


Concepts in Disaster Medicine

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Social Determinants and Indicators of COVID-19 Among Marginalized Communities: A Scientific Review and Call to Action for Pandemic Response and Recovery

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Abstract

Coronavirus disease 2019 (COVID-19) has placed massive socio-psychological, health, and economic burdens including deaths on countless lives; however, it has disproportionately impacted certain populations. Co-occurring Social Determinants of Health (SDoH) disparities and other underlying determinants have exacerbated the COVID-19 pandemic. This literature review sought to (1) examine literature focused on SDoH and COVID-19 outcomes ie, infectivity, hospitalization, and death rates among marginalized communities; and (2) identify SDoH disparities associated with COVID-19 outcomes. We searched electronic databases for studies published from October 2019 to October 2021. Studies that were selected were those intersecting SDoH indicators and COVID-19 outcomes and were conducted in the United States. Our review underscored the disproportionate vulnerabilities and adverse outcomes from COVID-19 that have impacted racial/ethnic minority communities and other disadvantaged groups (ie, senior citizens, and displaced/homeless individuals). COVID-19 outcomes were associated with SDoH indicators, ie, race/ethnicity, poverty, median income level, housing density, housing insecurity, health-care access, occupation, transportation/commuting patterns, education, air quality, food insecurity, old age, etc. Our review concluded with recommendations and a call to action to integrate SDoH indicators along with relevant health data when implementing intelligent solutions and intervention strategies to pandemic response/recovery among vulnerable populations.

In December of 2019, a highly transmissible and devastating disease known as the coronavirus disease 2019 (COVID-19) originated from Wuhan, China, leading to an epidemic of severe acute respiratory illnesses that rapidly spread to other countries across the globe. COVID-19, which is caused by a pathogen known as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is currently a leading cause of death in many countries and is responsible for more than 430 million cases, and almost 6 million mortalities in over 114 countries.¹⁻³ Although COVID-19 has placed massive socio-psychological, health, and economic burdens including deaths of countless lives, susceptibility to the pandemic's detrimental effects has disproportionately fallen on vulnerable populations with social-economic disadvantages. Several socio-contextual risk factors, eg, poverty, unemployment, food insecurity, lack of health-care access, insecure housing, racial segregation, health insurance, etc. could have considerable negative impacts on the current public health crisis as well as COVID-19 outcomes. Moreover, underlying health inequalities and co-morbid health conditions, eg, asthma, obesity, diabetes, etc., profoundly increase susceptibility to COVID-19 infections and deaths.^{4,5}

Accordingly, the World Health Organization describes social determinants of health (SDoH) as encompassing “the conditions of where a person is born, where they grow up, where they live, where they work, and where they age.”⁶ Based on the Healthy People 2030's taxonomy, SDoH is classified into 5 major domains: Economic Stability, Education, Neighborhood and Built Environment, Health and Healthcare Access, and Social and Community Context.^{7,8} There is scientific consensus that SDoH indicators, eg, available housing, social distancing, good hygiene, remote employment, food security, health access, etc., can mitigate the prevalence and severity associated with COVID-19 outcomes,⁹⁻¹¹ thereby significantly reducing the strain on the overburdened health-care systems posed by the pandemic. The impacts from COVID-19 are intricate and multi-layered; therefore, more studies are needed to explore the impacts of SDoH on COVID-19 and vice versa. Also, the B.1.617 (Delta) and more recently the B.1.1.529 (Omicron) variants of the SARS-CoV-2 have generated great concern due to their rapid spread and potential to reduce therapeutic effectiveness for treatments and vaccines.

Accordingly, the objectives of this literature review were to (1) examine literature focused on SDoH and COVID-19 outcomes among minority communities; and (2) identify SDoH disparities associated with COVID-19 outcomes. The integration of SDoH indicators into policies, surveillance, and intervention strategies could mitigate morbidities and mortalities associated with COVID-19 and future disease outbreaks/pandemics.

