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REVIEW

Racial and Ethnic Disparities in COVID-19–Related Infections, Hospitalizations, and Deaths

A Systematic Review

Katherine Mackey, MD, MPP; Chelsea K. Ayers, MPH; Karli K. Kondo, PhD; Somnath Saha, MD, MPH; Shailesh M. Advani, MD, MPH; Sarah Young, MPH; Hunter Spencer, DO; Max Rusek, MD; Johanna Anderson, MPH; Stephanie Veazie, MPH; Mia Smith, MPH; and Devan Kansagara, MD, MCR

Background: Data suggest that the effects of coronavirus disease 2019 (COVID-19) differ among U.S. racial/ethnic groups.

Purpose: To evaluate racial/ethnic disparities in severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection rates and COVID-19 outcomes, factors contributing to disparities, and interventions to reduce them. (PROSPERO: CRD42020187078)

Data Sources: English-language articles in MEDLINE, PsycINFO, CINAHL, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and Scopus, searched from inception through 31 August 2020. Gray literature sources were searched through 2 November 2020.

Study Selection: Observational studies examining SARS-CoV-2 infections, hospitalizations, or deaths by race/ethnicity in U.S. settings.

Data Extraction: Single-reviewer abstraction confirmed by a second reviewer; independent dual-reviewer assessment of quality and strength of evidence.

Data Synthesis: 37 mostly fair-quality cohort and cross-sectional studies, 15 mostly good-quality ecological studies, and data from the Centers for Disease Control and Prevention and APM Research Lab were included. African American/Black and Hispanic populations experience disproportionately higher rates of SARS-CoV-2 infection, hospitalization, and COVID-19–related mortality compared with non-Hispanic White populations, but not higher case-fatality rates (mostly reported as in-hospital mortality) (moderate- to high-strength evidence). Asian populations experience similar outcomes to non-Hispanic White populations (low-strength evidence). Outcomes for other racial/ethnic groups have been insufficiently studied. Health care access and exposure factors may underlie the observed disparities more than susceptibility due to comorbid conditions (low-strength evidence).

Limitations: Selection bias, missing race/ethnicity data, and incomplete outcome assessments in cohort and cross-sectional studies must be considered. In addition, adjustment for key demographic covariates was lacking in ecological studies.

Conclusion: African American/Black and Hispanic populations experience disproportionately higher rates of SARS-CoV-2 infection and COVID-19–related mortality but similar rates of case fatality. Differences in health care access and exposure risk may be driving higher infection and mortality rates.

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The health effects of coronavirus disease 2019 (COVID-19) due to spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have been unevenly distributed in the United States. Infections, hospitalizations, and deaths have varied among and within regions and communities, prompting questions about which populations are at higher risk and why. Health disparities, defined as a higher burden of illness, injury, disability, or mortality among one group relative to another, are well documented in the United States (1,2). In recent history, the 2009 H1N1 pandemic resulted in higher rates of hospitalizations and mortality among African American/Black and Hispanic populations (3). Early reports on disparities in COVID-19 have shown similar patterns (4,5).

According to a framework that describes the progress of health disparities research, once health disparities have been detected, the following phases of research are focused on identifying the factors driving disparities and designing and testing interventions to mitigate them (6–8). In contrast to past public health crises that were better understood after the fact, we are detecting disparities in COVID-19 in nearly real-time owing to online access to data sets, sharing of scientific work before the journal peer-review process (online posting of preprints), and use of social media (9). At this pace, it is possible to progress quickly to the intervention phase of health disparity research while the pandemic is still ongoing. The aim of this systematic review is to synthesize evidence on racial and ethnic disparities related to COVID-19, factors underlying them, and effectiveness of interventions to reduce them.

Methods

This article is based on a systematic review conducted by the Department of Veterans Affairs (VA) Evidence Synthesis Program (ESP) which examines health disparities

See also:

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Supplement

in COVID-19 and past public health crises (PROSPERO registration: CRD42020187078). Key questions were developed by 3 of the authors (D.K., K.K., S.S.) and were revised with input from the Veteran Health Administration's (VHA) Office of Health Equity. We followed standard methods and reporting guidelines for systematic reviews (10,11).

Data Sources and Searches

We searched the literature in 2 phases: from database inception through 3 June 2020 and then through 31 August 2020. Using terms related to COVID-19 and disparities, we searched the following sources for English-language articles: MEDLINE ALL (Ovid), PsycINFO, CINAHL, the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews (Ovid EBM Reviews), and Scopus (conference proceedings only). Initially, we also searched the preprint database medRxiv.org for relevant articles. We searched gray literature sources for data on our outcomes of interest through 2 November 2020 (the **Supplement**, available at Annals.org, shows the complete search strategy).

Study Selection

We included observational studies that examined SARS-CoV-2 infections, hospitalizations, and deaths stratified by race or ethnicity in U.S. settings. We included 2 types of studies examining SARS-CoV-2 infection: those based on polymerase chain reaction (PCR) testing and seroprevalence studies based on antibody testing (immunoassays for IgG, IgM, or total antibodies). We included all studies with unadjusted results for infection rates, reasoning that infection rates are minimally confounded by such factors as age and comorbid conditions. However, we excluded cohort and cross-sectional studies examining disparities in hospitalizations and deaths if results were not at least age-adjusted. We would have included observational studies or trials of interventions to mitigate disparities, but we found none.

We modified our study selection criteria for our second search, given an increase in the quality and number of studies we identified. We initially included preprints but excluded them from our second search. We also initially included ecological studies (studies of population-level outcome data, such as census tract, ZIP code, and state) but excluded them from our second search for 2 reasons. First, we found that results of individual-level and population-level studies from our first round of searching were largely consistent. Second, given the larger volume of relevant literature identified in our second search, we prioritized studies of individual-level data, on the rationale that they would more reliably address our key questions. Associations between outcomes and racial/ethnic composition in given region may not correspond to differences among racial/ethnic groups within regions (ecological fallacy). Two authors (D.K., H.S., K.K., K.M., M.R., or S.Y.) examined titles and abstracts for potential relevance, and 2 authors (C.A., D.K., K.K., K.M., S.A., or S.Y.) independently reviewed full-text articles for inclusion.

Data Extraction and Quality Assessment

One author (C.A., H.S., K.M., M.R., or S.Y.) abstracted details of study setting, population, exposures, and outcomes of interest, and a second author (C.A., D.K., K.K., K.M., M.R., S.A., S.S., or S.Y.) verified accuracy. Two authors (C.A., D.K., J.A., K.K., K.M., S.A., S.V., or S.Y.) independently assessed study methodological quality by using adapted versions of the Newcastle-Ottawa Quality Assessment Scale (12).

Data Synthesis and Analysis

We synthesized evidence qualitatively and did not perform meta-analyses owing to limited or differently reported data and study heterogeneity (for example, different covariates used in adjusted models). To synthesize evidence on factors mediating disparities, we used the framework developed by Quinn and Kumar and their colleagues to categorize factors into 3 groups related to exposure, susceptibility, and health care access (13, 14).

Two reviewers (K.M. and D.K.) independently rated the strength of the body of evidence using criteria that assessed study limitations, directness of the population studied and the outcomes measured, consistency of results across studies, and precision of effect estimates (15). All authors discussed strength of evidence assessments to achieve consensus. For this review, we applied the following general algorithm: Evidence from multiple large methodologically sound studies with consistent results received a rating of "high"; evidence from fewer studies or studies with smaller sample sizes but consistent results received a rating of "moderate"; and this same type of evidence with inconsistent results received a rating of "low."

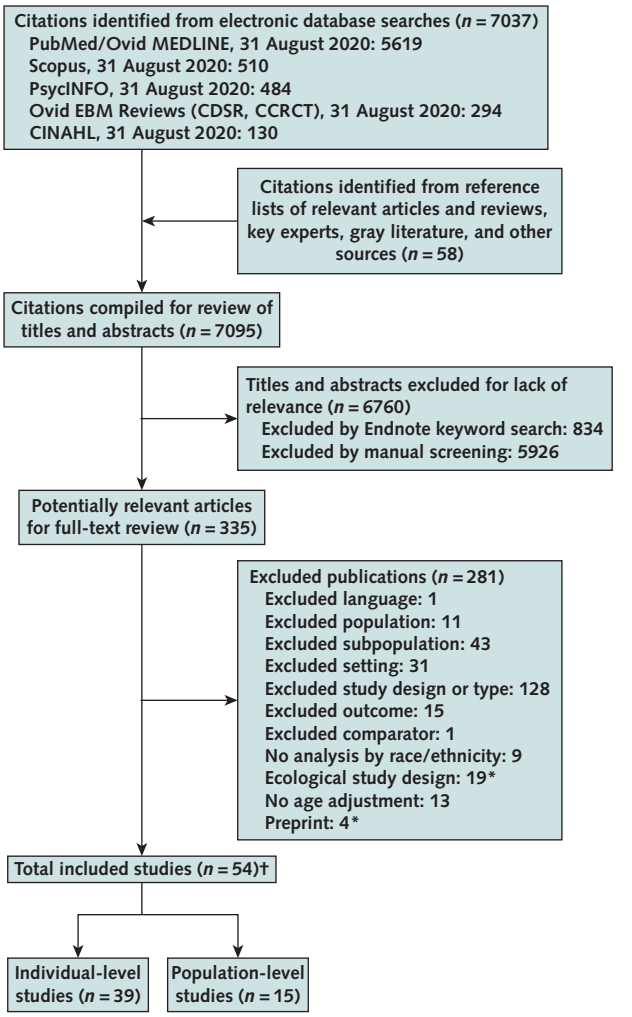
Role of the Funding Source

The authors did not receive funding for this study outside of salary support from their respective institutions.

