275 (**Table 4**). Results were similar in complete case analysis (**eTable 3**).

276

277 **Discussion**

278 Our analysis represents over 2 million veterans, aged 54-75 years, receiving care in the largest
279 integrated healthcare system in the United States. The study was conducted within an
280 established cohort and based on well annotated national electronic health record data,
281 enabling a rapid and reliable analysis of Covid-19 testing and initial outcomes. As a result, we
282 were able to validate and extend previous findings, to include a careful consideration of who is
283 Covid-19+ and, given a positive test, what factors were independently associated with
284 hospitalization and intensive care. We found that black Veterans were twice as likely to be
285 tested and 2.5 times as likely to test positive than non-black Veterans, even after adjusting for
286 urban residence and conditioning on geographic location. While we saw modest evidence of an
287 association between exposure to NSAIDs and risk of Covid-19+, vital signs and laboratory
288 measures better characterized risk of hospitalization and intensive care than did comorbid
289 diagnoses or prior medication exposures.

290

291 In unadjusted analyses, black Veterans were over four times as likely to test positive compared
292 to non-black Veterans; adjusting for urban versus rural residence did not change this
293 association. While black Veterans were much more likely to be tested at high prevalence
294 facilities, conditioning our analysis by site did not eliminate the association; black race retained
295 over a two-fold increased risk for testing Covid-19+. Of note, black Veterans were also more

296 likely to be tested, which could dilute the proportion positive. Further, black Veterans did not
297 experience higher rates of hospitalization or intensive care. Based on prior experience with
298 1918 Spanish Flu and 2009 H1N1 epidemic, public health experts have warned that minority
299 populations may be at higher risk of infection due to reduced capacity to implement physical
300 distancing.^{21,22} Our findings may be an underestimate of the US population as racial health
301 disparities in VA tend to be smaller than in the private sector.²³

302

303 Women were more likely to be tested for Covid-19 than men, and men were twice as likely to
304 test positive. This association strengthened after adjustment and in conditional analyses (**Table**
305 **2**) but should be considered preliminary given limited numbers of women in this analysis.

306

307 As reported previously²⁴ elevated temperature was independently associated with testing
308 positive, hospital admission and intensive care, underscoring the value of including fever in the
309 current testing algorithms. Findings from the multivariable regression suggest that other factors
310 might also be used to indicate a test, including black race, male sex, and lack of an alternative
311 explanation for cough symptoms. To wit, we found that current smoking, COPD, and alcohol
312 use disorder, factors that generally increase risk of pneumonia, were associated with decreased
313 probability of testing positive. While they were not associated with hospitalization or intensive
314 care, it is too early to tell if these factors are associated with subsequent outcomes such as
315 respiratory failure or mortality.

316

317 Presence of particular comorbid diagnoses may be less prognostic than overall acute on chronic
318 injury reflected in laboratory abnormalities largely encompassed in the VACS Index. In
319 unadjusted analyses, several comorbid conditions were associated with hospitalization and
320 intensive care but were not independently associated after adjusting for vital signs and
321 laboratory data. Further, while elevated white blood cell counts and decreased lymphocyte
322 counts were associated with hospitalization and intensive care, the pronounced independent
323 association with FIB-4 (a composite of platelets and transaminases) and albumin suggest that
324 virally induced hepatic inflammation may be a harbinger of the cytokine storm.²⁵⁻²⁷

325

326 VACS Index, which includes FIB-4, albumin, and white blood cell count, is predictive of mortality
327 in many clinical settings.¹⁸ A five-point difference in score corresponds to a 30% difference in
328 mortality. The 12.5-point difference in medians between the Veterans who were and were not
329 admitted, and the 12.6-point difference between those who received and did not receive
330 intensive care underscores the wide range of prognoses seen with Covid-19. Future work will
331 need to determine whether VACS Index might be used in medical triage of Covid-19+ patients.

332

333 Our analysis is one of the first to address concerns regarding exposure to NSAIDs and ACE/ARBs
334 and Covid-19.^{9,10} We found NSAID exposure was modestly associated with Covid-19+ in
335 unadjusted and adjusted analyses, but not with hospitalization or intensive care. Among those
336 testing positive, ACE/ARB exposure was associated with hospitalization and intensive care in
337 unadjusted analyses, but associations lost statistical significance with hospitalization and
338 diminished with intensive care after adjusting for clinical measures, including hypertension and

339 blood pressure. However, confidence intervals were wide, include clinically important
340 differences, and conclusions may change as the epidemic evolves. We will continue to update
341 these analyses as more data become available.

342

343 While this analysis adds information to the evolving pandemic, its limitations must be kept in
344 mind. First, a small proportion of Veterans have been tested and rates of testing vary widely by
345 site. Second, women represented a small number of Veterans in the sample (184 tested, 13
346 positive). Third, our analysis of outcomes is preliminary as many Covid-19+ patients are still in
347 care. Fourth, while a strength of this analysis is our ability to determine active VA medications,
348 we could only detect NSAID exposure based upon VA pharmacy fill/refill data, individuals are
349 also likely to purchase NSAIDS over the counter. As real-world data become available, more
350 sophisticated and focused pharmacoepidemiological analyses will be required to address
351 concerns regarding potential risk of medications associated with Covid-19.

352

353 **Conclusion**

354 Black race was strongly associated with Covid-19+, but not with hospitalization or intensive
355 care. Unadjusted associations between medication exposure, comorbid disease, and
356 hospitalization and intensive care are diminished after adjustment. Risk of hospitalization and
357 intensive care associated with Covid-19 may be better characterized by vital signs and
358 measures of physiologic injury than by comorbid conditions or medication history.

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366

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446 **Figure legends**

447 **Figure 1.** Distribution of Covid-19 cases in the Veterans Birth Cohort as of March 30, 2020

448 **Caption:** (a) Shown is the distribution of 585/1244 (47%) Covid-19 cases in the Veterans Health
449 Administration captured in the Veterans Birth Cohort as of March 30, 2020 and included in the
450 current study. (b) Shown is the proportion of Covid-19 test results that are positive by the
451 proportion of Covid-19 cases of black race by site of care.

452

Table 1. Characteristics of patients tested for Covid-19 among all patients aged 54-75 years in the Veterans Health Administration as of March 30, 2020