Methods

Search Strategy

The review of literature incorporated studies that were identified from 2 databases (PubMed and Social Science Research Network [SSRN]) published between October 2019 and October 2021). We adopted October 2019 as our timeline for study selection because this represented when COVID-19 first emerged from China. Our search terms were combined and used based on the following thesaurus and keywords: “Social Determinants of Health and COVID-19”, “Effects of Social Determinants of Health on COVID-19 Infection”, “Race and/or Ethnicity and COVID-19/SARS-CoV-2”, “Education and/or Income Level and COVID-19”, “Crime rates and COVID-19”, “Violent Crime and COVID-19”, “Transportation and Health Disparities, COVID-19”, and “Housing and/or Neighborhood and Health Disparities, COVID-19.”

Eligibility Criteria

Studies were included for review if they met the following eligibility criteria: (1) examined SDoH indicators (ie, race/ethnicity, poverty, median income level, housing density, housing insecurity, health-care access, occupation, etc.) and COVID-19 outcomes (ie, infectivity, hospitalization, and death rates among the populations studied), (2) were conducted in the United States, and (3) cross-sectional and cohort studies which were available in English language. Reviews and editorials were also included in our literature review. Studies were excluded if they neither focused on the COVID-19 pandemic nor addressed 1 or more of the 5 SDoH domains defined by the Healthy People 2030’s taxonomy.

Study Selection, Data Extraction, and Analysis

Our initial electronic database search generated articles whose titles/abstracts were collectively screened by 2 reviewers (B.W. and W.B.) using the eligibility criteria and which yielded 39 studies. Following the full-text screening, 11 studies were eliminated because they did not meet the inclusion criteria. Overall, a total of 28 studies were selected for the data extraction and analysis conducted by BW and WB see Figure 1). A third reviewer (O.O.) verified the study selection and data extraction process. The following data were extracted: title, lead author, publication year, study purpose, study design, sample size, sampling technique, participants’ demographics, and SDoH predictors. Extracted data were collated and stored on an excel spreadsheet coding matrix.

Results

A total of 28 studies met the inclusion criteria for our review. Study characteristics and general information on articles selected for review are shown in Table 1. In this article, we also described 5 domains that focused on the SDoH detrimental factors exacerbating the rapid spread of COVID-19 cases and deaths. Specifically, extracted data describing SDoH characteristics from

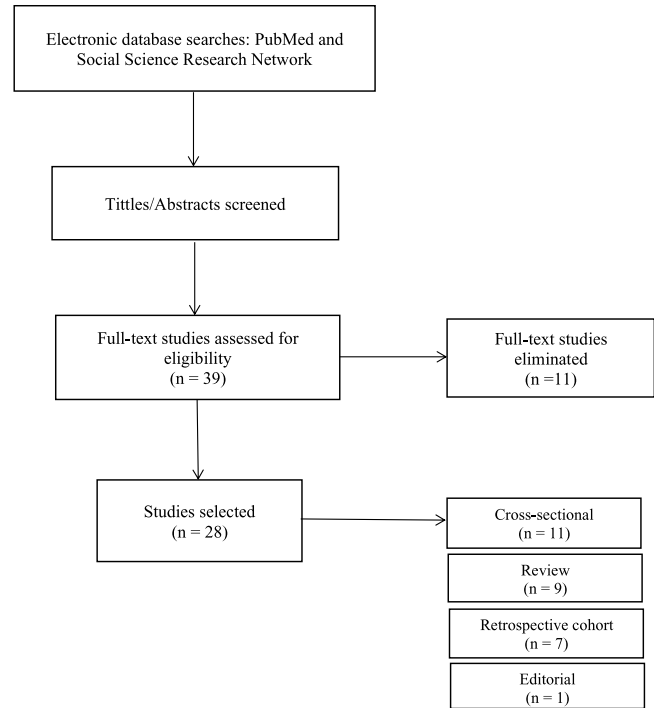


Figure 1. Literature review flow diagram.

our literature review findings were categorized into the 5 domains from the Healthy People 2030’s SDoH taxonomy: (1) Economic Stability, (2) Education, (3) Neighborhood and Built Environment, (4) Health and Healthcare Access, and (5) Social and Community Context (see Table 2). Overall, COVID-19 positive cases and/or mortality were found to be impacted by SDoH indicators such as race/ethnicity, poverty, median income level, housing density, housing insecurity, health-care access, occupation, transportation/commuting patterns, education, air quality, food insecurity, old age, etc.