RESULTS

The study flow diagram (**Figure**) shows the search and study selection processes (10). We included 52 studies plus data retrieved on 2 November 2020 from the Centers for Disease Control and Prevention (CDC) and APM Research Lab (16–18). We identified 37 cohort or cross-sectional studies of individuals tested for or diagnosed with SARS-CoV-2 and 15 ecological studies (**Appendix Table 1**, available at Annals.org) (16–47-48–70). Among studies of individuals tested for SARS-CoV-2, sample sizes ranged from 121 to more than 62 000, and most studies were conducted within a single hospital or health care system. Two cohort studies and 9 ecological studies examined disparities across the United States, and the remainder focused on specific cities or states. Studies most frequently evaluated SARS-CoV-2 infections, followed by COVID-19 deaths and hospitalizations, and most frequently evaluated these outcomes for African American/Black and Hispanic populations. Data regarding Asian, American Indian/Alaska Native, Native Hawaiian, Pacific Islander, and other populations were much less commonly reported. Studies adjusted for a

Figure. Study flow diagram.



CCRCT = Cochrane Central Register of Controlled Trials; CDSR = Cochrane Database of Systematic Reviews; EBM = Evidence-Based Medicine.

* Exclusions applied to July–August search results (second literature search) owing to the high volume of new studies, including those based on individual-level (rather than population-level) data.

† Includes 12 preprints from April–June publications (first literature search) as well as 6 published studies that were first identified as preprints.

wide variety of covariates, which are categorized according to the Quinn–Kumar framework in **Supplement Table 1** (available at Annals.org).

Four (11%) cohort and cross-sectional studies were good methodological quality and 25 (68%) were fair quality. Reasons that studies were assessed to be fair (rather than good) quality included lack of reporting of missing data; lack of adjustment for potential confounders; and unclear assessment of outcomes, including whether outcomes were assessed for all participants and whether follow-up was adequate. Eight (22%) cohort and cross-sectional studies were poor methodological quality due to possible selection bias and/or high levels of missing data (defined as ≥20%). Most (80%) ecological studies were good-quality. **Supplement Table 2** and **Table 3** (available at Annals.org) present quality assessments.

SARS-CoV-2 Infections

Evidence suggests that African-American/Black and Hispanic populations experience higher rates of SARS-CoV-2 infection compared with non-Hispanic White populations (**Appendix Table 2**, available at Annals.org). Among 15 cohort and cross-sectional studies (13 fair-quality, 2 poor-quality) comparing the risk for a positive SARS-CoV-2 PCR test between African American/Black and White populations, including 10 large studies of more than 1000 individuals each, all but 2 studies detected a disparity (19, 21, 23-25, 29, 32, 34–36, 40, 45, 47, 51, 53). The studies detecting a disparity estimate that African American/Black populations have a 1.5 to 3.5 times higher risk for infection than White populations. Our confidence in these findings is high, meaning that future studies are very likely to show similar estimates (both in direction of findings and magnitude). These results are supported by evidence from 6 ecological studies (4 good-quality, 2 fair-quality) (**Supplement Table 4**, available at Annals.org), which also consistently found that a higher percentage of African American/Black individuals in a given population was associated with a higher rate of diagnosed COVID-19 (55, 58, 60, 62–64). Two seroprevalence studies also identified disproportionate infection rates among African American/Black populations (30, 48). Of the 3 studies that did not find a difference, 2 were small studies of unique participants (homeless patients and pregnant or postpartum patients) (23, 29). The third study was a large seroprevalence study of health care personnel in the New York City region (42). It is unclear why findings from this study are inconsistent with others.

Similarly, evidence from 13 of 19 cohort and cross-sectional studies (1 good-quality, 15 fair-quality, 3 poor-quality), including 8 large studies of more than 1000 individuals each, suggests that Hispanic populations have higher rates of SARS-CoV-2 infection (according to SARS-CoV-2 PCR or serologic tests) compared with non-Hispanic White populations (**Appendix Table 2**) (19–21,23, 24, 26, 27, 29, 32, 35, 36, 40, 42, 47, 48, 51, 53). We have moderate confidence in these findings (rather than high) given that results were less consistent overall (compared with findings for African American populations) and estimates of the magnitude of increased risk varied. For example, 8 studies conducted in a hospital or health care setting found that Hispanic populations had a 1.3 to 7.7 times higher risk for a positive SARS-CoV-2 PCR result compared with non-Hispanic White populations, but a community-based study of residents and workers within a San Francisco census tract found that the risk was more than 28 times higher (20, 24, 26, 29, 32, 40, 47, 51, 53). Results of the community-based study, in which more than 52% of individuals with a positive PCR result were asymptomatic at the time of testing, may signal that disparities in infection rates are more pronounced than is being detected through testing in

health care settings (26). Eight ecological studies detected a disparity in infection rates among Hispanic populations compared with non-Hispanic White populations or generally among minority populations compared with non-Hispanic White populations (55, 56, 59–61, 65, 67, 68). The studies that did not detect a disparity in SARS-CoV-2 infections included the large seroprevalence study of health care personnel discussed above that also did not identify a disparity for African American/Black populations (42). Other studies not finding a disparity in infection rates among Hispanic populations had low representation of Hispanic persons (ranging from less than 1% to 9%) and may not have been adequately powered to detect a difference or were small studies of unique participants (19, 23, 31, 36, 45).

Among 7 cohort and cross-sectional studies that evaluated SARS-CoV-2 infection risk (according to SARS-CoV-2 PCR or serologic tests) in Asian populations, 6 found no difference and 1 identified a higher risk for infection compared with White populations (23, 24, 30, 36, 42, 45, 53). The only ecological study to evaluate infections among Asian populations specifically identified a higher risk (55). Given less data overall and inconsistency, we have low confidence in these findings. It is likely that more nuanced studies of specific subpopulations and settings will have different results.

American Indian/Alaska Native, Pacific Islanders, and other racial/ethnic groups were not studied sufficiently to draw any conclusions regarding disparities in infection risk.

COVID-19 Hospitalizations

Evidence suggests that African-American/Black populations have a higher risk for hospitalization due to SARS-CoV-2 compared with White populations (Table 1). Among 11 cohort and cross-sectional studies (1 good-quality, 10 fair-quality) evaluating hospitalization rates, results of 7 studies suggest that African-American/Black populations are 1.5 to 3 times more likely to be hospitalized compared with White populations (19, 22, 28, 32, 34, 37, 39, 43, 44, 46, 52). These findings are supported by data from the CDC's COVID-19-Associated Hospitalization Surveillance Network (COVID-NET), which show that African-American/Black populations have a 4 times higher risk for hospitalization compared with White populations (16). We have moderate confidence in these findings (rather than high) because not all study findings are consistent. Results of 4 studies, including a large nationally representative retrospective cohort study conducted in the VHA setting, did not identify a statistically significant difference in hospitalization rates (28, 43, 46, 52). Reasons for this inconsistency are unclear. Although future studies are likely to find that African-Americans have disproportionately higher rates of hospitalization due to SARS-CoV-2, the size of this disparity may vary by geographic region, health care access, and other factors not yet identified.

Five cohort studies (1 good-quality, 3 fair-quality, 1 poor-quality) found that Hispanic populations have a higher risk for hospitalization compared with White and non-Hispanic populations, although this finding was only statistically significant in 2 studies, which both found that the risk is 1.5 times higher (Table 1) (19, 22, 28, 32, 43). We have moderate confidence in this finding, given that the direction of results (evidence of a disparity) is consistent. Moreover, results of cohort studies are supported by data from COVID-NET showing that Hispanic persons have more than 4 times the risk for hospitalization compared with non-Hispanic White persons (16).

Hospitalization rates appear to be equal for Asian populations compared with non-Hispanic White populations on the basis of 2 retrospective cohort studies and COVID-NET data (16, 22, 43). However, our confidence in this finding is low, given that hospitalization rates among Asian persons have been infrequently studied and results to date may not be generalizable to diverse Asian subpopulations.

Hospitalization risk for other racial/ethnic groups has not been sufficiently studied to draw conclusions. No studies of individual-level data have focused on the American Indian/Alaskan Native population, although COVID-NET data suggest that this group has a 4 times higher risk for hospitalization compared with non-Hispanic White persons (16).

COVID-19 Mortality

Evidence suggests that African-American/Black populations disproportionately account for COVID-19 deaths compared with non-Hispanic White populations (Table 2). Our confidence in this finding is high, meaning that future studies are very likely to show the same estimate of effect. Analysis of data from the CDC's National Center for Health Statistics (NCHS) shows that African-American/Black populations experience approximately 15% excess deaths (defined as the percentage of COVID-19 deaths for a racial/ethnic group compared with the percentage of that racial/ethnic group in the population), and data from APM Research Lab show that African American/Black populations have 3.2 times the risk for mortality compared with White populations (17, 18). In addition, 5 ecological studies (all good-quality) consistently found higher mortality among African-American/Black populations, although not all results are statistically significant (57, 60, 63, 64, 66).