	Covid-19 test result							% Covid-19+ (95% CI)	
	No. tested	(%)	missing	Positive	(%)	Negative	(%)		p-value ^a
Sample size, n	3789	(100.0)		585	(100.0)	3204	(100.0)		15.4 (14.3-16.6)
Demographics									
Age, years									
Median (IQR)	65.7 (60.5-70.7)		0	66.1 (60.4-71.0)		65.6 (60.5-70.7)		0.24	
54-59	861	(22.7)		135	(23.1)	726	(22.7)	0.21	15.7 (13.3-18.3)
60-64	906	(23.9)		135	(23.1)	771	(24.1)		14.9 (12.6-17.4)
65-69	877	(23.1)		120	(20.5)	757	(23.6)		13.7 (11.5-16.1)
70-75	1145	(30.2)		195	(33.3)	950	(29.7)		17.0 (14.9-19.3)
Sex									
Female	372	(9.8)	0	27	(4.6)	345	(10.8)	<0.001	7.3 (4.8-10.4)
Male	3417	(90.2)		558	(95.4)	2859	(89.2)		16.3 (15.1-17.6)
Race/ethnicity									
White	2135	(56.3)	0	161	(27.5)	1974	(61.6)	<0.001	7.5 (6.5-8.7)
Black	1126	(29.7)		350	(59.8)	776	(24.2)		31.1 (28.4-33.9)
Latinx	294	(7.8)		48	(8.2)	246	(7.7)		16.3 (12.3-21.1)
Other/unknown	234	(6.2)		26	(4.4)	208	(6.5)		11.1 (7.4-15.9)
Residence type									
Rural	718	(18.9)	0	56	(9.6)	662	(20.7)	<0.001	7.8 (6.0-10.0)
Urban	3071	(81.1)		529	(90.4)	2542	(79.3)		17.2 (15.9-18.6)
Baseline comorbidity									
Asthma									
No	3506	(92.5)	0	540	(92.3)	2966	(92.6)	0.80	15.4 (14.2-16.6)
Yes	283	(7.5)		45	(7.7)	238	(7.4)		15.9 (11.8-20.7)
Cancer									
No	3218	(84.9)	0	502	(85.8)	2716	(84.8)	0.57	15.6 (14.4-16.9)
Yes	571	(15.1)		83	(14.2)	488	(15.2)		14.5 (11.8-17.7)
Chronic kidney disease									
No	3228	(85.2)	0	474	(81.0)	2754	(86.0)	0.003	14.7 (13.5-16.0)
Yes	561	(14.8)		111	(19.0)	450	(14.0)		19.8 (16.6-23.3)
Chronic obstructive pulmonary disease									
No	2796	(73.8)	0	495	(84.6)	2301	(71.8)	<0.001	17.7 (16.3-19.2)
Yes	993	(26.2)		90	(15.4)	903	(28.2)		9.1 (7.4-11.0)
Diabetes mellitus									
No	2358	(62.2)	0	325	(55.6)	2033	(63.5)	<0.001	13.8 (12.4-15.2)
Yes	1431	(37.8)		260	(44.4)	1171	(36.5)		18.2 (16.2-20.3)
Hypertension									
No	1326	(35.0)	0	162	(27.7)	1164	(36.3)	<0.001	12.2 (10.5-14.1)
Yes	2463	(65.0)		423	(72.3)	2040	(63.7)		17.2 (15.7-18.7)
Liver disease									
No	3323	(87.7)	0	525	(89.7)	2798	(87.3)	0.12	15.8 (14.6-17.1)
Yes	466	(12.3)		60	(10.3)	406	(12.7)		12.9 (10-16.3)
Vascular disease									
No	2694	(71.1)	0	422	(72.1)	2272	(70.9)	0.59	15.7 (14.3-17.1)
Yes	1095	(28.9)		163	(27.9)	932	(29.1)		14.9 (12.8-17.1)
Substance use									
Alcohol use disorder									
No	3261	(86.1)	0	537	(91.8)	2724	(85.0)	<0.001	16.5 (15.2-17.8)
Yes	528	(13.9)		48	(8.2)	480	(15.0)		9.1 (6.8-11.9)
Smoking									
Never	1042	(27.5)	261	216	(36.9)	826	(25.8)	<0.001	20.7 (18.3-23.3)
Former	883	(23.3)		179	(30.6)	704	(22.0)		20.3 (17.7-23.1)
Current	1603	(42.3)		159	(27.2)	1444	(45.1)		9.9 (8.5-11.5)
Medication history in year prior to test date									
Any angiotensin converting enzyme inhibitor or angiotensin II receptor blocker									
No	2257	(59.6)	0	330	(56.4)	1927	(60.1)	0.10	14.6 (13.2-16.2)
Yes	1532	(40.4)		255	(43.6)	1277	(39.9)		16.6 (14.8-18.6)
Angiotensin converting enzyme inhibitor									
No	2778	(73.3)	0	416	(71.1)	2362	(73.7)	0.20	15.0 (13.7-16.4)
Yes	1011	(26.7)		169	(28.9)	842	(26.3)		16.7 (14.5-19.2)
Angiotensin II receptor blocker									
No	3226	(85.1)	0	491	(83.9)	2735	(85.4)	0.38	15.2 (14.0-16.5)
Yes	563	(14.9)		94	(16.1)	469	(14.6)		16.7 (13.7-20.0)
Chemotherapy or immunosuppressive drug									
No	3568	(94.2)	0	556	(95.0)	3012	(94.0)	0.39	15.6 (14.4-16.8)
Yes	221	(5.8)		29	(5.0)	192	(6.0)		13.1 (9.0-18.3)
Nonsteroidal anti-inflammatory drug, (-365, -14 days)									
No	2634	(69.5)	0	392	(67.0)	2242	(70.0)	0.16	14.9 (13.5-16.3)
Yes	1155	(30.5)		193	(33.0)	962	(30.0)		16.7 (14.6-19.0)
Vital signs at test date									
Body mass index, kg/m ²									
<25.0	779	(20.6)	393	73	(12.5)	706	(22.0)	<0.001	9.4 (7.4-11.6)
25.0-29.9	1070	(28.2)		166	(28.4)	904	(28.2)		15.5 (13.4-17.8)
≥30	1547	(40.8)		291	(49.7)	1256	(39.2)		18.8 (16.9-20.9)
Hypoxia (oxygen saturation ≤93%)									

No	2433 (64.2)	860	443 (75.7)	1990 (62.1)	0.20	18.2 (16.7-19.8)
Yes	496 (13.1)		78 (13.3)	418 (13.0)		15.7 (12.6-19.2)
Pulse ≥90 beats per minute						
No	2033 (53.7)	416	295 (50.4)	1738 (54.2)	<0.001	14.5 (13.0-16.1)
Yes	1340 (35.4)		257 (43.9)	1083 (33.8)		19.2 (17.1-21.4)
Systolic blood pressure, mm Hg						
<90	355 (9.4)	448	63 (10.8)	292 (9.1)	0.11	17.8 (13.9-22.1)
90-140	1565 (41.3)		274 (46.8)	1291 (40.3)		17.5 (15.7-19.5)
≥140	1421 (37.5)		211 (36.1)	1210 (37.8)		14.9 (13.0-16.8)
Temperature, °F						
≤98.6	2142 (56.5)	405	204 (34.9)	1938 (60.5)	<0.001	9.5 (8.3-10.9)
98.7-100.3	953 (25.2)		227 (38.8)	726 (22.7)		23.8 (21.2-26.7)
≥100.4	289 (7.6)		120 (20.5)	169 (5.3)		41.5 (35.8-47.4)
Laboratory findings at test date						
Alanine aminotransferase, U/L						
Median (IQR)	23.0 (16.0-34.0)	400	28.0 (19.0-41.0)	22.0 (16.0-33.0)	<0.001	
≤40	2829 (74.7)		406 (69.4)	2423 (75.6)	<0.001	14.4 (13.1-15.7)
>40	560 (14.8)		138 (23.6)	422 (13.2)		24.6 (21.1-28.4)
Albumin, g/dL						
Median (IQR)	3.9 (3.5-4.2)	383	3.8 (3.5-4.2)	3.9 (3.5-4.2)	0.78	
≥3.5	2596 (68.5)		415 (70.9)	2181 (68.1)	1.00	16.0 (14.6-17.5)
<3.5	810 (21.4)		129 (22.1)	681 (21.3)		15.9 (13.5-18.6)
Aspartate aminotransferase, U/L						
Median (IQR)	23.0 (18.0-32.0)	356	29.0 (21.5-43.0)	22.0 (17.0-30.0)	<0.001	
≤40	2902 (76.6)		391 (66.8)	2511 (78.4)	<0.001	13.5 (12.3-14.8)
>40	531 (14.0)		157 (26.8)	374 (11.7)		29.6 (25.7-33.7)
Creatinine, mg/dL						
Median (IQR)	1.1 (0.9-1.3)	186	1.1 (1.0-1.5)	1.0 (0.9-1.3)	<0.001	
≤1.5	3033 (80.0)		435 (74.4)	2598 (81.1)	<0.001	14.3 (13.1-15.6)
>1.5	570 (15.0)		130 (22.2)	440 (13.7)		22.8 (19.4-26.5)
eGFR, mL/min						
Median (IQR)	75.0 (59.0-91.0)	168	71.5 (53.0-87.0)	76.0 (60.0-92.0)	<0.001	
≥15	3492 (92.2)		541 (92.5)	2951 (92.1)	0.11	15.5 (14.3-16.7)
<15	129 (3.4)		27 (4.6)	102 (3.2)		20.9 (14.3-29.0)
FIB-4						
<1.45	1499 (39.6)	628	139 (23.8)	1360 (42.4)	<0.001	9.3 (7.9-10.9)
1.45-3.25	1266 (33.4)		263 (45.0)	1003 (31.3)		20.8 (18.6-23.1)
>3.25	396 (10.5)		114 (19.5)	282 (8.8)		28.8 (24.4-33.5)
Hemoglobin, g/dL						
Median (IQR)	13.8 (12.2-15.0)	445	13.9 (12.6-14.9)	13.8 (12.2-15.0)	0.09	
≥10	3097 (81.7)		523 (89.4)	2574 (80.3)	<0.001	16.9 (15.6-18.3)
<10	247 (6.5)		17 (2.9)	230 (7.2)		6.9 (4.1-10.8)
Platelet count, K/μL						
Median (IQR)	218 (173-267)	423	193 (154-230)	223 (178-275)	<0.001	
≥150	2875 (75.9)		416 (71.1)	2459 (76.7)	<0.001	14.5 (13.2-15.8)
<150	491 (13.0)		121 (20.7)	370 (11.5)		24.6 (20.9-28.7)
White blood cell count, K/μL						
Median (IQR)	7.5 (5.7-10.0)	288	5.9 (4.7-7.5)	7.8 (6.0-10.4)	<0.001	
<4	191 (5.0)		72 (12.3)	119 (3.7)	<0.001	37.7 (30.8-45.0)
4-9.9	2448 (64.6)		432 (73.8)	2016 (62.9)		17.7 (16.2-19.2)
≥10	862 (22.8)		49 (8.4)	813 (25.4)		5.7 (4.2-7.5)
Lymphocyte count, K/μL						
Median (IQR)	1.4 (1.0-2.0)	628	1.1 (0.8-1.6)	1.5 (1.0-2.1)	<0.001	
≥0.8	2626 (69.3)		363 (62.1)	2263 (70.6)	<0.001	13.8 (12.5-15.2)
<0.8	535 (14.1)		130 (22.2)	405 (12.6)		24.3 (20.7-28.2)
Clinical outcomes						
Hospitalized						
No	2277 (60.1)	0	288 (49.2)	1989 (62.1)	<0.001	12.7 (11.3-14.1)
Yes	1512 (39.9)		297 (50.8)	1215 (37.9)		19.6 (17.7-21.7)
Intensive care unit admission						
No	3381 (89.2)	0	463 (79.1)	2918 (91.1)	<0.001	13.7 (12.6-14.9)
Yes	408 (10.8)		122 (20.9)	286 (8.9)		29.9 (25.5-34.6)
Death during hospitalization						
No	3744 (98.8)	0	568 (97.1)	3176 (99.1)	<0.001	15.2 (14.0-16.4)
Yes	45 (1.2)		17 (2.9)	28 (0.9)		37.8 (23.8-53.5)