Economic Stability

Employment

The US Bureau of Labor Statistics reported that only 19.7% of African Americans were able to work from home in contrast to 29.4% of White employees who worked remotely during the pandemic.¹² Concurrently, minorities were more predisposed to working low-wage positions (eg, cleaners, grocery workers, delivery truck drivers) in the service industry and essential work settings (eg, grocery stores, transportation, health-care facility) and more likely to rely on abbreviated train and bus schedules for transportation, thereby increasing susceptibility to COVID-19 infectivity and death rates.^{13,14} In addition, some low-wage workers were denied paid sick leave thus increasing the likelihood of nonadherence to quarantine measures when exposed and/or sick.¹³ Moreover, unemployment and residence in a rural county were significantly associated with COVID-19 mortality (unadjusted relative risk [RR] = 1.868; Bayesian credible interval [CrI] = 1.171, 2.127) in another study.⁹

Poverty

Data from the US population census depicted that median income for Black (\$41,361) and Hispanic (\$51,450) households was among the lowest when compared with other races.¹⁵ Likewise, the most

Table 1. Summary table representing the characteristics of selected studies

Reference first author	Purpose	Study/article location	Study type	Analytical method	SDoH indicators	Author's conclusion
⁹ Paul	Explored the county-level effects of SDoH on COVID-19 mortality rates in rural-urban settings	USA	Retrospective Cohort	Binomial regression, Cluster Analysis, Bayesian Model,	Neighborhood and built environment, race/ethnicity, socioeconomic status, education level, access to health care, rurality, walkability, access to transportation, percent unemployed, income inequality ratio, health status, substance abuse rates.	SDoH plays an important role in explaining differential COVID-19 mortality rates and should be considered for resource allocations and policy decisions on operational needs for businesses and schools at county levels.
¹⁰ Palacio	Evaluate self-reported and census-based SDoH as a mediator of health disparities in COVID-19	USA	Cross-sectional	Ecological analysis	Race and ethnicity, median household income, average household size, education, financial strain, stress, social isolation scale, health literacy, and delays in receiving health care.	Study depicts that in Miami-Dade County, COVID-19 infection is associated with the economic disadvantage and stress reported in a particular geographical area and not with its racial/ethnic distribution.
¹¹ Cyrus	Examined the impact of the density of African American communities on (COVID-19) prevalence and death rate within the 3 most populous counties in each U.S. state and territory	USA	Cross-sectional	Ecological analysis	Percentage of county/parish population who identified as African American, poverty level, and median age for the counties/parishes.	There was a direct association between African American density and COVID-19 prevalence. COVID-19 prevalence was found to increase by 5% for every 1% increase in county African American density ($p < 0.01$). Likewise, there was also an association between county African American density and COVID-19 death.
¹² Shah	Examined the COVID-19's epidemiologic evidence and racial disparities in COVID-19 outcomes	Michigan, USA	Editorial	---	Densely populated neighborhoods, lower socioeconomic status, closer contact between individuals, less equitable health care access, and lower rates of COVID-19 testing.	Studies are still needed to gain a thorough understanding of the epidemiology of COVID-19. The call to action suggests a higher priority assessment of racial and ethnic disparities as related to COVID-19, which they believe will reduce morbidity and mortality among African Americans.
¹³ Vasquez Reyes	Discussed the disproportional impact of COVID-19 on African Americans as related to SDoH	USA	Review	---	Race/ethnicity, racism/discrimination, socioeconomic status, residential segregation, housing type and transportation, health status	Conclusion suggests the COVID-19 pandemic has had an unprecedented effect on African American communities and is unmasking higher vulnerabilities among people of color.
¹⁴ Rozenfeld	Examined multiple risk factors including clinical, sociodemographic, and environmental variables associated with COVID-19 infection	USA	Retrospective Cohort	Multivariable Logistic Regression	Health status, race/ethnicity, gender, age, population density, household composition and disability, language barriers, socioeconomic status, substance abuse status, transportation insecurity, relationship status, employment, housing insecurity, and age-stratified communal living	SDoH such as older age, male gender, non-White race, speaking a primary language that is not English, being employed or retired, being married, religious affiliation, having a lower education level, and experiencing financial insecurity were associated with higher risk of COVID-19 infection.
¹⁶ Neelon	Examined temporal trends among counties with high and low social vulnerability to quantify disparities in COVID-19 incidence trends	USA	Cross-sectional	Retrospective Longitudinal Analysis	Social Vulnerability Index (SVI), population size, race/ethnicity, socioeconomic status, gender, daily PCR testing, rurality, health status, household composition and disability	Results suggest that the impact of COVID-19 is not static, rather migrates from less vulnerable populations to more vulnerable populations and back again over time.
¹⁷ Hathaway	Examined the relationship between social vulnerability of American Indian and Alaska Native populations and risk of COVID-19 infection	USA, American Indian, and Alaska Native People	Review	---	Social Vulnerability Index (SVI), household composition and disability, neighborhoods and areas, race/ethnicity, minority status and language, housing type and transportation	Conclusion finds that American Indian and Alaska Native populations are at high risk for COVID-19 contraction and complications due to numerous SDoH.