Evidence also suggests that Hispanic populations disproportionately account for COVID-19 deaths (Table 2). We have moderate (rather than high) confidence in this finding, given that fewer studies examined this outcome and results are less consistent. Data from NCHS shows that Hispanic populations have approximately 21% excess deaths, and data from APM Research Lab shows that Hispanic populations have 3.2 times the mortality risk compared with non-Hispanic White persons (17, 18). While results of studies evaluating mortality specifically for Hispanic populations are inconsistent, 2 ecological studies found that a greater proportion of non–English-speaking individuals and those with minority status in each county or state are associated with higher rates of COVID-19 deaths (57, 60, 61, 65). Conversely, a study of 1624 counties found that a higher percent minority population was associated with fewer COVID-19 deaths (69). Reasons for these different findings are unclear, and a limitation of this

Table 1. Cohort and Cross-sectional Studies of COVID-19 Hospitalizations, by Race/Ethnicity

Study, Year (Reference)	Total Participants, *n*	Hospitalized Participants, %	Outcomes*	Model Adjustments	Results
COVID-19 hospitalization rates					
CDC, COVID-NET, 2020 (16)	65 143 adults hospitalized 1 March–24 October 2020	199.8 per 100 000 population (overall cumulative rate)	Rate ratio by race/ethnicity versus white	Age	African American/Black: 4.2 Asian/Pacific Islander: 1.3 American Indian/Alaska Native: 4.3 Hispanic: 4.4
Risk for COVID-19 hospitalization					
Adegunsoye et al, 2020 (19)	785	NR	OR (95% CI) for hospitalization with positive SARS-COV-2 test: African American/Black versus non-Black and Hispanic versus non-Hispanic	Age, sex, ZIP code	African American/Black: 3.17 (1.86–5.43)† Hispanic: 1.44 (0.46-4.51)
Azar et al, 2020 (22)	1052	24	OR (95% CI) for hospitalization	Age, sex, smoking status, comorbid conditions (diabetes, hypertension, CHF, CVD, cancer, COPD, asthma, depression) homelessness, insurance, income	African American/Black: 2.67 (1.30–5.47)† Non-Hispanic Asian/Pacific Islander: 1.16 (0.61–2.20) Hispanic: 1.24 (0.78–1.98)
Ebinger et al, 2020 (28)	442	48	OR (95% CI) for illness severity, categorized by escalating levels of care (hospitalization, intensive care, intubation)	Age, sex, obesity, hypertension, diabetes, Elixhauser Comorbidity Index score, prior myocardial infarction of heart failure, prior COPD or asthma, ACEI or ARB use	African American/Black: 1.66 (0.78–3.53) Hispanic: 1.16 (0.58–2.33)
Golestaneh et al, 2020 (32)	2934	60	OR (95% CI) for hospitalization	Age, sex, diabetes, asthma, smoking, morbid obesity, hypertension, Charlson comorbidity Index score	African American/Black: 1.7 (1.2–2.4)† Hispanic: 1.5 (1.1–2.2)†
Gu et al, 2020 (34)	1139	46	OR (95% CI) for hospitalization	Age, sex, persons per square mile, less than high school education, unemployed, annual income below FPL, comorbidity score‡	African American/Black: 1.72 (1.15–2.58)†
Killerby et al, 2020 (37)	531	41	OR (95% CI) for hospitalization	Age, sex, obesity, smoking status, insurance status, hypertension, diabetes, CVD, chronic respiratory disease, CKD	African American/Black: 3.2 (1.8–5.8)†
Lara et al, 2020 (39)	121	55	RR (95% CI) for hospitalization	Age >64 y, ECOG performance status, ≥3 comorbid conditions, history of smoking	African American/Black: 1.56 (1.13–2.15)†
Petrilli et al, 2020 (43)	5279	52	OR (95% CI) for hospitalization	Age, sex, smoking, BMI, diabetes, asthma/COPD, CKD, cancer	African American/Black: 0.81 (0.65-1.01) Hispanic: 1.63 (1.35-1.97)† Asian: 1.29 (0.97-1.72)
Price-Haywood et al, 2020 (44)	3481	40	OR (95% CI) for hospitalization	Age, sex, Charlson Comorbidity Index score, residence in low-income area, insurance plan, obesity	African American/Black: 1.96 (1.62–2.37)†

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Table 1–Continued

Study, Year (Reference)	Total Participants, *n*	Hospitalized Participants, %	Outcomes*	Model Adjustments	Results
Rentsch et al, 2020 (46) et al, 2020§	585	51	OR (95% CI) for hospitalization: African American/Black versus non–African American/Black	Age, sex, urban versus rural, comorbid conditions (asthma, cancer, CKD, COPD, diabetes, hypertension, liver disease, CVD) alcohol use, tobacco use, vital signs, ACEI/ARB, NSAID, chemotherapy or immunosuppressive drug use	African American/Black: 0.96 (0.61–1.53)
van Gerwen et al, 2020 (52)	3703	54	OR (95% CI) for hospitalization	Age, sex, BMI, smoking status, hypertension, CAD, atrial fibrillation, CHF, PVD, CVA/TIA, dementia, diabetes, hypothyroidism, CKD, cancer, asthma, COPD, prior VTE	African American/Black: 1.08 (0.86–1.35)

ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; BMI = body mass index; CAD = coronary artery disease; CDC = Centers for Disease Control and Prevention; CHF = congestive heart failure; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; COVID-19 = coronavirus disease 2019; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network; CVA = cerebrovascular accident; ECOG = Eastern Oncology Cooperative Group; FPL = federal poverty level; NR = not reported; NSAID = nonsteroidal anti-inflammatory drug; OR = odds ratio, PVD = peripheral vascular disease; RR = relative risk; SARS-CoV-2 = severe acute respiratory syndrome-coronavirus 2; TIA = transient ischemic attack; VTE = venous thromboembolism.
* Compared with non-Hispanic White persons unless otherwise stated.
† Statistically significant.
‡ Defined from International Classification of Diseases codes and aggregated into a comorbidity score.
§ Preprint.

study was that county data on COVID-19 deaths were often not disaggregated by race or ethnicity.

Evidence suggests that Asian populations have similar COVID-19 mortality compared with White populations, whereas American Indian/Alaska Native and Pacific Islander populations have higher mortality rates. Data from NCHS shows that Asian populations experience 2.2% fewer deaths than would be expected on the basis of population (17), whereas data from APM Research Lab finds that Asian populations have 1.2 times the mortality risk compared with White persons (18). Data from NCHS shows that American Indian/Alaska Native populations experience 1.9% excess deaths (17), whereas APM Research Lab finds that indigenous populations and Pacific Islanders have 3.1 and 2.4 times the mortality risk compared with White persons, respectively (18). We have low confidence in these findings, given less data overall. More research is needed to draw stronger conclusions regarding disparities in COVID-19 mortality for these groups.

COVID-19 Case Fatality

In contrast to overall mortality, which reflects deaths due to diagnosed and undiagnosed COVID-19, case fatality reflects deaths among those with confirmed COVID-19. Evidence from 15 cohort and cross-sectional studies (2 good-quality, 10 fair-quality, and 3 poor-quality) suggests that there is not disparity in case fatality by race/ethnicity (**Table 2**) (19, 32, 34, 38, 39, 41, 43, 44, 47, 49, 50, 52–54, 70). We have moderate confidence in this finding for African-American/Black and Hispanic populations. Despite the consistency of findings, our confidence is not higher because studies were predominantly conducted within a single health care system, allowing only a determination of case fatality within that system but not*across* systems. Exceptions were a small study of women with gynecologic cancer and COVID-19 treated in 6 different hospital systems in New York City and a larger study of 154 acute care hospitals in 13 states (data from COVID-NET) (38, 39). These studies also did not identify a racial/ethnic disparity in case fatality rates, but future studies explicitly designed to evaluate case fatality rates by race/ethnicity including different hospitals and health systems may have different findings.

Similarly, no disparity in case fatality was found in 2 studies including Asian populations, although our confidence in these findings is low, given less data overall (43,53). We identified no studies or data reporting case-fatality for other racial/ethnic groups.

Factors Underlying Racial/Ethnic Disparities in COVID-19

A subset of 20 studies (10 individual-level and 10 ecological) used 1 or more statistical models to control for variables that could influence SARS-CoV-2 infection rates, hospitalizations, and/or deaths. These variables may be categorized into factors affecting exposure, susceptibility, and health care access by using the Quinn–Kumar framework (**Supplement Table 1**) (12, 13). A smaller subset of studies (5 cohort and 2 ecological) used a series of statistical models sequentially incorporating susceptibility and/or exposure and health care access variables to determine which factors explained the observed disparities (**Supplement Table 5**, available

Table 2. Cohort and Cross-sectional Studies of COVID-19 Deaths, by Race/Ethnicity