Abbreviations: Covid-19, coronavirus disease 2019; IQR, interquartile range; eGFR, estimated glomerular filtration rate, FIB-4, fibrosis 4 score

*P-values calculated on non-missing data

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Table 2. Crude and adjusted associations with testing positive for Covid-19 as of March 30, 2020

	Positive Covid-19 test (n=585/3789)		
	Univariable OR (95% CI)	Multivariable OR (95% CI)	Conditional OR ^a (95% CI)
Model details			
C-statistic	-	0.806	n/a
Demographics			
Age, per 5-year increase	1.04 (0.97-1.12)	1.05 (0.96-1.15)	1.02 (0.91-1.15)
Sex, male vs. female	2.49 (1.67-3.73)	3.17 (2.03-4.94)	3.85 (2.20-6.74)
Race/ethnicity, black vs. other	4.66 (3.88-5.60)	4.68 (3.79-5.78)	2.56 (1.89-3.46)
Residence type, urban vs. rural	2.46 (1.84-3.28)	1.60 (1.17-2.20)	1.04 (0.64-1.68)
Baseline comorbidity			
Chronic kidney disease, yes vs. no	1.43 (1.14-1.80)	1.00 (0.76-1.33)	0.92 (0.64-1.31)
Chronic obstructive pulmonary disease, yes vs. no	0.46 (0.37-0.59)	0.67 (0.50-0.88)	0.77 (0.54-1.09)
Diabetes mellitus, yes vs. no	1.39 (1.16-1.66)	1.01 (0.80-1.26)	0.89 (0.67-1.19)
Hypertension, yes vs. no	1.49 (1.23-1.81)	1.23 (0.95-1.60)	1.40 (1.00-1.96)
Substance use			
Alcohol use disorder, yes vs. no	0.51 (0.37-0.69)	0.58 (0.41-0.83)	0.52 (0.34-0.82)
Current smoking, yes vs. no	0.43 (0.35-0.52)	0.45 (0.35-0.57)	0.45 (0.34-0.61)
Medication history in year prior to test date			
Angiotensin converting enzyme inhibitor or angiotensin II receptor blocker, yes vs. no	1.17 (0.98-1.39)	0.98 (0.78-1.23)	0.93 (0.69-1.24)
Nonsteroidal anti-inflammatory drug, yes vs. no	1.15 (0.95-1.39)	1.27 (1.02-1.58)	1.16 (0.87-1.54)
Vital signs			
Systolic blood pressure, <140 vs. ≥140 mm Hg	1.25 (1.03-1.51)	1.44 (1.16-1.78)	1.29 (0.99-1.69)
Body mass index, per 5 kg/m ² increase	1.15 (1.08-1.23)	1.09 (1.00-1.18)	1.10 (0.99-1.22)
Oxygen saturation, ≤93% vs >93%	0.88 (0.68-1.15)	1.04 (0.76-1.42)	1.04 (0.67-1.61)
Pulse, per 5-beats per minute increase	0.99 (0.99-1.00)	0.99 (0.99-1.00)	1.00 (0.99-1.00)
Temperature, per 1°F increase	1.74 (1.62-1.87)	1.70 (1.58-1.84)	1.69 (1.53-1.88)

Abbreviations: Covid-19, coronavirus disease 2019; OR, odds ratio; CI, confidence interval

^aModeling stations with five or more Covid-19 cases and conditioning on station

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Table 3a. Associations with hospitalization among Covid-19 cases aged 54-75 years in the Veterans Health Administration as of March 30, 2020

				Hospitalization					
	No. cases	(%)	missing	Yes	(%)	No	(%)	p-value ^a	% hospitalized (95% CI)
n	585	(100)		297	(100.0)	288	(100.0)		50.8 (46.6-54.9)
Demographics									
Age, years									
Median (IQR)	66.1 (60.4-71.0)		0	67.6 (61.7-71.6)		64.5 (59.7-70.5)		0.001	
54-59	135 (23.1)			58 (19.5)		77 (26.7)		0.02	43.0 (34.5-51.8)
60-64	135 (23.1)			62 (20.9)		73 (25.3)			45.9 (37.3-54.7)
65-69	120 (20.5)			62 (20.9)		58 (20.1)			51.7 (42.4-60.9)
70-75	195 (33.3)			115 (38.7)		80 (27.8)			59.0 (51.7-66.0)
Sex									
Female	27 (4.6)		0	8 (2.7)		19 (6.6)		0.03	29.6 (13.8-50.2)
Male	558 (95.4)			289 (97.3)		269 (93.4)			51.8 (47.6-56.0)
Race/ethnicity									
White	161 (27.5)		0	79 (26.6)		82 (28.5)		0.32	49.1 (41.1-57.1)
Black	350 (59.8)			187 (63.0)		163 (56.6)			53.4 (48.1-58.8)
Latinx	48 (8.2)			20 (6.7)		28 (9.7)			41.7 (27.6-56.8)
Other/unknown	26 (4.4)			11 (3.7)		15 (5.2)			42.3 (23.4-63.1)
Residence type									
Rural	56 (9.6)		0	27 (9.1)		29 (10.1)		0.78	48.2 (34.7-62.0)
Urban	529 (90.4)			270 (90.9)		259 (89.9)			51.0 (46.7-55.4)
Baseline comorbidity									
Asthma									
No	540 (92.3)		0	273 (91.9)		267 (92.7)		0.76	50.6 (46.3-54.9)
Yes	45 (7.7)			24 (8.1)		21 (7.3)			53.3 (37.9-68.3)
Cancer									
No	502 (85.8)		0	252 (84.8)		250 (86.8)		0.55	50.2 (45.7-54.7)
Yes	83 (14.2)			45 (15.2)		38 (13.2)			54.2 (42.9-65.2)
Chronic kidney disease									
No	474 (81.0)		0	222 (74.7)		252 (87.5)		<0.001	46.8 (42.3-51.4)
Yes	111 (19.0)			75 (25.3)		36 (12.5)			67.6 (58.0-76.2)
Chronic obstructive pulmonary disease									
No	495 (84.6)		0	236 (79.5)		259 (89.9)		<0.001	47.7 (43.2-52.2)
Yes	90 (15.4)			61 (20.5)		29 (10.1)			67.8 (57.1-77.3)
Diabetes mellitus									
No	325 (55.6)		0	141 (47.5)		184 (63.9)		<0.001	43.4 (37.9-49.0)
Yes	260 (44.4)			156 (52.5)		104 (36.1)			60.0 (53.8-66.0)
Hypertension									
No	162 (27.7)		0	59 (19.9)		103 (35.8)		<0.001	36.4 (29.0-44.3)
Yes	423 (72.3)			238 (80.1)		185 (64.2)			56.3 (51.4-61.1)
Liver disease									
No	525 (89.7)		0	260 (87.5)		265 (92.0)		0.08	49.5 (45.2-53.9)
Yes	60 (10.3)			37 (12.5)		23 (8.0)			61.7 (48.2-73.9)
Vascular disease									
No	422 (72.1)		0	184 (62.0)		238 (82.6)		<0.001	43.6 (38.8-48.5)
Yes	163 (27.9)			113 (38.0)		50 (17.4)			69.3 (61.6-76.3)
Substance use									
Alcohol use disorder									
No	537 (91.8)		0	269 (90.6)		268 (93.1)		0.29	50.1 (45.8-54.4)
Yes	48 (8.2)			28 (9.4)		20 (6.9)			58.3 (43.2-72.4)
Smoking									
Never	216 (36.9)		31	106 (35.7)		110 (38.2)		0.30	49.1 (42.2-55.9)
Former	179 (30.6)			89 (30.0)		90 (31.3)			49.7 (42.2-57.3)
Current	159 (27.2)			90 (30.3)		69 (24.0)			56.6 (48.5-64.4)
Medication history in year prior to test date									
Any angiotensin converting enzyme inhibitor or angiotensin II receptor blocker									
No	330 (56.4)		0	150 (50.5)		180 (62.5)		0.004	45.5 (40.0-51.0)
Yes	255 (43.6)			147 (49.5)		108 (37.5)			57.7 (51.3-63.8)
Angiotensin converting enzyme inhibitor									
No	416 (71.1)		0	194 (65.3)		222 (77.1)		0.002	46.6 (41.8-51.6)
Yes	169 (28.9)			103 (34.7)		66 (22.9)			61.0 (53.2-68.4)
Angiotensin II receptor blocker									
No	491 (83.9)		0	248 (83.5)		243 (84.4)		0.82	50.5 (46.0-55.0)
Yes	94 (16.1)			49 (16.5)		45 (15.6)			52.1 (41.6-62.5)
Chemotherapy or immunosuppressive drug									
No	556 (95.0)		0	279 (93.9)		277 (96.2)		0.25	50.2 (45.9-54.4)
Yes	29 (5.0)			18 (6.1)		11 (3.8)			62.1 (42.3-79.3)
Nonsteroidal anti-inflammatory drug, (-365, -14 days)									
No	392 (67.0)		0	207 (69.7)		185 (64.2)		0.19	52.8 (47.7-57.8)
Yes	193 (33.0)			90 (30.3)		103 (35.8)			46.6 (39.4-53.9)
Vital signs at test date									
Body mass index, kg/m ²									
<25.0	73 (12.5)		55	45 (15.2)		28 (9.7)		0.25	61.6 (49.5-72.8)
25.0-29.9	166 (28.4)			85 (28.6)		81 (28.1)			51.2 (43.3-59.0)
≥30	291 (49.7)			149 (50.2)		142 (49.3)			51.2 (45.3-57.1)
Hypoxia (oxygen saturation ≤93%)									
No	443 (75.7)		64	226 (76.1)		217 (75.3)		<0.001	51.0 (46.3-55.8)