(Continued)

Table 1. (Continued)

Reference first author	Purpose	Study/article location	Study type	Analytical method	SDoH indicators	Author's conclusion
¹⁸ Kakol	Explored relationship between COVID-19 inequities and COVID-19 vaccine acceptance in BIPOC populations		Review	---	Socioeconomic status, education level, crowded living conditions, household air pollution, lack of running water that makes washing hands challenging, access to health care, transportation insecurity, and inadequate access to healthy foods	Results demonstrate that identification of populations at high risk, with a number of SDoH for COVID-19 infection, morbidity, and mortality is important to developing forecasting model analyses of the spread of infection with the help of machine learning and artificial intelligence.
¹⁹ Fielding-Miller	Assessed associations between COVID-19 mortality and social determinants such as work environment, immigration status, and insurance coverage	USA	Cross-sectional	Linear Regression and Spatial Autoregressive Models	Non-English-speaking households, hired farmworkers, uninsured individuals under the age of 65, and poverty, higher population density, urban counties, rural counties	COVID-19 mortality is significantly associated with SDoH at the county level, with exacerbation in nonurban counties. Individuals who are non-English speaking, farm work, or impoverished may be at heightened risk for COVID-19 mortality
²⁰ Calderón-Larrañaga	Examined the unproportioned effects of the COVID-19 pandemic on elderly populations		Review	---	Age, race/ethnicity, socioeconomic status, education level, access to health care, employment, neighborhood and built environment, population composition, lifestyle and living conditions	Results suggest that the current COVID-19 pandemic is further amplifying SDoH and inequities already placing pressure on elderly populations
²¹ Bauer	Examined the notion that SDoH may contribute to the disparities in COVID-19 incidence and mortality among minority and underserved Hispanic populations	South Texas, USA	Cross-sectional	Bayesian spatiotemporal negative binomial model	Neighborhoods and areas, race/ethnicity, age, minority status, primary language, socioeconomic status, household composition, housing type and transportation, education level, health status	Findings suggest that the risk of COVID-19 infection was statistically significantly higher among highly disadvantaged Hispanic population, who had identified SDoH such as higher percentages of single-parent households, low income, younger population, and limited English-speaking proficiency.
²² Coughlin	Discussed the relationship between housing and homelessness as related to pediatric health during the COVID-19 pandemic	USA	Review	---	Access to housing, housing quality, socioeconomic status, age, race/ethnicity, health status	Conclusion suggests that the COVID-19 pandemic has magnified the vulnerability of housing insecure and homeless families, leading to an increase in morbidity and mortality.
²³ Ogunyemi	Examined the association of Structural and Social Determinants of Health within minority populations with individual risk factors for COVID-19 infection	Arrowhead Regional Medical Center - Colton, California	Retrospective Cohort	Logistic Regression Model	Health status, race/ethnicity, gender, age, population density, household composition and disability, sexual orientation, incarceration, language barriers, socioeconomic status, lack of health insurance, Internet access, violent crimes, physical inactivity, education level, access to exercise	Results suggest that socially and economically disadvantaged populations are at an increased risk of developing COVID-19 infections.
²⁴ Bai	Examined transmission risk of COVID-19 throughout multiple counties in New York State in early stages of the pandemic	New York State, USA	Retrospective cohort	Network Analysis	Commute type - transmission risk (High commute - inward, High commute - outward, High commute - bidirectional, Low inter-county commute)	The use of generated risk maps can provide extra guidance and aid for local or state governments in the fight against COVID-19. These predictions will continue to help officials distribute enough medical resources to increasing areas of risk.
²⁵ Islam	Examined the temporal association between race/ethnic composition of the Social Vulnerability Index (SVI) with COVID-19 incidence/mortality	USA	Cross-sectional	Negative Binomial Mixed Model	Social Vulnerability Index (SVI), neighborhoods and areas, race/ethnicity, minority status and language, socioeconomic status, household composition and disability, housing type and transportation	Results suggest that communities with high social vulnerability index and high minority populations experienced proportionately worse COVID-19 outcomes when compared to communities with a majority White population.