Study, Year (Reference)	Total Participants, *n*	Participants Who Died, %	Outcomes*	Model Adjustments	Results
COVID-19–related mortality					
APM Research Lab, 2020 (18)	217 084	–	Indirectly age-adjusted death rate per 100 000 persons	Age†	White: 39.6 Black: 128.4 Asian: 49.3 Pacific Islander: 94.1 Indigenous: 121 Latinx: 125.5
			COVID-19 mortality rate ratio	Age†	Black: 3.2 Asian: 1.2 Pacific Islander: 2.4 Indigenous: 3.1 Latinx: 3.2
CDC, National Center for Health Statistics, 2020 (17)	212 328	–	Excess percentage of COVID deaths: Difference between the percentage of age-adjusted COVID-related deaths and population distribution by race/ethnicity‡	Age†	White: −35.1§ African American/Black: 15.2§ Asian: −2.2§ American Indian/Alaska Native: 1.9§ Hispanic: 20.8§
Gross et al, 2020 (33)	U.S. population	–	Standardized mortality ratio (95% CI): African American/Black and Hispanic versus white	Age (indirect standardization), state-level random effects	African American/Black: 3.57 (2.84–4.48)‖ Hispanic: 1.88 (1.61–2.19)‖
Case-fatality rates et al, 2020 (deaths among individuals with diagnosed COVID-19)					
Adegunsoye et al, 2020 (19)	785 hospitalized adults	NR	Case-fatality OR (95% CI)	Age, sex, ZIP code	African American/Black: 1.01 (0.20–5.04)
Fox et al, 2020 (70)	355 hospitalized adults	23	OR (95% CI) for in-hospital death compared with African American/Black	Age, sex, BMI, COPD, asthma, HF, CAD, hypertension, atrial fibrillation, CKD	Non-Hispanic white: 2.73 (0.59–12.5) Hispanic: 0.84 (0.24–3.02)
Golasteneh et al, 2020 (32)	1755 hospitalized adults	22	RR (95% CI) for in-hospital mortality	Age, sex, diabetes, hypertension, asthma, Charlson Comorbidity Index score, smoking, obesity, SES, household size, proportion of Black residents, >60% residents using public transportation regularly	African American/Black: 1.2 (0.7–2.0) Hispanic: 1.0 (0.6–1.7)
Gu et al, 2020 (34)	761 adults	11	Case-fatality OR (95% CI)	Age, sex, persons per square mile, less than high school education, unemployed, annual income below FPL, comorbidity score¶	African American/Black: 1.14 (0.54–2.43)
Kim et al, 2020 (38)	2490 hospitalized adults (data from CDC's COVID-NET)	17	RR (95% CI) for in-hospital death	Age, sex, tobacco use, hypertension, obesity, diabetes, obesity, diabetes, chronic lung disease, cardiovascular disease, neurologic disease, renal disease, immunosuppression, hematologic disorders, and rheumatologic or autoimmune disease	African American/Black: 1.07 (0.85–1.35) Hispanic: 1.17 (0.91–1.51)
Lara et al, 2020 (39)	121 adults	14	RR (95% CI) for COVID-related death	Age >64 y, ECOG performance status, ≥3 comorbid conditions, history of smoking	African American/Black: 1.79 (0.72–4.44)
McCarty et al, 2020 (41)	379 hospitalized adults	15	OR (95% CI) for all-cause in-hospital death	Age, sex, obesity, cardiac disease, pulmonary disorders, hypertension, diabetes	African American/Black: 0.39 (0.13–1.12) Hispanic: 0.55 (0.23–1.29)
Petrilli et al, 2020 (43)	2737 hospitalized adults	24**	OR (95% CI) for in-hospital death	Age, sex, smoking, BMI, diabetes, asthma/COPD, CKD, cancer, CAD, CHF, hyperlipidemia, hypertension	African American/Black: 0.78 (0.60–1.02) Asian: 1.29 (0.94–1.77) Hispanic: 1.17 (0.95–1.44)
Price-Haywood et al, 2020 (44)	1382 hospitalized adults	24	HR (95% CI) for in-hospital death	Age, sex, Charlson Comorbidity Index score, residence in low-income area, insurance plan, obesity, and baseline vital signs and laboratory measures††	African American/Black HR: 0.89 (0.68–1.17)
Rentsch et al, 2020 (47)‡‡	2420 adults who tested positive for SARS-CoV-2 on PCR	12	OR for 30-day mortality§§	Age and comorbid conditions: asthma, cancer, CKD, COPD, diabetes, hypertension, liver disease, CVD	African American/Black: 0.93 (0.68–1.25) Hispanic: 1.05 (0.64–1.72)

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Table 2–Continued

Study, Year (Reference)	Total Participants, *n*	Participants Who Died, %	Outcomes*	Model Adjustments	Results
Salacup et al, 2020 (49)	242 hospitalized adults	21	OR (95% CI) for in-hospital death compared with African American/Black	Age, sex, BMI, COPD and asthma, diabetes, hypertension, CHF, cirrhosis, CKD	White: 2.9 (0.61–13.9) Hispanic: 0.74 (0.19–2.83)
Shah et al, 2020 (50)	522 hospitalized adults	18	OR (95% CI) for in-hospital death	Age, sex, BMI, comorbid conditions: hypertension, CAD, CHF, COPD, asthma, CKD, diabetes, immunosuppression, chronic liver disease, cancer, tobacco smoking	African American/Black: 0.82 (0.37–1.78)
Van Gerwen et al, 2020 (52)	2015 hospitalized adults	31	OR (95% CI) for in-hospital death	Age, sex, BMI, smoking status, hypertension, CAD, atrial fibrillation, CHF, PVD, CVA/TIA, dementia, diabetes, hypothyroidism, CKD, malignancy, asthma, COPD, and prior VTE	African American/Black: 0.96 (0.72–1.28)
Wang et al, 2020 (53)‡‡‖‖	3273 hospitalized adults	23	Log odds OR (CI not reported) for in-hospital mortality	Age, sex, duration of stay, vital signs, comorbid conditions: smoking status, asthma, COPD, hypertension, obesity, diabetes, HIV, and cancer, care in ICU unit, and laboratory tests at hospital admission (leukocyte count, creatinine level >1.2 mg/dL, ALT level)	African American/Black: 0.95 Asian: 1.04 Hispanic: 0.93
Yehia et al, 2020 (54)	7139 hospitalized adults	20	HR (95% CI) for all-cause in-hospital death	Age, sex, insurance, Elixhauser Comorbidity Index score, NDI¶¶, asthma, cancer, CKD, COPD, CHF, CAD, diabetes, obesity	African American/Black: 0.93 (0.80–1.09)

ALT = alanine aminotransferase; BMI = body mass index; CAD = coronary artery disease; CDC = Centers for Disease Control and Prevention; CHF = congestive heart failure; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; COVID-19 = coronavirus disease 2019; CVA = cerebrovascular accident; ECOG = Eastern Oncology Cooperative Group; FPL = federal poverty level; HR = hazard ratio; ICU = intensive care unit; NDI = neighborhood deprivation index; NR = not reported; NSAID = nonsteroidal anti-inflammatory drug; OR = odds ratio, PVD = peripheral vascular disease; RR = relative risk; SARS-CoV-2 = severe acute respiratory syndrome-coronavirus 2; SES = socioeconomic status; TIA = transient ischemic attack; VTE = venous thromboembolism.

* Compared with non-Hispanic White persons unless otherwise stated.

† Indirect standardization using state-level race-specific age distributions from the 2018 American Community Survey and nationwide age-specific death rates from COVID-19.

‡ For example, African American/Black individuals account for 28.54% of total age-adjusted COVID-related deaths, but the African American/Black population comprises 12.70% of the total population. The percentage excess COVID-19-related deaths is 28.54 – 12.7 = 15.8.

§ These differences are calculated using unweighted population distributions (i.e., they are not adjusted for differences in geographic distribution of COVID-19).

‖ Statistically significant.

¶ Defined from International Classification of Diseases codes and aggregated into a comorbidity score.

** Died or discharged–hospice.

†† Respiratory rate; aspartate aminotransferase, venous lactate, creatinine, bilirubin, procalcitonin, and C-reactive protein levels; and lymphocyte and platelet counts.

‡‡ Preprint.

§§ Limited–persons testing positive for COVID-19 on or before 3 April 2020–allow 30 days of follow-up.

‖‖ Accepted for publication.

¶¶ The NDI is a composite of social and material deprivation composed of 8 variables collected in the American Community Survey focused on poverty, employment, education, and housing.

at Annals.org) (22, 32, 34, 44, 47, 63, 65). Overall, results of these models suggest that exposure and health care access variables underlie COVID-19-related disparities more than susceptibility (that is, comorbid conditions), although our confidence in this finding is low. When models controlled for susceptibility factors only, observed disparities persisted in 3 studies (22, 47, 65). However, in full statistical models incorporating susceptibility, exposure, and health care access, the magnitude of the disparity decreased or the disparity was no longer observed in five studies (22, 34, 44, 47, 65). Further supporting the concept that exposure factors may be largely driving COVID-19 racial/ethnic disparities, results of a study of more than 20 000 adults tested for SARS-CoV-2 in Houston found that that population density explained disparities in infection rates for non-Hispanic Black populations (odds ratio [OR], 1.03 [95% CI, 1.01 to 1.05]) and population density and income explained infection-rate disparities for Hispanic populations (OR, 1.02 [CI 1.01 to 1.02] and OR, 1.04 [CI, 1.02 to 1.06], respectively) (51). Moreover, the lack of difference in COVID-19 case-fatality rates by race/ethnicity also suggests that exposure-related factors are contributing more to disparities than susceptibility. If susceptibility was driving disparities, we would expect to find a disproportionate rate of in-hospital deaths among minority groups, which so far has not been the case.

Interventions to Mitigate Racial/Ethnic Disparities in COVID-19

We did not identify any studies addressing interventions to mitigate racial/ethnic disparities in COVID-19.