Yes	78 (13.3)		58 (19.5)	20 (6.9)		74.4 (63.2-83.6)
Pulse ≥90 beats per minute						
No	295 (50.4)	33	150 (50.5)	145 (50.3)	0.20	50.9 (45.0-56.7)
Yes	257 (43.9)		145 (48.8)	112 (38.9)		56.4 (50.1-62.6)
Systolic blood pressure, mm Hg						
<90	63 (10.8)	37	43 (14.5)	20 (6.9)	0.04	68.3 (55.3-79.4)
90-140	274 (46.8)		145 (48.8)	129 (44.8)		52.9 (46.8-59.0)
≥140	211 (36.1)		106 (35.7)	105 (36.5)		50.2 (43.3-57.2)
Temperature, °F						
≤98.6	204 (34.9)	34	88 (29.6)	116 (40.3)	0.002	43.1 (36.2-50.2)
98.7-100.3	227 (38.8)		134 (45.1)	93 (32.3)		59.0 (52.3-65.5)
≥100.4	120 (20.5)		70 (23.6)	50 (17.4)		58.3 (49.0-67.3)
Laboratory findings at test date						
Alanine aminotransferase, U/L						
Median (IQR)	28.0 (19.0-41.0)	41	30.0 (20.0-42.0)	26.0 (18.0-37.0)	0.01	
≤40	406 (69.4)		205 (69.0)	201 (69.8)	0.01	50.5 (45.5-55.5)
>40	138 (23.6)		87 (29.3)	51 (17.7)		63.0 (54.4-71.1)
Albumin, g/dL						
Median (IQR)	3.8 (3.5-4.2)	41	3.7 (3.3-4.0)	4.1 (3.7-4.3)	<0.001	
≥3.5	415 (70.9)		191 (64.3)	224 (77.8)	<0.001	46.0 (41.2-51.0)
<3.5	129 (22.1)		103 (34.7)	26 (9.0)		79.8 (71.9-86.4)
Aspartate aminotransferase, U/L						
Median (IQR)	29.0 (21.5-43.0)	37	35.5 (25.0-54.0)	25.0 (20.0-33.0)	<0.001	
≤40	391 (66.8)		173 (58.2)	218 (75.7)	<0.001	44.3 (39.3-49.3)
>40	157 (26.8)		121 (40.7)	36 (12.5)		77.1 (69.7-83.4)
Creatinine, mg/dL						
Median (IQR)	1.1 (1.0-1.5)	20	1.3 (1.0-1.8)	1.1 (0.9-1.3)	<0.001	
≤1.5	435 (74.4)		200 (67.3)	235 (81.6)	<0.001	46.0 (41.2-50.8)
>1.5	130 (22.2)		97 (32.7)	33 (11.5)		74.6 (66.2-81.8)
eGFR, mL/min						
Median (IQR)	71.5 (53.0-87.0)	17	63.0 (42.0-82.0)	75.0 (64.0-93.0)	<0.001	
≥15	541 (92.5)		277 (93.3)	264 (91.7)	0.03	51.2 (46.9-55.5)
<15	27 (4.6)		20 (6.7)	7 (2.4)		74.1 (53.7-88.9)
FIB-4						
<1.45	139 (23.8)	69	36 (12.1)	103 (35.8)	<0.001	25.9 (18.9-34.0)
1.45-3.25	263 (45.0)		153 (51.5)	110 (38.2)		58.2 (52.0-64.2)
>3.25	114 (19.5)		94 (31.6)	20 (6.9)		82.5 (74.2-88.9)
Hemoglobin, g/dL						
Median (IQR)	13.9 (12.6-14.9)	45	13.6 (12.0-14.7)	14.2 (13.2-15.1)	<0.001	
≥10	523 (89.4)		273 (91.9)	250 (86.8)	0.02	52.2 (47.8-56.6)
<10	17 (2.9)		14 (4.7)	3 (1.0)		82.4 (56.6-96.2)
Platelet count, K/μL						
Median (IQR)	193 (154-230)	48	175 (143-216)	208 (173-252)	<0.001	
≥150	416 (71.1)		200 (67.3)	216 (75.0)	<0.001	48.1 (43.2-53.0)
<150	121 (20.7)		88 (29.6)	33 (11.5)		72.7 (63.9-80.4)
White blood cell count, K/μL						
Median (IQR)	5.9 (4.7-7.5)	32	5.9 (4.6-7.7)	5.9 (4.7-7.3)	0.54	
<4	72 (12.3)		42 (14.1)	30 (10.4)	0.005	58.3 (46.1-69.9)
4-9.9	432 (73.8)		217 (73.1)	215 (74.7)		50.2 (45.4-55.1)
≥10	49 (8.4)		36 (12.1)	13 (4.5)		73.5 (58.9-85.1)
Lymphocyte count, K/μL						
Median (IQR)	1.1 (0.8-1.6)	92	0.9 (0.6-1.3)	1.4 (1.0-1.9)	<0.001	
≥0.8	363 (62.1)		179 (60.3)	184 (63.9)	<0.001	49.3 (44.1-54.6)
<0.8	130 (22.2)		105 (35.4)	25 (8.7)		80.8 (72.9-87.2)
VACS Index score ^b , median (IQR)	72.4 (63.6-82.5)	51	78.7 (71.1-87.3)	66.2 (60.0-73.2)	<0.001	

Abbreviations: Covid-19, coronavirus disease 2019; IQR, interquartile range; eGFR, estimated glomerular filtration rate; FIB-4, fibrosis 4 score; VACS, Veterans Aging Cohort Study

^aP-values calculated on non-missing data

^bThe VACS Index score is a validated measure of physiologic injury and combining age, aspartate and alanine transaminase, albumin, creatinine, hemoglobin, platelets, white blood cell count, hepatitis C status, and body mass index

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Table 3b. Associations with intensive care among Covid-19 cases aged 54-75 years in the Veterans Health Administration as of March 30, 2020