DISCUSSION

We conducted this systematic review to synthesize evidence on racial and ethnic disparities during the COVID-19 pandemic in the United States, specifically disparities in SARS-CoV-2 infections, hospitalizations, and deaths. Identifying health disparities is the first step in disparities research, followed by identifying which factors are driving disparities and designing and testing interventions to mitigate them. This review helps advance this research agenda with 6 main findings. First, African-American/Black populations experience disproportionately higher SARS-CoV-2 infection rates and excess mortality due to COVID-19 (high strength of evidence) but not higher case-fatality rates (moderate strength of evidence). Second, Hispanic populations experience disproportionately higher infection rates and excess mortality due to COVID-19, but not higher case-fatality rates (moderate strength of evidence). Third, African American/Black and Hispanic populations have an increased risk for hospitalization due to COVID-19 (moderate strength of evidence). Fourth Asian populations appear to have similar rates of infections, hospitalizations, and deaths as White populations (low strength of evidence). Fifth, American Indian, Alaska Native, and Pacific Islander populations experience excess mortality due to COVID-19 (low strength of evidence). Finally, observed disparities are more likely to be due to exposure-related factors than susceptibility (that is, comorbid conditions) (low strength of evidence). To our knowledge, this is the first systematic review to comprehensively characterize racial/ethnic health disparities in COVID-19 in the United States and the factors underlying observed disparities. We only identified one other relevant review in our search of a COVID-19 review repository (www.covid19reviews.org/) (search date 2 November 2020), which was not limited to U.S. settings (71).

Given that SARS-CoV-2 testing to date has largely occurred in the health care context (rather than in community-based settings), findings are most applicable to populations seeking or engaged in health care. Findings are also largely derived from regions most affected by the first six months of the COVID-19 pandemic (mostly large cities), although CDC and APM Research Lab data are updated regularly and we reported their findings through early autumn 2020. It is unclear how the disparities discussed in this review will change as the COVID-19 pandemic evolves, particularly considering how closely linked access to testing is with SARS-CoV-2 infection rates, hospitalization rates, and case fatality rates. For example, if testing rates increase or testing expands to more community-based settings, we may find that observed disparities in test positivity become smaller if more testing leads to more negative test results. Alternatively, more testing may uncover more asymptomatic infections and widen the observed disparities. Similarly, changes in testing may have downstream effects on the observed disparities in hospitalization rates if the percentage of those tested requiring hospitalization increases or decreases. Population-based mortality is less affected by testing rates and will ultimately be the most informative outcome to monitor as the pandemic evolves.

This evidence base has limitations. First, 23% of studies (12 of 52) are preprints and have not gone through a formal journal peer-review process. Although we performed quality assessment of each study, the overall vetting process for these studies has not been as rigorous as for studies published in peer-reviewed journals, and we may have missed errors in reporting or data analysis. Second, most cohort and cross-sectional studies had varying levels of incomplete data on race and ethnicity and handled these missing data in different ways (either by excluding participants from analysis or grouping them into "unknown" race). The implications of these missing data in terms of our synthesis and strength of evidence ratings is unknown. Third, disparities for African-American/Black and Hispanic populations were more frequently described than disparities for other racial/ethnic groups. More research is needed to understand the magnitude and nuances of disparities for other populations and subpopulations, especially for Asian subpopulations and American Indian/Alaska Native and Pacific Islander populations overall. Fourth, owing to the nature of available data, cohort and cross-sectional studies infrequently evaluated exposure and health care access covariates, whereas ecologic studies infrequently evaluated susceptibility covariates. The result is that no study provides a complete picture of the relative importance of exposure, susceptibility, and health care access on racial/ethnic disparities for a given population. The number, type, and definition of these covariates also varied considerably across studies, making it difficult to quantitatively synthesize results. Finally, findings of ecological studies could be confounded by differences in local public health policies or programs.

Limitations of our methods include our focus on racial/ethnic health disparities. Several other types of disparities likely exist, including those related to socioeconomic status, disability status, and urban or rural location. A second limitation of our methods was our search process. We may have missed studies that stratified SARS-CoV-2 infection rates and other outcomes by race/ethnicity if the information was in an online appendix or otherwise not prominently featured in the text.

In conclusion, moderate- to high-strength evidence from this systematic review of 52 studies and analysis of data from the CDC and APM Research Lab finds that African-American/Black and Hispanic populations experience a disproportionate burden of SARS-CoV-2 infections and COVID-19-related mortality, but not higher case-fatality rates (mostly defined as in-hospital morality). Evidence is insufficient to draw strong conclusions regarding disparities in COVID-19 for other racial/ethnic groups. Increased susceptibility to COVID-19 does not seem to explain the observed disparities, but more evidence is needed to confirm this finding and evaluate the effects of health care access and exposure-related factors, such as population density. Most urgently, interventions to mitigate these disparities need to be designed and tested.

From VA Evidence Synthesis Program, VA Portland Health Care System and Oregon Health & Science University, Portland, Oregon (K.M., K.K.K., S.S., D.K.); VA Evidence Synthesis

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Corresponding Author: Katherine Mackey, MD, MPP, VA Evidence Synthesis Program, VA Portland Health Care System, 3710 SW U.S. Veterans Hospital Road, P3MED, Portland, OR 97239; e-mail, katherine.mackey@va.gov.

Current author addresses and author contributions are available at Annals.org.

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Current Author Addresses: Dr. Mackey: VA Evidence Synthesis Program, VA Portland Health Care System, 3710 SW U.S. Veterans Hospital Road, P3MED, Portland, OR 97239.
Ms. Ayers; Drs. Kondo and Saha; Ms. Young; Ms. Anderson; Ms. Veazie; and Dr. Kansagara: VA Portland Health Care System, 3710 SW U.S. Veterans Hospital Road, Mail Code R&D 71, Portland, OR 97239.
Drs. Advani: Department of Oncology, Lombardi Comprehensive Cancer Center, Georgetown University, 3300 Whitehaven Street, NW, Suite 4100, Washington, DC 20007.
Drs. Rusek and Spencer: Oregon Health & Science University, Department of Medicine, 3181 SW Sam Jackson Park Road, Portland, OR 97239.
Ms. Smith: Oregon Health & Science University–Portland State University School of Public Health, 840 SW Gaines Street, Hall Room 230, Portland, OR 97239.

Author Contributions: Conception and design: K. Mackey, C.K. Ayers, K.K. Kondo, S. Saha, D. Kansagara.
Analysis and interpretation of the data: K. Mackey, C.K. Ayers, K.K. Kondo, S. Saha, S.M. Advani, S. Young, H. Spencer, M. Rusek, J. Anderson, D. Kansagara.
Drafting of the article: K. Mackey, C.K. Ayers, S.M. Advani, D. Kansagara.
Critical revision for important intellectual content: K. Mackey, C.K. Ayers, K.K. Kondo, S. Saha, S.M. Advani, S. Young, D. Kansagara.
Final approval of the article: K. Mackey, C.K. Ayers, K.K. Kondo, S. Saha, S.M. Advani, S. Young, H. Spencer, M. Rusek, J. Anderson, S. Veazie, M. Smith, D. Kansagara.
Provision of study materials or patients: M.S. Rusek.
Statistical expertise: S.M Advani.
Administrative, technical, or logistic support: C.K. Ayers, K.K. Kondo, S. Young.
Collection and assembly of data: K. Mackey, C.K. Ayers, K.K. Kondo, S.M Advani, S. Young, H. Spencer, M. Rusek, J. Anderson, S. Veazie, M. Smith, D. Kansagara.

Appendix Table 1. Characteristics of Included Studies

Study, Year (Reference)	Study Duration	Participants, *n*	Population Description	Population Characteristics*	Race/Ethnicity, %	Funding†	Overall Methodologic Quality‡
Cohort and cross-sectional studies (individual-level data)							
Adegunsoye et al, 2020 (19)	1 January–15 April 2020	4413	Adults tested for SARS-CoV-2 with PCR after clinical screening at the University of Chicago, IL	Mean age: 46 y (SD, 9 y) Female: 65% Comorbid conditions: NR	White: 24 African American/Black: 58 Asian/Mideast Indian: 4 Native Hawaiian/Pacific Islander: <1 American Indian/Alaska Native: <1 Multiple race: 3 Hispanic: 6 Declined: <1 Unknown: 10	NIH	Fair
Ahmed et al, 2020 (20)§	10 March–24 April 2020	20 088	Individuals with and without symptoms tested for SARS-CoV-2 o– PCR at University of Utah Health, UT	Median age: SARS-CoV-2 positive, 38 y (IQR, 28–51 y) SARS-CoV-2 negative, 39 y (IQR, 28–54 y) Female: 55% Hypertension: 15% Obesity: 2% Chronic lung disease: 1%	Non-Hispanic White: 65 African American/Black: 2 Asian: 2 American Indian/Alaska Native: 1 Native Hawaiian/Pacific Islander: 1 Hispanic: 14 Other: 3 Refused/unknown: 12	NR	Fair
Anyane-Yeboa et al, 2020 (21)	Start NR; end date 9 May 2020	16; total population NR	Data from 16 state health departments (CA, CT, FL, GA, IL, IN, LA, MA, MD, MI, NJ, NY, OH, PA, TX, VA)	NR	NR	NR	Fair
APM Research Lab, 2020 (18)	9 April–13 October 2020	217 084	U.S. COVID-19–related deaths (nationwide)	NR	White: 52 African American/Black: 21 Asian: 4 American Indian/Alaska Native: 1 Pacific Islander: <1 Hispanic: 21 Missing data: 3	Dorsey & Whitney Foundation	NA
Azar et al, 2020 (22)	1 January–1 April 2020	1052	Adults with confirmed COVID-19 (by PCR or other documentation) at Sutter Health, CA	Mean age: 51 y Female: 61% Hypertension: 30% Asthma: 14% Diabetes: 11%	Non-Hispanic White: 48 African American/Black: 7 Asian: 10 American Indian/Pacific Islander: 1 Hispanic: 19 Other/unknown: 15	NR	Fair
Baggett et al, 2020 (23)§	20 March 2020	408	Adults with and without symptoms tested for SARS-CoV-2 with PCR at Boston Health Care for the Homeless Program, MA	Mean age: 52, Female: 28% Comorbid conditions: NR	White: 47 African American/Black: 33 Asian: 2 American Indian/Alaska Native: 1 Multiple: 3 Hispanic: 19 Other: 15	NR	Fair
Blitz et al, 2020 (24)	1 April–9 June 2020	4674	Pregnant women tested for SARS-CoV-2 with PCR (universal testing) at obstetrical units within 7 hospitals in New York City and Long Island, NY	Age: NR, Female: 100% Comorbid conditions: NR	Non-Hispanic White: 44 African American/Black: 12 Asian: 13 Hispanic: 18 Other: 13	None	Fair
Caraballo et al, 2020 (25)‖	Start date NR; end date 16 April 20	900	Adults from the Yale Heart Failure Registry, CT tested for SARS-CoV-2 with PCR based on symptoms	Mean age: 73, Female: 50% Hypertension: 74% CKD: 35% CAD: 30%	White: 66 African American/Black: 23	None	Fair
CDC, National Center for Health Statistics, 2020 (17)	1 March–24 October 2020	65 143	Adults hospitalized with SARS-CoV-2, data from COVID-NET	NR	Missing: 6	HHS	NA
CDC, COVID-NET, 2020 (16)	1 February–28 October 2020	212 328	Adults who died of COVID-19, National Center for Health Statistics	NR	Non-Hispanic White: 60 African American/Black: 13 Asian: 6 American Indian/Alaska Native: <1 Hispanic: 19	HHS	NA
Chamie et al, 2020 (26)	25–28 April 2020	3953	Residents or workers in a census tract participating in the longitudinal Unidos en Salud study in San Francisco, CA tested for SARS-CoV-2 with PCR regardless of symptoms	Age distribution: 4–10 y: 3% 11–17 y: 4% 18–50 y: 64% 51–70 y: 24% >70 y: 5% Female: 47% Tobacco use: 23% Hypertension: 13% Chronic lung disease: 13%	White: 41 African American/Black: 2 Asian/Pacific Islander: 9 Hispanic: 40 Other: 7 Missing data: 9	Chan Zuckerberg Biohub, UCSF, Program for Breakthrough Biomedical Research, Abbott Laboratories	Good
Chow et al, 2020 (27)§	12 March–22 April 2020	1940	Individuals residing in 583 census tracts in Orange County, CA	154/210 SARS-CoV-2–positive patients Mean age: 45 y Female: 48% Comorbid conditions: NR	White: 24 African American/Black: 3 Asian: 21 Hispanic: 40 Other/Unknown: 12	NR	Fair
Ebinger et al, 2020 (28)‖	Start date 8 March 2020; end date NR	442	Adults with PCR-confirmed SARS-CoV-2, Cedars-Sinai Health System, CA	Mean age: 53 y Female: 42% Hypertension: 19% Chronic lung disease: 12% Diabetes: 8%	White: 64 African American/Black: 13 Asian: 8 Other: 8 Hispanic: 15 Missing race data: 7 Missing ethnicity data: 8	Erika J. Glazer Family Foundation	Good

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Appendix Table 1–Continued

Study, Year (Reference)	Study Duration	Participants, *n*	Population Description	Population Characteristics*	Race/Ethnicity, %	Funding†	Overall Methodologic Quality‡
Emeruwa et al, 2020 (29)	13 March–23 April 2020	673	Pregnant women tested for SARS-CoV-2 with PCR with symptoms 13–21 March 2020 and regardless of symptoms 22 March–23 April 2020, two Presbyterian-affiliated hospitals, New York City	Median age: 29 y (range, 17–47 y), Female: 100% Gestational hypertension: 17% Asthma: 12% Gestational diabetes: 10% Preeclampsia: 10%	Non-Hispanic white: 2 African American/Black: 12 Hispanic: 60 Other: 8	NR	Fair
Flannery et al, 2020 (30)	4 April–3 June 2020	1293	Parturient women tested for IgG and/or IgM SARS-CoV-2 antibodies with symptoms or COVID-19 exposure history 4–12 April 20 and regardless of symptoms 13 April–3 June 2020, two hospitals, Philadelphia, PA	Median age: 31 y (IQR, 27–35 y) Female: 100% Hypertension: 31% Asthma: 15% Diabetes: 9%	Non-Hispanic white: 35 African American/Black: 42 Asian: 8 Hispanic: 10 Other/unknown: 6	University of Pennsylvania and NIH (institutional support); J. Lurie, J. Embiid, J. Harris, D. Blitzer (philanthropic support)	Fair
Fox et al, 2020 (70)¶	1 March–24 April 2020	355	Adults with PCR-confirmed SARS-CoV-2, Einstein Medical Center, PA	Age: 66 y (±14 y) Female: 49% Hypertension: 77% Diabetes: 47% Chronic lung disease: 21%	White: 8 African American/Black: 71 Hispanic: 11 Other: 11	None	Fair
Goldfarb et al, 2020 (31)	6 March–4 May 2020	136	Women (pregnant or within 2 weeks postpartum) tested for SARS-CoV-2 with PCR based on symptoms, Massachusetts General Hospital, Boston, MA	61 SARS-CoV-2–positive patients Median age: Hispanic: 29 y Non-Hispanic: 35 y Female: 100% Obesity: 43% Asthma: 10% Diabetes: 8%	61 patients with confirmed SARS-CoV-2: Hispanic: 36 Non-Hispanic: 64	NR	Poor
Golestaneh et al, 2020 (32)	11 March–11 April 2020 (testing period)	505 992 overall cohort; 4312 tested	Adults receiving care at Bronx Montefiore Health System, NY, 1 January 2018–1 January 2020 and tested for SARS-CoV-2 with PCR 11 March–11 April 2020	Mean age (SD): White: 53 y (24 y) African American/Black: 41 y (24 y) Hispanic 38 y (24 y) Other: 35 y (29 y) Female: 59% Hypertension: 33% Asthma: 13% Morbid obesity: 13%	White: 6 African American/Black: 27 Hispanic: 38 Other: 29	None	Fair
Gross et al, 2020 (33)	Start date NR; end date 21 April 2020	28	U.S. states plus New York City	NR	NR	NR	Poor
Gu et al, 2020 (34)‖	10 March–22 April 2020	5698	Adults tested for SARS-CoV-2 with PCR based on symptoms or risk factors, Michigan Medicine, MI	Mean age: 47 y Female: 62% Obesity: 42% Tobacco use (current or past): 38% Mean comorbidity score (SD): 2.6 (1.6)**	White: 66 African American/Black: 19 Other: 9 Missing data: 15	UM Precision Health Initiative, UM Rogel Cancer Center, Michigan Institute of Data Science, NSF, NIH NCI	Fair
Holtgrave et al, 2020 (35)	Start date NR; end date 9 April 20	NR	NY adult residents; data sets from CDC, New York State Department of Health, and New York City Department of Health and Mental Hygiene	NR	NR Missing data: 59	NR	Poor
Jehi et al, 2020 (36)	Start date NR; end date 2 April 2020	11 672	Individuals with and without symptoms and risk factors tested for SARS-CoV-2 with PCR, Cleveland Clinic, OH and FL	Median age (IQR): COVID-19–negative: OH: 47 (32-63) FL: 56 (42-68) COVID-19 positive: OH 54 (39-66) FL 52 (37-63) Female: 60% Median BMI: 28–29 kg/m^2 Hypertension: 32% Diabetes: 21%	Non-Hispanic white: 67 African American/Black: 19 Asian: 2 Hispanic: 9 Other: 12 Unknown ethnicity: 7	Cleveland Clinic, NIH/ NCATS	Fair
Killerby et al, 2020 (37)	1–30 March 2020	531	Adults with PCR-confirmed SARS-CoV-2, academic healthcare system, GA	Median age: Hospitalized: 61 y Nonhospitalized: 45 y Female: 57% Comorbid conditions: NR	Non-Hispanic White: 22 African American/Black: 59 Hispanic: 3 Other/Unknown: 19	CDC	Fair
Kim et al, 2020 (38)	1 March–2 May 2020	2491	Adults hospitalized with PCR-confirmed SARS-CoV-2; data from COVID-NET	Median age: 62 y (IQR, 50–75 y) Female: 47% Hypertension: 57% Obesity: 50% CVD: 35%	Non-Hispanic White: 47 African American/Black: 30 Hispanic: 12 Non-Hispanic Other: 6 Unknown: 4	CDC	Good
Lara et al, 2020 (39)	1 March–22 April 2020	121	Women with gynecologic cancer and COVID-19 (diagnosed by PCR, serologic testing, or radiologic imaging), 6 hospital systems, NY	Median age: 64 y (IQR, 51–73 y) Female: 100% Cancer: 100% Hypertension: 57% Diabetes: 31%	White: 50 African American/Black: 28 Hispanic: 16 Other: 21	AHRQ, NIH/NCI	Fair
Martinez et al, 2020 (40)	11 March–25 May 2020	37 727	Individuals with symptoms or risk factors tested for SARS-CoV-2 with PCR, Johns Hopkins Health System, MD	Age: NR for overall sample Female: 8% Comorbid conditions (among 2212 hospitalized patients): Hypertension: 69% CHF: 51% Diabetes: 41%	Non-Hispanic White: 45 African American/Black: 31 Hispanic: 11 Other: 13	NR	Fair
McCarty et al, 2020 (41)	22 March–2 April 2020	379	Adults hospitalized with PCR-confirmed SARS-CoV-2, Mass General Brigham hospitals, MA	Mean age: 63 y (SD, 17 y) Female: 44% Lung disorders: 57% CAD: 45% Hypertension: 44	Non-Hispanic White: 50 African American/Black: 14 Asian: 4 Hispanic: 30 Other: 3	NIH, Defense Health Agency, Vattikuti Urology Institute	Good