				Intensive care					
	No. cases	(%)	missing	Yes	(%)	No	(%)	p-value ^a	% admitted (95% CI)
n	585	(100)		122	(100.0)	463	(100.0)		20.9 (17.6-24.4)
Demographics									
Age, years									
Median (IQR)	66.1 (60.4-71.0)		0	69.9 (64.4-71.7)		64.7 (59.8-70.8)		<0.001	
54-59	135 (23.1)			11 (9.0)		124 (26.8)		<0.001	8.2 (4.1-14.1)
60-64	135 (23.1)			24 (19.7)		111 (24.0)			17.8 (11.7-25.3)
65-69	120 (20.5)			28 (23.0)		92 (19.9)			23.3 (16.1-31.9)
70-75	195 (33.3)			59 (48.4)		136 (29.4)			30.3 (23.9-37.2)
Sex									
Female	27 (4.6)		0	3 (2.5)		24 (5.2)		0.33	11.1 (2.4-29.2)
Male	558 (95.4)			119 (97.5)		439 (94.8)			21.3 (18.0-25.0)
Race/ethnicity									
White	161 (27.5)		0	37 (30.3)		124 (26.8)		0.89	23.0 (16.7-30.3)
Black	350 (59.8)			71 (58.2)		279 (60.3)			20.3 (16.2-24.9)
Latinx	48 (8.2)			9 (7.4)		39 (8.4)			18.8 (9.0-32.6)
Other/unknown	26 (4.4)			5 (4.1)		21 (4.5)			19.2 (6.6-39.4)
Residence type									
Rural	56 (9.6)		0	9 (7.4)		47 (10.2)		0.49	16.1 (7.6-28.3)
Urban	529 (90.4)			113 (92.6)		416 (89.8)			21.4 (17.9-25.1)
Baseline comorbidity									
Asthma									
No	540 (92.3)		0	111 (91.0)		429 (92.7)		0.57	20.6 (17.2-24.2)
Yes	45 (7.7)			11 (9.0)		34 (7.3)			24.4 (12.9-39.5)
Cancer									
No	502 (85.8)		0	104 (85.2)		398 (86.0)		0.88	20.7 (17.3-24.5)
Yes	83 (14.2)			18 (14.8)		65 (14.0)			21.7 (13.4-32.1)
Chronic kidney disease									
No	474 (81.0)		0	90 (73.8)		384 (82.9)		0.03	19.0 (15.6-22.8)
Yes	111 (19.0)			32 (26.2)		79 (17.1)			28.8 (20.6-38.2)
Chronic obstructive pulmonary disease									
No	495 (84.6)		0	94 (77.0)		401 (86.6)		0.02	19.0 (15.6-22.7)
Yes	90 (15.4)			28 (23.0)		62 (13.4)			31.1 (21.8-41.7)
Diabetes mellitus									
No	325 (55.6)		0	49 (40.2)		276 (59.6)		<0.001	15.1 (11.4-19.4)
Yes	260 (44.4)			73 (59.8)		187 (40.4)			28.1 (22.7-34.0)
Hypertension									
No	162 (27.7)		0	17 (13.9)		145 (31.3)		<0.001	10.5 (6.2-16.3)
Yes	423 (72.3)			105 (86.1)		318 (68.7)			24.8 (20.8-29.2)
Liver disease									
No	525 (89.7)		0	107 (87.7)		418 (90.3)		0.40	20.4 (17.0-24.1)
Yes	60 (10.3)			15 (12.3)		45 (9.7)			25.0 (14.7-37.9)
Vascular disease									
No	422 (72.1)		0	74 (60.7)		348 (75.2)		0.002	17.5 (14.0-21.5)
Yes	163 (27.9)			48 (39.3)		115 (24.8)			29.5 (22.6-37.1)
Substance use									
Alcohol use disorder									
No	537 (91.8)		0	115 (94.3)		422 (91.1)		0.35	21.4 (18.0-25.1)
Yes	48 (8.2)			7 (5.7)		41 (8.9)			14.6 (6.1-27.8)
Smoking									
Never	216 (36.9)		31	43 (35.2)		173 (37.4)		0.60	19.9 (14.8-25.9)
Former	179 (30.6)			36 (29.5)		143 (30.9)			20.1 (14.5-26.7)
Current	159 (27.2)			38 (30.9)		121 (26.1)			23.9 (17.5-31.3)
Medication history in year prior to test date									
Any angiotensin converting enzyme inhibitor or angiotensin II receptor blocker									
No	330 (56.4)		0	53 (43.4)		277 (59.8)		0.001	16.1 (12.3-20.5)
Yes	255 (43.6)			69 (56.6)		186 (40.2)			27.1 (21.7-33.0)
Angiotensin converting enzyme inhibitor									
No	416 (71.1)		0	72 (59.0)		344 (74.3)		0.002	17.3 (13.8-21.3)
Yes	169 (28.9)			50 (41.0)		119 (25.7)			29.6 (22.8-37.1)
Angiotensin II receptor blocker									
No	491 (83.9)		0	99 (81.1)		392 (84.7)		0.34	20.2 (16.7-24.0)
Yes	94 (16.1)			23 (18.9)		71 (15.3)			24.5 (16.2-34.4)
Chemotherapy or immunosuppressive drug									
No	556 (95.0)		0	115 (94.3)		441 (95.2)		0.64	20.7 (17.4-24.3)
Yes	29 (5.0)			7 (5.7)		22 (4.8)			24.1 (10.3-43.5)
Nonsteroidal anti-inflammatory drug, (-365, -14 days)									
No	392 (67.0)		0	90 (73.8)		302 (65.2)		0.08	23.0 (18.9-27.5)
Yes	193 (33.0)			32 (26.2)		161 (34.8)			16.6 (11.6-22.6)
Vital signs at test date									
Body mass index, kg/m ²									
<25.0	73 (12.5)		55	19 (15.6)		54 (11.7)		0.18	26.0 (16.5-37.6)
25.0-29.9	166 (28.4)			28 (23.0)		138 (29.8)			16.9 (11.5-23.5)
≥30	291 (49.7)			67 (54.4)		224 (48.4)			23.0 (18.3-28.3)
Hypoxia (oxygen saturation ≤93%)									
No	443 (75.7)		64	87 (71.3)		356 (76.9)		<0.001	19.6 (16.0-23.7)

Yes	78 (13.3)		30 (24.6)	48 (10.4)		38.5 (27.7-50.2)
Pulse ≥90 beats per minute						
No	295 (50.4)	33	53 (43.4)	242 (52.3)	0.02	18.0 (13.8-22.8)
Yes	257 (43.9)		68 (55.7)	189 (40.8)		26.5 (21.2-32.3)
Systolic blood pressure, mm Hg						
<90	63 (10.8)	37	17 (13.9)	46 (9.9)	0.57	27.0 (16.6-39.7)
90-140	274 (46.8)		60 (49.2)	214 (46.2)		21.9 (17.2-27.3)
≥140	211 (36.1)		44 (36.1)	167 (36.1)		20.9 (15.6-27.0)
Temperature, °F						
≤98.6	204 (34.9)	34	28 (23.0)	176 (38.0)	0.002	13.7 (9.3-19.2)
98.7-100.3	227 (38.8)		56 (45.9)	171 (36.9)		24.7 (19.2-30.8)
≥100.4	120 (20.5)		34 (27.9)	86 (18.6)		28.3 (20.5-37.3)
Laboratory findings at test date						
Alanine aminotransferase, U/L						
Median (IQR)	28.0 (19.0-41.0)	41	32.0 (21.0-47.0)	27.0 (19.0-38.0)	0.02	
≤40	406 (69.4)		78 (63.9)	328 (70.8)	0.004	19.2 (15.5-23.4)
>40	138 (23.6)		43 (35.2)	95 (20.5)		31.2 (23.6-39.6)
Albumin, g/dL						
Median (IQR)	3.8 (3.5-4.2)	41	3.6 (3.2-3.9)	3.9 (3.6-4.2)	<0.001	
≥3.5	415 (70.9)		68 (55.7)	347 (74.9)	<0.001	16.4 (13.0-20.3)
<3.5	129 (22.1)		54 (44.3)	75 (16.2)		41.9 (33.2-50.9)
Aspartate aminotransferase, U/L						
Median (IQR)	29.0 (21.5-43.0)	37	42.0 (27.0-68.0)	27.0 (21.0-39.0)	<0.001	
≤40	391 (66.8)		59 (48.4)	332 (71.7)	<0.001	15.1 (11.7-19.0)
>40	157 (26.8)		63 (51.6)	94 (20.3)		40.1 (32.4-48.2)
Creatinine, mg/dL						
Median (IQR)	1.1 (1.0-1.5)	20	1.4 (1.1-2.0)	1.1 (0.9-1.4)	<0.001	
≤1.5	435 (74.4)		72 (59.0)	363 (78.4)	<0.001	16.6 (13.2-20.4)
>1.5	130 (22.2)		50 (41.0)	80 (17.3)		38.5 (30.1-47.4)
eGFR, mL/min						
Median (IQR)	71.5 (53.0-87.0)	17	55.5 (37.0-76.0)	74.0 (58.0-90.0)	<0.001	
≥15	541 (92.5)		110 (90.2)	431 (93.1)	0.006	20.3 (17.0-24.0)
<15	27 (4.6)		12 (9.8)	15 (3.2)		44.4 (25.5-64.7)
FIB-4						
<1.45	139 (23.8)	69	6 (4.9)	133 (28.7)	<0.001	4.3 (1.6-9.2)
1.45-3.25	263 (45.0)		66 (54.1)	197 (42.5)		25.1 (20.0-30.8)
>3.25	114 (19.5)		44 (36.1)	70 (15.1)		38.6 (29.6-48.2)
Hemoglobin, g/dL						
Median (IQR)	13.9 (12.6-14.9)	45	13.6 (11.9-14.7)	14.0 (12.8-15.0)	0.02	
≥10	523 (89.4)		109 (89.3)	414 (89.4)	0.02	20.8 (17.4-24.6)
<10	17 (2.9)		8 (6.6)	9 (1.9)		47.1 (23.0-72.2)
Platelet count, K/μL						
Median (IQR)	193 (154-230)	48	175 (144-228)	195 (157-231)	0.05	
≥150	416 (71.1)		82 (19.7)	334 (72.1)	0.03	19.7 (16.0-23.9)
<150	121 (20.7)		35 (28.9)	86 (18.6)		28.9 (21.1-37.9)
White blood cell count, K/μL						
Median (IQR)	5.9 (4.7-7.5)	32	6.2 (5.2-8.9)	5.7 (4.6-7.2)	<0.001	
<4	72 (12.3)		12 (16.7)	60 (13.0)	0.002	16.7 (8.9-27.3)
4-9.9	432 (73.8)		89 (20.6)	343 (74.1)		20.6 (16.9-24.7)
≥10	49 (8.4)		21 (42.9)	28 (6.0)		42.9 (28.8-57.8)
Lymphocyte count, K/μL						
Median (IQR)	1.1 (0.8-1.6)	92	0.8 (0.6-1.1)	1.2 (0.8-1.8)	<0.001	
≥0.8	363 (62.1)		71 (19.6)	292 (63.1)	<0.001	19.6 (15.6-24.0)
<0.8	130 (22.2)		48 (36.9)	82 (17.7)		36.9 (28.6-45.8)
VACS Index score ^b , median (IQR)	72.4 (63.6-82.5)	51	82.0 (74.0-91.1)	69.4 (61.1-79.1)	<0.001	

Abbreviations: Covid-19, coronavirus disease 2019; IQR, interquartile range; eGFR, estimated glomerular filtration rate; FIB-4, fibrosis 4 score; VACS, Veterans Aging Cohort Study

^aP-values calculated on non-missing data

^bThe VACS Index score is a validated measure of physiologic injury and combining age, aspartate and alanine transaminase, albumin, creatinine, hemoglobin, platelets, white blood cell count, hepatitis C status, and body mass index

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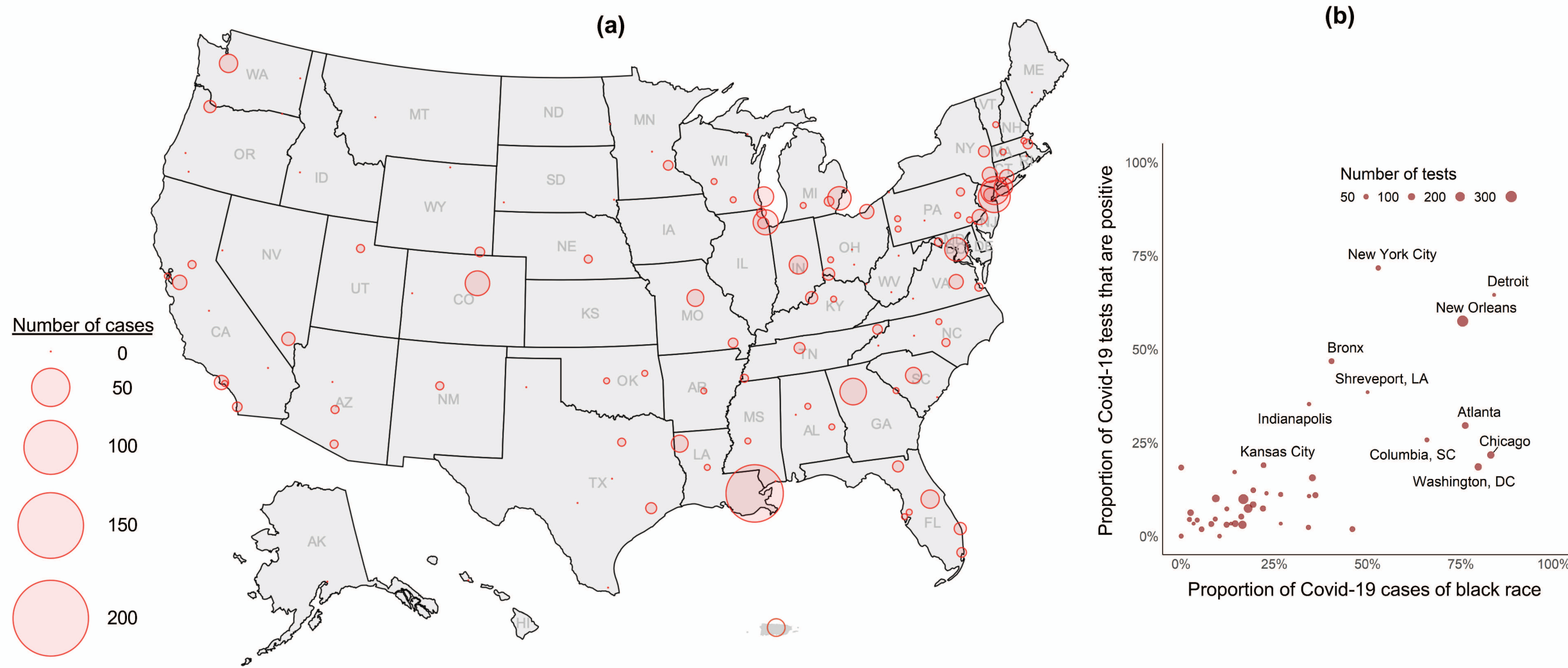
Table 4. Crude and adjusted associations with hospitalization and intensive care among Covid-19 cases as of March 30, 2020

	Hospitalization (n=297/585)			Intensive care (n=122/585)		
	Univariable OR (95% CI)	Multivariable OR (95% CI)	Multivariable OR (95% CI)	Univariable OR (95% CI)	Multivariable OR (95% CI)	Multivariable OR (95% CI)
Model details						
C-statistic	-	0.859	0.834	-	0.876	0.835
Demographics						
Age, per 5-year increase	1.26 (1.10-1.44)	0.87 (0.71-1.05)	0.64 (0.51-0.80)	1.55 (1.30-1.86)	1.31 (1.03-1.66)	0.98 (0.76-1.26)
Race/ethnicity, black vs. other	1.30 (0.94-1.82)	0.96 (0.61-1.53)	1.14 (0.74-1.74)	0.92 (0.61-1.38)	0.94 (0.55-1.63)	0.98 (0.60-1.61)
Baseline comorbidity						
Chronic kidney disease, yes vs. no	2.36 (1.53-3.66)	0.80 (0.41-1.56)	0.84 (0.47-1.49)	1.73 (1.08-2.77)	0.50 (0.24-1.06)	0.65 (0.35-1.21)
Chronic obstructive pulmonary disease, yes vs. no	2.31 (1.43-3.72)	1.77 (0.92-3.41)	1.15 (0.62-2.12)	1.93 (1.17-3.18)	1.81 (0.92-3.58)	1.47 (0.79-2.73)
Diabetes mellitus, yes vs. no	1.96 (1.41-2.73)	1.59 (1.00-2.53)	1.36 (0.89-2.09)	2.20 (1.46-3.30)	1.69 (0.96-2.98)	1.41 (0.85-2.35)
Hypertension, yes vs. no	2.25 (1.55-3.26)	1.39 (0.78-2.46)	1.50 (0.88-2.54)	2.81 (1.63-4.88)	1.51 (0.70-3.28)	1.89 (0.93-3.87)
Vascular disease, yes vs. no	2.92 (1.99-4.29)	1.58 (0.93-2.69)	1.58 (0.96-2.60)	1.96 (1.29-2.99)	0.73 (0.40-1.33)	0.77 (0.44-1.34)
Medication history in year prior to test date						
Angiotensin converting enzyme inhibitor or angiotensin II receptor blocker, yes vs. no	1.63 (1.17-2.27)	1.15 (0.71-1.87)	1.24 (0.79-1.95)	1.94 (1.30-2.90)	1.66 (0.94-2.93)	1.69 (1.01-2.84)
Nonsteroidal anti-inflammatory drug, yes vs. no	0.78 (0.55-1.10)	1.18 (0.74-1.89)	1.09 (0.71-1.67)	0.67 (0.43-1.04)	1.16 (0.65-2.06)	0.98 (0.57-1.67)
Vital signs						
Systolic blood pressure, per 5 mm Hg decrease	1.10 (1.03-1.17)	1.08 (1.00-1.18)	1.09 (1.00-1.17)	1.05 (0.98-1.13)	1.00 (0.92-1.10)	1.00 (0.91-1.09)
Oxygen saturation, per 1% decrease	1.14 (1.06-1.23)	1.04 (0.95-1.14)	1.12 (1.02-1.22)	1.16 (1.09-1.24)	1.05 (0.97-1.14)	1.13 (1.05-1.21)
Pulse, per 5-beats per minute increase	0.97 (0.95-0.99)	0.97 (0.95-0.99)	0.97 (0.95-0.99)	0.99 (0.97-1.00)	1.00 (0.97-1.02)	0.99 (0.97-1.01)
Temperature, per 1°F increase	1.20 (1.07-1.36)	1.15 (0.98-1.34)	1.24 (1.08-1.44)	1.28 (1.12-1.47)	1.32 (1.10-1.58)	1.37 (1.16-1.61)
Laboratory findings						
Albumin, per 1 g/dL decrease	10.43 (5.70-19.08)	3.75 (1.91-7.35)	-	6.17 (3.62-10.52)	3.34 (1.70-6.54)	-
eGFR, per 10 mL/min decrease	1.29 (1.19-1.40)	1.18 (1.05-1.32)	-	1.31 (1.21-1.43)	1.29 (1.15-1.46)	-
FIB-4						
<1.45	ref	ref	-	ref	ref	-
1.45-3.25	3.92 (2.53-6.08)	2.96 (1.69-5.17)	-	6.31 (2.74-14.50)	4.59 (1.72-12.22)	-
>3.25	12.37 (6.73-22.72)	8.73 (4.11-18.56)	-	12.43 (5.24-29.50)	8.40 (2.90-24.28)	-
Hemoglobin, per 1 g/dL decrease	1.55 (1.32-1.83)	1.16 (0.93-1.43)	-	1.33 (1.14, 1.54)	1.00 (0.81-1.23)	-
White blood cell count, per 1 K/ μ L increase	1.05 (0.96-1.15)	1.24 (1.08-1.43)	-	1.22 (1.10-1.36)	1.49 (1.27-1.73)	-
Lymphocyte count, per 1 K/ μ L decrease	2.68 (2.00-3.60)	2.38 (1.68-3.39)	-	2.76 (1.87-4.09)	2.65 (1.68-4.18)	-
VACS Index score ^a , per 5-point increase	1.48 (1.36-1.61)	-	1.62 (1.43-1.84)	1.45 (1.33-1.58)	-	1.47 (1.31-1.65)

Abbreviations: Covid-19, coronavirus disease 2019; OR, odds ratio; CI, confidence interval; eGFR, estimated glomerular filtration rate, FIB-4, fibrosis 4 score; VACS, Veterans Aging Cohort Study

^aThe VACS Index score is a validated measure of physiologic injury combining age, aspartate and alanine transaminase, albumin, creatinine, hemoglobin, platelets, white blood cell count, hepatitis C status, and body mass index

Figure 1. Distribution of Covid-19 cases in the Veterans Birth Cohort as of March 30, 2020



(a) Shown is the distribution of 585/1244 (47%) Covid-19 cases in the Veterans Health Administration captured in the Veterans Birth Cohort as of March 30, 2020 and included in the current study. (b) Shown is the proportion of Covid-19 test results that are positive by the proportion of Covid-19 cases of black race by site of care.