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Appendix Table 1–Continued

Study, Year (Reference)	Study Duration	Participants, *n*	Population Description	Population Characteristics*	Race/Ethnicity, %	Funding†	Overall Methodologic Quality‡
Moscola et al, 2020 (42)	20 April–23 June 2020	40 329	Healthcare workers tested with SARS-CoV-2 PCR or for antibodies (IgG or total immunoreactivity) with symptoms or COVID-19 exposure history 7 March–19 April 2020 and regardless of symptoms 20 April–23 June 2020, Northwell Health System, NY	Median age: 42 y (IQR, 32–55 y) Female: 74% Comorbid conditions: NR	White: 53 African American/Black: 16 Asian: 15 American Indian: <1 Pacific Islander: <1 Hispanic: 14 Other/multiple: <1	NIA, NLM	Poor
Petrilli et al, 2020 (43)	1 March–8 April 2020	5279	Adults with PCR-confirmed SARS-CoV-2, Langone Health System, NY	Median age: 54 y Female: 50% CVD: 52% Obesity 35% Diabetes: 23%	Non-Hispanic White: 38 African American/Black: 16 Asian: 7 Hispanic: 25% Other/unknown: 14	Kenneth C. Griffin Charitable Fund	Poor
Price-Haywood et al, 2020 (44)	1 March–11 April 2020	3481	Adults with PCR-confirmed SARS-CoV-2, Ochsner Health, LA	Mean age: 54 y Female: 60% Obesity: 50% Hypertension: 31% Diabetes: 16%	Non-Hispanic white: 30 African American/Black: 70	Ochsner Health Center for Outcomes and Health Services Research	Fair
Reichberg et al, 2020 (45)	2 March–10 April 2020	46 793	Individuals tested for SARS-CoV-2 with PCR, Northwell Health Laboratories, NY	Age: NR Female: 52% Comorbid conditions: NR	Non-Hispanic White: 25 African American/Black: 10 Asian: 3 Indian: <1 Hispanic:<1 Missing race data: 62	NIA, NLM	Poor
Rentsch et al, 2020 (46)§	8 February–30 March 2020	3789	Adults born 1945–1965 tested for SARS-CoV-2 with PCR, VHA (national)	Median age: 66 y Female: 5% Tobacco use (current or past): 66% Hypertension: 65% Obesity: 40	White: 28 African American/Black: 60 Hispanic: 8 Other/unknown: 4	NIAAA	Fair
Rentsch et al, 2020 (47)§	3 February–4 May 2020	62 098	Adults tested for SARS-CoV-2 with PCR, VHA (national)	Age: 61% ≥ 60 y Female: 12% Comorbid conditions: NR	White: 74 African American/Black: 19 Hispanic: 8	NIAAA	Fair
Rosenberg et al, 2020 (48)	19–28 April 2020	15 101	Adults tested for SARS-CoV-2 antibodies (IgG) regardless of symptoms or history of COVID-19, New York City grocery stores	Age: 18–54 y: 64% ≥55 y: 32% Female: 52% Comorbid conditions: NR	Non-Hispanic White: 58 African American/Black: 14 Asian: 9 Hispanic: 17 Other/multiple: 2	No specific funding	Fair
Salacup et al, 2020 (49)¶	1 March–24 April 2020	242	Adults hospitalized with PCR-confirmed SARS-CoV-2, Einstein Medical Center, Philadelphia, PA	Median age: 66 y (IQR, 58–76 y) Female: 49% Hypertension: 74% Diabetes: 49% Obesity: 40%	White: 7 African American/Black: 70 Hispanic: 11 Other: 12	None	Poor
Shah et al, 2020 (50)	2 March–6 May 2020	522	Adults hospitalized with PCR-confirmed SARS-CoV-2, Phoebe Putney Health System, GA	Median age: 63 y (IQR, 50–72 y), Female: 57% Hypertension: 80% Obesity: 67% Diabetes: 42%	White: 11 African American/Black: 87	NR	Poor
Vahidy et al, 2020 (51)‖	5 March–31 May 2020	20 228	Adults with symptoms or exposure risk tested for SARS-CoV-2 with PCR, Houston Methodist Hospital system, TX	Mean age: 51 y Female: 62% Hypertension: 47% Obesity: 28% Diabetes: 24%	White: 62 African American/Black: 22 Asian: 9 Multiple/other: 1 Hispanic: 18 Unknown/declined race: 6 Unknown/declined ethnicity: 3	No specific funding	Fair
van Gerwen et al, 2020 (52)	1 March–1 April 2020	3703	Adults with PCR-confirmed SARS-CoV-2, Mount Sinai Health System, NY	Age: 57 y (SD, 18 y) Female: 45% Hypertension: 44% Obesity: 29% Diabetes: 28%	Non-Hispanic white 27 African American/Black 27 Other/unknown: 46	No specific funding	Fair
Wang et al, 2020 (53)§††	24 February–15 April 2020	28 336	Adults tested for SARS-CoV-2 with PCR, Mount Sinai Health System, NY	NR	White: 38 African American/Black: 1 Asian/Pacific Islander: 7 Hispanic: 23 Other: 13	NR	Fair
Yehia et al, 2020 (54)	19 February–31 May 2020	7139	Adults hospitalized with PCR-confirmed SARS-CoV-2, Ascension hospitals in 12 states (AL, MD, FL, IL, IN, KS, MI, NY, OK, TN, TX, WI)	Median age: 68% (IQR, 56–79%) Female: 50% Diabetes: 31% Hypertension: 30% Obesity: 29%	Non-Hispanic White: 44 African American/Black: 39 Other: 16	NR	Fair
Ecological studies (population-level data)							
Abedi et al, 2020 (55)‡	Start date NR; end date 9 April 20	369	Counties in 7 states (CA, LA, MA, MI, NJ, NY, PA)	NR	NR	No specific funding	Good
Bilal et al, 2020 (56)§	Start date NR; end date 18 May 20	307	ZIP codes in New York City, Philadelphia, and Chicago	NR	NR	NIH, RWJF	Good
Goldstein and Atherwood, 2020 (57)§	Start date NR; end date 13 May 20	322	U.S. counties nationwide	NR	NR	NIH	Good
Guha et al, 2020 (58)§	Start date NR; end date 11 April 20	442	Zip codes in Chicago, Detroit, Miami, New York City, and Seattle (representing 93,170 COVID-19–positive cases)	Median age: 38.2 y Female: 51%	White: 45 African American/Black: 6 Other: 35 Hispanic: 15	NIH	Good
Karaye and Horney, 2020 (59)	Start date NR; end date 12 May 20	2844	U.S. counties nationwide	NR	NR	NR	Good

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Appendix Table 1–Continued

Study, Year (Reference)	Study Duration	Participants, *n*	Population Description	Population Characteristics*	Race/Ethnicity, %	Funding†	Overall Methodologic Quality‡
Khanijahani, 2020 (60)§	Start date NR; end date 18 May 20	2,738	U.S. counties nationwide	Median age: 41 y Female: 50%	African American/Black: 10 Hispanic: 9 Other/unknown: NR	NR	Good
Khazanchi et al, 2020 (61)	Start date NR; end date 19 April 20	2754	U.S. counties nationwide	NR	NR	NR	Fair
Khose et al, 2020 (62)	1 March–8 April 2020	253	Counties in Texas	NR	NR	None	Fair
Li et al, 2020 (63)	Start date NR; end date 14 April 20	661	U.S. counties nationwide	Age >65 y in the lowest vs. highest quartile of cases per 100 000 persons: 16% vs. 18% Female: 51%	Race/ethnicity in lowest vs. highest quartile cases per 100 000 persons: African American/Black: 9 vs. 16 Asian: 5 vs. 3 Native Hawaiian/Pacific Islander: 0.34 vs. 0.11 American Indian/Alaska Native: 1 vs. 2 Hispanic: 16 vs. 11	None	Fair
Millett et al, 2020 (64)	Start date NR; end date 13 April 20	3142	U.S. counties nationwide	Age ≥65 y in counties with ≥13% vs. <13% African American/Black residents: 15% vs. 18% Female: NR	Counties with ≥13% vs. <13% African American/Black residents: White: 65 vs. 93 African American/Black: 29 vs. 1	NR	Good
Nayak et al, 2020 (65)§	Start date NR; end date 4 April 20	433	U.S. counties nationwide	NR	NR	NR	Good
Sehra et al, 2020 (66)	22 January–18 April 2020	50	U.S. states nationwide	NR	NR	No specific funding	Good
Sy et al, 2020 (67)§	4 January–11 April	126 and 4	ZIP codes and boroughs in New York City	NR	NR	NIH, NSF, Google.org, Tides Foundation	Good
Whittle and Diaz-Artiles, 2020 (68)‖	Start date NR; end date 5 April 20	177	ZIP codes in New York City	NR	NR	None	Good
Zhang and Schwartz, 2020 (69)	Start date NR; end date 1 May 20	1624	U.S. counties nationwide	NR	NR	NR	Good

AHRQ = Agency for Healthcare Research and Quality; BMI = body mass index; CDC = Centers for Disease Control and Prevention; CMS = Centers for Medicare & Medicaid Services; COVID-19 = coronavirus disease 2019; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network; IQR = interquartile ratio; IR = Incidence rate; IRR = Incidence rate ratio; NA = not applicable; NIAAA = National Institute on Alcohol Abuse and Alcoholism; NCATS = National Center for Advancing Translational Sciences; NCI = National Cancer Institute; NIA = National Institute on Aging; NIH = National Institutes of Health; NLM = National Library of Medicine; NR = not reported; NS = not significant; OR = odds ratio; RR = risk ratio; RWJF = Robert Wood Johnson Foundation; SARS-CoV-2 = severe acute respiratory syndrome-coronavirus 2; UCSF = University of California, San Francisco; UM = University of Michigan; VHA = Veterans Health Administration.