Online-Only Supplements

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eMethods

Functional forms of vital signs and laboratory results

After assessing the distribution and crude shapes of associations, each vital sign and laboratory measure used in multivariable analyses were processed for analysis using the following steps. Body mass index (BMI) was treated as a linear variable and assessed per 5 kg/m² increase, which broadly aligns with widely used categories. Pulse rate was treated as a linear variable and assessed per 5-beats per minute increase. Temperature was treated as a linear variable and assessed per 1°F increase.

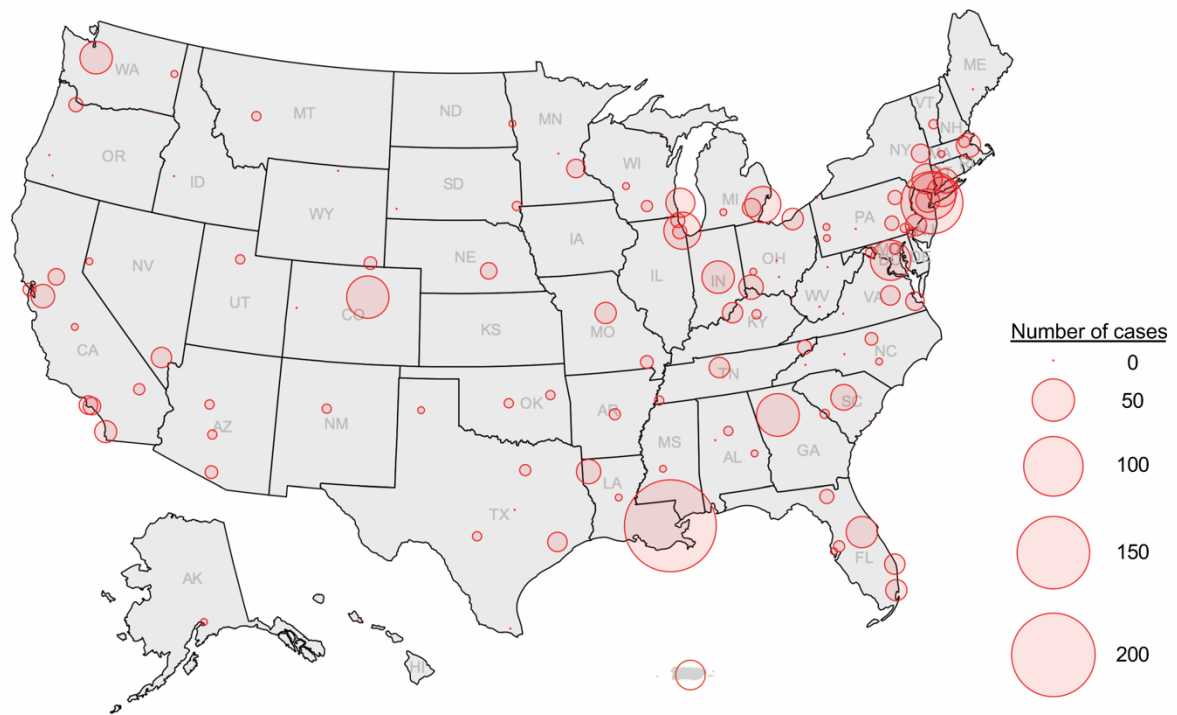
We transformed systolic blood pressure, oxygen saturation, and all labs used in multivariable analyses to benefit clinical interpretation. Systolic blood pressure values above 140 mm Hg were truncated, and we assessed linear associations per 5 mm Hg decrease. Oxygen saturation values above 98% were truncated, and we assessed linear associations per 1% decrease. Albumin values above 4 g/dL were truncated, and we assessed linear associations per 1 g/dL decrease. eGFR values above 90 mL/min were truncated, and we assessed linear associations per 10 mL/min decrease. Hemoglobin values above 14 g/dL were truncated, and we assessed linear associations per 1 g/dL decrease. White blood cell counts below 4 K/ μ L and above 10 K/ μ L were truncated, and we assessed linear associations per 1 K/ μ L increase. Lymphocyte counts above 5 K/ μ L were truncated, and we assessed linear associations per 1 K/ μ L decrease. VACS Index score was treated as a linear variable and assessed per 5-point increase.

Calculating VACS Index

Full details on constructing the VACS Index in a Veteran population have been published previously.¹ In brief, the VACS Index is a summary measure combining age, aspartate and alanine transaminase, albumin, creatinine, hemoglobin, platelets, white blood cell count, hepatitis C status, and body mass index. (Among people with HIV, we also consider HIV-1 viral load and CD4 count. These components were not used in this analysis.) Composite markers of liver and renal injury were calculated. FIB-4 is a validated indicator of liver fibrosis.² Estimated glomerular filtration rate (eGFR) is a validated indicator of impaired renal function.³ Hepatitis C status was based on presence of ICD-10-CM codes (**eTable 1**).

Because clinicians tend to order laboratory tests that they are concerned to be abnormal, we assumed laboratory values as normal if it was the only missing value for calculating the VACS Index. We used continuous functional forms for each variable including quadratic, cubic, and natural log terms to account for U-shaped associations. Splines were used for eGFR. Using regression coefficients from the original validation work, we applied regression equations to each patient using their lab values and the model coefficients to create linear predictors for each patient, which were then scaled to create scores of approximately 0 to 100.

eFigure 1. Distribution of all 1244 Covid-19 cases in the Veterans Health Administration as of March 30, 2020



eTable 1. Conditions based on International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) Diagnosis Codes

	ICD-10-CM codes
Comorbid conditions	
Asthma	J45.X
Cancer	
Cancer	C00.X-C43.X, C45.X-C76.X, C80.X-C96.X, C7A.X
Metastatic cancer	C77.X-C79.X
Chronic obstructive pulmonary disease	J41.X, J42.X, J43.X, J44.X
Chronic kidney disease	I12.0X, I13.1X, N03.2X-N03.7X, N18.X, N19.X, N05.2X-N05.7X, N25.0X, Z49.0X - Z49.2X, Z94.0X, Z99.2X
Diabetes mellitus	E08.X, E10.X, E11.X, E13.X
Hypertension	I10.X-I13.X, I15.X, I16.X
Liver disease	
Hepatitis B virus	B16.X, B18.0X, B18.1X, B19.1X, Z22.51
Hepatitis C virus	B17.10, B17.11, B18.2, B19.20, B19.21, Z22.52
Hepatic decompensation	I85.01, K65.2, K70.31, K72.1X, K72.9X, K76.7, R18.8
Other mild liver disease	B18.8X, B18.9X, K70.0X-K70.2X, K70.30, K70.9X, K71.3X-K71.5X, K71.7X, K73.X, K74.X, K76.0X, K76.2X-K76.4X, K76.8X, K76.9X, Z94.4
Other severe liver disease	K76.6, I85.00, I85.9X, I86.4, I98.2X, K70.4X, K71.1X, K76.5X
Vascular disease	
Acute myocardial infarction	I21.X (not including I21.AX), I22.X
Cardiomyopathy	I42.X, I43.X
Coronary heart disease	I20.X, I24.X, I25.10, I25.110, I25.2, I25.3, I25.41, I25.42, I25.5, I25.700, I25.710, I25.720, I25.730, I25.750, I25.760, I25.790, I25.8X, I25.9
Heart failure	I09.9, I11.0, I25.5, I13.0, I13.2, I50.X, P29.0
Cerebrovascular accident	I60.X-I69.X, G45.X, G46.X, H34.0
Peripheral vascular disease	I70.X, I71.X, I73.1-I73.9, I77.1, I79.0, I79.2, K55.1X, K55.8X, K55.9X, Z95.8X, Z95.9
Substance use	
Alcohol use disorder	F10.1X, F10.2X

eTable 2. Complete-case analysis estimating crude and adjusted associations with testing positive for Covid-19 as of March 30, 2020

	Positive Covid-19 test (n=585/3789)		
	Univariable OR (95% CI)	Multivariable OR (95% CI)	Conditional OR ^a (95% CI)
Model details			
Number complete cases	-	2458	1366
C-statistic	-	0.820	n/a
Demographics			
Age, per 5-year increase	1.04 (0.97-1.12)	1.04 (0.93-1.15)	1.04 (0.91-1.19)
Sex, male vs. female	2.49 (1.67-3.73)	3.51 (2.06-5.95)	4.59 (2.37-8.89)
Race/ethnicity, black vs. other	4.66 (3.88-5.60)	5.68 (4.43-7.28)	2.71 (1.91-3.86)
Residence type, urban vs. rural	2.46 (1.84-3.28)	1.65 (1.12-2.44)	1.00 (0.56-1.78)
Baseline comorbidity			
Chronic kidney disease, yes vs. no	1.43 (1.14-1.80)	1.02 (0.74-1.40)	1.01 (0.68-1.50)
Chronic obstructive pulmonary disease, yes vs. no	0.46 (0.37-0.59)	0.69 (0.51-0.93)	0.81 (0.55-1.19)
Diabetes mellitus, yes vs. no	1.39 (1.16-1.66)	0.96 (0.74-1.25)	0.78 (0.56-1.08)
Hypertension, yes vs. no	1.49 (1.23-1.81)	1.27 (0.93-1.75)	1.41 (0.95-2.11)
Substance use			
Alcohol use disorder, yes vs. no	0.51 (0.37-0.69)	0.52 (0.35-0.78)	0.48 (0.29-0.78)
Current smoking, yes vs. no	0.43 (0.35-0.52)	0.41 (0.31-0.53)	0.41 (0.30-0.58)
Medication history in year prior to test date			
Angiotensin converting enzyme inhibitor or angiotensin II receptor blocker, yes vs. no	1.17 (0.98-1.39)	1.05 (0.81-1.37)	0.98 (0.70-1.36)
Nonsteroidal anti-inflammatory drug, yes vs. no	1.15 (0.95-1.39)	1.31 (1.01-1.69)	1.18 (0.85-1.64)
Vital signs			
Systolic blood pressure, <140 vs. ≥140 mm Hg	1.22 (1.01-1.47)	1.46 (1.14-1.86)	1.47 (1.08-2.00)
Body mass index, per 5-unit increase	1.15 (1.08-1.23)	1.09 (0.99-1.19)	1.12 (1.00-1.25)
Oxygen saturation, ≤93% vs >93%	0.84 (0.64-1.09)	0.98 (0.71-1.37)	0.96 (0.60-1.54)
Pulse, per 5-beats per minute increase	1.05 (1.02-1.08)	1.03 (1.00-1.07)	1.05 (1.00-1.10)
Temperature, per 1°F increase	1.73 (1.61-1.85)	1.62 (1.48-1.78)	1.55 (1.38-1.74)

Abbreviations: Covid-19, coronavirus disease 2019; OR, odds ratio; CI, confidence interval

^aModeling stations with five or more Covid-19 cases and conditioning on station

eTable 3. Complete-case analysis estimating crude and adjusted associations with hospitalization and intensive care among Covid-19 cases as of March 30, 2020

	Hospitalization (n=297/585)			Intensive care (n=122/585)		
	Univariable OR (95% CI)	Multivariable OR (95% CI)	Multivariable OR (95% CI)	Univariable OR (95% CI)	Multivariable OR (95% CI)	Multivariable OR (95% CI)
Model details						
Number complete cases	-	404	484	-	404	484
C-statistic	-	0.822	0.812	-	0.864	0.828
Demographics						
Age, per 5-year increase	1.26 (1.10-1.44)	0.97 (0.78-1.21)	0.67 (0.53-0.85)	1.55 (1.30-1.86)	1.33 (1.01-1.74)	1.03 (0.79-1.35)
Race/ethnicity, black vs. other	1.30 (0.94-1.82)	1.04 (0.60-1.78)	1.08 (0.68-1.71)	0.92 (0.61-1.38)	0.94 (0.50-1.75)	1.01 (0.59-1.71)
Baseline comorbidity						
Chronic kidney disease, yes vs. no	2.36 (1.53-3.66)	0.97 (0.45-2.09)	0.93 (0.50-1.74)	1.73 (1.08-2.77)	0.58 (0.25-1.33)	0.80 (0.42-1.52)
Chronic obstructive pulmonary disease, yes vs. no	2.31 (1.43-3.71)	1.34 (0.64-2.85)	0.98 (0.51-1.87)	1.93 (1.17-3.18)	1.21 (0.56-2.58)	1.21 (0.63-2.35)
Diabetes mellitus, yes vs. no	1.96 (1.41-2.73)	1.62 (0.95-2.77)	1.36 (0.86-2.15)	2.20 (1.46-3.30)	1.79 (0.94-3.39)	1.45 (0.85-2.48)
Hypertension, yes vs. no	2.25 (1.55-3.26)	1.23 (0.64-2.37)	1.62 (0.92-2.85)	2.82 (1.63-4.88)	1.65 (0.68-4.01)	1.89 (0.88-4.05)
Vascular disease, yes vs. no	2.92 (1.99-4.29)	1.36 (0.75-2.46)	1.51 (0.88-2.57)	1.96 (1.29-2.99)	0.75 (0.39-1.43)	0.80 (0.45-1.42)
Medication history in year prior to test date						
Angiotensin converting enzyme inhibitor or angiotensin II receptor blocker, yes vs. no	1.63 (1.17-2.27)	1.15 (0.66-1.99)	1.15 (0.71-1.86)	1.94 (1.30-2.90)	1.44 (0.78-2.68)	1.57 (0.92-2.70)
Nonsteroidal anti-inflammatory drug, yes vs. no	0.78 (0.55-1.10)	1.06 (0.62-1.80)	1.01 (0.64-1.59)	0.67 (0.43-1.04)	0.97 (0.50-1.85)	0.85 (0.48-1.50)
Vital signs						
Systolic blood pressure, per 5 mm Hg decrease	1.11 (1.04-1.18)	1.12 (1.01-1.23)	1.09 (1.00-1.18)	1.05 (0.98-1.13)	1.01 (0.91-1.11)	1.00 (0.92-1.10)
Oxygen saturation, per 1% decrease	1.15 (1.07-1.24)	1.07 (0.95-1.19)	1.14 (1.03-1.25)	1.16 (1.09-1.24)	1.05 (0.96-1.15)	1.11 (1.03-1.19)
Pulse, per 5-beats per minute increase	1.06 (1.01-1.12)	1.03 (0.95-1.11)	1.02 (0.95-1.10)	1.13 (1.06-1.20)	1.13 (1.04-1.23)	1.12 (1.03-1.21)
Temperature, per 1°F increase	1.20 (1.07-1.36)	1.14 (0.96-1.36)	1.24 (1.06-1.45)	1.28 (1.12-1.47)	1.33 (1.08-1.63)	1.36 (1.14-1.61)
Laboratory findings						
Albumin, per 1 g/dL decrease	10.92 (5.88-20.25)	2.70 (1.27-5.73)	-	5.91 (3.45-10.12)	3.99 (1.81-8.80)	-
eGFR, per 10 mL/min decrease	1.29 (1.19-1.39)	1.15 (1.00-1.31)	-	1.31 (1.20-1.42)	1.29 (1.12-1.48)	-
FIB-4						
<1.45	ref	ref	-	ref	ref	-
1.45-3.25	3.98 (2.53-6.25)	2.11 (1.11-4.02)	-	7.42 (3.13-17.62)	4.59 (1.39-15.13)	-
>3.25	13.45 (7.28-24.84)	5.52 (2.39-12.75)	-	13.93 (5.66-34.29)	6.88 (1.94-24.39)	-
Hemoglobin, per 1 g/L decrease	1.51 (1.29-1.78)	1.09 (0.85-1.40)	-	1.28 (1.10-1.48)	0.96 (0.75-1.21)	-
White blood cell count, per 1 K/ μ L increase	1.06 (0.97-1.16)	1.23 (1.05-1.44)	-	1.23 (1.11-1.37)	1.41 (1.18-1.68)	-
Lymphocyte count, per 1 K/ μ L decrease	2.62 (1.95-3.52)	2.30 (1.52-3.46)	-	2.52 (1.70-3.74)	2.42 (1.44-4.07)	-
VACS Index score ^a , per 5-point increase	1.47 (1.35-1.60)	-	1.55 (1.36-1.77)	1.45 (1.33-1.58)	-	1.44 (1.27-1.64)

Abbreviations: Covid-19, coronavirus disease 2019; OR, odds ratio; CI, confidence interval; eGFR, estimated glomerular filtration rate, FIB-4, fibrosis 4 score; VACS, Veterans Aging Cohort Study

^aThe VACS Index score is a validated measure of physiologic injury combining age, aspartate and alanine transaminase, albumin, creatinine, hemoglobin, platelets, white blood cell count, hepatitis C status, and body mass index

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