* Three most prevalent comorbid conditions reported.

† If authors indicated that this work was supported by specific funding, the source is listed. If authors indicated that no funding was received, a lack of funding is noted. If authors provided conflict of interest information or listed salary support but did not specifically indicate whether those funds supported this work, then funding is categorized as NR (not reported).

‡ See Supplement Tables 2 and 3 (available at Annals.org) for details of quality assessment.

§ Preprint.

‖ Originally identified as a preprint and subsequently published.

¶ These 2 studies are based on the same patient sample from Einstein Medical Center, Philadelphia, Pennsylvania.

** Defined from International Classification of Diseases codes and aggregated into a comorbidity score.

†† Accepted for publication.

Appendix Table 2. Cohort and Cross-sectional Studies of SARS-CoV-2 Infection and Seroprevalence Rates, by Race/Ethnicity

Study, Year (Reference)	Participants, *n*	Outcomes*	Model Adjustments	Results
Risk for positive SARS-CoV-2 result on PCR				
Adegunsoye et al, 2020 (19)	4413	OR (95% CI) for testing SARS-COV-2 positive African American/Black versus non-Black persons and Hispanic persons versus non-Hispanic persons	Age, sex, ZIP code	African American/Black: 2.16 (1.73–2.70)† Hispanic: 1.00 (0.61–1.63)
Ahmed et al, 2020 (20)‡	20 088	OR (95% CI) for testing SARS-COV-2 positive among Hispanic persons versus non-Hispanic White persons	Symptoms and known SARS-CoV-2 exposure	Non-White§: 1.1 (0.8–1.6) Hispanic: 2.0 (1.3–3.1)†
Anyane-Yeboa et al, 2020 (21)	NR	Infection rate per 100 000 population	Unadjusted	White: 193 (120–266) African American/Black: 530 (312–748)† Asian: 194 (133–254) Hispanic: 652 (363–941)
Baggett et al, 2020 (23)‡	408	OR (95% CI) for testing SARS-COV-2 positive	Unadjusted	African American/Black: 0.92 (0.58–1.47)‖ Asian: 1.71 (0.41–7.04)‖ American Indian/Alaska Native: 1.71 (0.23–12.39)‖ Hispanic: 0.78 (0.43–1.38)‖
Blitz et al, 2020 (24)	4674	OR (95% CI) for testing SARS-COV-2 positive	Unadjusted	African American/Black: 1.8 (1.3–2.4)†‖ Asian: 0.7 (0.4–1.0)†‖ Hispanic: 2.5 (2.0–3.2)†‖
Caraballo et al, 2020 (25)	900	OR (95% CI) for testing SARS-COV-2 positive	Unadjusted	African American/Black: 1.75 (1.22–2.5)†‖
Chamie et al, 2020 (26)	3953	OR (95% CI) for testing SARS-COV-2 positive among Hispanic persons versus non-Hispanic persons	Unadjusted	Hispanic: 28 (12–93)†
Chow et al, 2020 (27)‡	1940 individuals from 583 census tracts	COVID-19 cases per 100 000 persons, by race/ethnicity	NA	Asian: 3.0 (1.4–6.1) vs. White: 2.9 (0.71–6.8) Hispanic: 9.4 (95% CI: 7.2–12.6) vs. White: 2.9 (95% CI: 0.71–6.8)
Emeruwa et al, 2020 (29)	673	OR (95% CI) for testing SARS-COV-2 positive	Unadjusted	African American/Black: 1.39 (0.58–3.34)‖ Hispanic: 2.13 (1.14–3.97)†‖
Goldfarb et al, 2020 (31)	136	OR (95% CI) for testing SARS-COV-2 positive among Hispanic versus non-Hispanic persons	Unadjusted	Hispanic: 1.56 (0.78–3.11)‖
Golestaneh et al, 2020 (32)	505 992	OR (95% CI) for testing SARS-COV-2 positive	Age, sex, diabetes, hypertension, asthma, Charlson Comorbidity Index score, smoking, obesity, neighborhood characteristics (average household size, proportion living under poverty level, proportion who completed high school, proportion with active internet subscription, proportion using public transportation to commute to work, proportion of Black residents)	African American/Black: 1.7 (1.5–2.0)† Hispanic: 1.3 (1.1–1.5)†
Gu et al, 2020 (34)	5698	OR (95% CI) for testing SARS-COV-2 positive (PCR or antibody test)	Age, sex, persons per square mile; less than high school education; unemployed, annual income below FPL; comorbidity score¶	African American/Black: 3.51 (2.84–4.33)†
Holtgrave et al, 2020 (35)	NR	Ratio infection risk	Unadjusted	African American/Black: 2.35 Hispanic: 3.56
Jehi et al, 2020 (36)	11 672	OR (95% CI) for testing SARS-CoV-2 positive among African American/Black persons versus White persons, Asian persons versus White persons, and Hispanic versus non-Hispanic persons	Unadjusted	African American/Black: 1.42 (1.20–1.68)†‖ Asian: 0.76 (0.39–1.49)‖ Hispanic: 1.31 (0.96–1.78)‖
Martinez et al, 2020 (40)	37 727	OR (95% CI) for testing SARS-COV-2 positive	Unadjusted	African American/Black: 2.21 (2.06–2.38)†‖ Hispanic: 7.68 (7.08–8.33) *Appendix Table 2.*
Rentsch et al, 2020 (47)‡	62 098	OR (95% CI) for testing SARS-COV-2 positive	Age and comorbid conditions**	African American/Black: 2.83 (2.65–3.03)† Hispanic: 1.80 (1.63–1.99)†
Reichberg et al, 2020 (45)	46 793	OR for testing SARS-CoV-2 positive among African American/Black persons versus non-Hispanic White persons and Asian persons versus non-Hispanic White persons	Unadjusted	African American/Black: 1.67 (1.56–1.80)† Asian: 1.31 (1.18–1.47)†
Vahidy et al, 2020 (51)	20 228	OR (95% CI) for testing SARS-COV-2 positive among non-Hispanic Black persons versus non-Hispanic White persons and Hispanic persons versus non-Hispanic persons	Age, sex, ZIP code household income, insurance type, Charlson Comorbidity Index score, hypertension, diabetes, obesity	Non-Hispanic Black: 2.23 (1.90-2.60)† Hispanic: 1.95 (1.72–2.20)†
Wang et al, 2020 (53)‡††	28 336	OR (95% CI) for testing SARS-CoV-2 positive	Age	Black: 1.89 (1.79–2.03)†‡‡ Asian/Pacific Islander: 1.02 (0.90–1.14)†† Hispanic/Latinx: 7.24 (6.75–7.69)†‡‡
Risk for positive SARS-CoV-2 antibody test et al, 2020 (seroprevalence studies)				
Flannery et al, 2020 (30)	1293	OR (95% CI) for positive SARS-CoV-2 IgG or IgM antibody test	Unadjusted	African American/Black: 5.2 (2.5–10.7)†‖ Asian: 0.5 (0.1–3.7)‖ Hispanic: 5.6 (2.4–13.5)†‖
Moscola et al, 2020 (42)	40 329	RR for SARS-CoV-2 IgG antibodies	Age, sex, borough/county of residence, job function, PCR test (negative or positive), self-reported suspicion of virus exposure, primary work location, direct patient care, work in a COVID-19–positive unit	African American/Black: 1.03 (0.99–1.07) Asian: 0.98 (0.94–1.01) American Indian: 1.01 (0.90–1.13) Pacific Islander: 0.99 (0.89–1.11) Hispanic: 1.02 (0.98–1.05)

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Appendix Table 2–Continued

Study, Year (Reference)	Participants, *n*	Outcomes*	Model Adjustments	Results
Rosenberg et al, 2020 (48)	15 101	Proportion of infection-experienced versus proportion of population (adults)	Test characteristics	Non-Hispanic White: 34 vs. 58 African American/Black: 20 vs. 14 Asian: 8 vs. 9 Hispanic: 37 vs. 17

COVID-19 = coronavirus disease 2019; FPL = federal poverty level; NR = not reported; OR = odds ratio, PCR = polymerase chain reaction; RR = relative risk; SARS-CoV-2 = severe acute respiratory syndrome-coronavirus 2.
* Compared with non-Hispanic White persons unless otherwise stated.
† Statistically significant.
‡ Preprint.
§ Hispanic/Latinx, Asian, African American/Black or African American, Native Hawaiian or other Pacific Islander, American Indian/Native Alaskan and other race individuals, as well as those with unknown race and those who chose not to disclose their race.
‖ Calculated by using MedCalc (https://www.medcalc.org/calc/odds_ratio.php).
¶ Defined from International Classification of Diseases codes and aggregated into a comorbidity score.
** Asthma, cancer, chronic kidney disease, chronic obstructive pulmonary disease, diabetes mellitus, hypertension, liver disease, and vascular.
†† Accepted for publication.
‡‡ Reviewers converted logistic regression b coefficients and 95% CIs to ORs by raising e^{b}.