Table 1. (Continued)

²⁶ Chen	Utilized spatial analysis to examine the effects of the COVID-19 pandemic and other similar outbreaks in NYC	New York City, New York	Retrospective cohort	OLS and Geographical Weighted Regression	Medical density, green space density, mean distance traveled, and commuting (walking, carpooling, and public transit), working from home and race/ethnicity	Policymakers should implement prevention measures and re-opening strategies based on localized unique events and within the context of the pandemic.
²⁸ Wu	Investigated the impact of long-term PM _{2.5} exposure on COVID-19 mortality rates in US counties	USA	Cross-sectional	Binomial Mixed Model	Race/ethnicity (Black, Hispanic), housing density, education, population density, median household income, median house value, long-term PM _{2.5} exposure	Ecological regression analyses are crucial in understanding rapidly evolving areas of research such as COVID-19.
²⁹ Millett	Investigated racial disparities in COVID-19 disease, death rates and associated determinants	USA	Cross-sectional	Bayesian-Hierarchical Model	More likely to be uninsured and unemployed, higher household occupancy per room, diabetes diagnoses, increased cardiovascular/cerebrovascular risk, HIV diagnoses, air quality	Social conditions, structural racism, and other factors significantly increase the risk for COVID-19 infection and death within Black communities. Overall, advancing the health and well-being of all Americans relies on the use of big data to affect policy change that makes equity a reality in the US.
³² Sharma	Examined multiple SDoH and their interrelatedness to COVID-19 infection in low-income households with children	USA	Cross-sectional	Thematic analysis, Qualitative and Quantitative	Socioeconomic status, employment status, availability of food, affordability of food, availability or affordability of housing, access to reliable transportation, access to childcare, access to health care	Results suggest that the risk of negative health outcomes associated with COVID-19 infection is higher for low-income households with children.
³⁴ Kim	Examined the effects of social vulnerability and other health risk factors based on the spatial distribution of COVID-19 deaths	Chicago, Illinois	Cross-sectional	Multivariable Linear Regression	African American density, poverty level, the median age in counties/parishes	Areas with a higher percentage of African American citizens were associated with higher levels of SVI and risk factor scores. These areas with higher levels of SVI and risk factor scores had a significantly higher COVID-19 death rate
³⁵ Gold	Examined the characteristics and clinical outcomes of adult patients hospitalized with COVID-19 in Georgia in March 2020	Georgia, USA	Cross-sectional	Statistical Analysis, Akaike information criterion approach	Race/ethnicity, health status, access to health insurance	Results found that clinical COVID-19 outcomes of Black patients did not differ significantly from those of non-Black patients. It is important to note that the study found Black patients to be overrepresented in the study population.
³⁷ Yancy	Discussed COVID-19 increased mortality and health care disparities within African American communities	Chicago, Illinois	Review	---	High housing density, high crime rates, and poor access to healthy foods, low socioeconomic status, cardiovascular risk factors	COVID-19 has presented a “moment of ethical reckoning” related to how disparities within minority populations are connected to negative health outcomes. There is a call to action for the U.S. to begin to identify and address disparities to aid in the fight against COVID-19 and other infectious diseases.
⁴⁰ Hooper	Examined mortalities and economic disruption related to COVID-19 in vulnerable populations	Maryland, USA	Review	---	Racism and discrimination, economic and educational disadvantages, health care access and quality, individual behavior, and biology, occupation, high-density areas, poverty, education	Studies are needed to determine the short-term and long-term effects of COVID-19 on population health and how these are connected to disparities minority populations encounter.
⁴¹ Laurencin	Examined the racial and ethnic distribution of COVID-19 confirmed cases and fatalities in the state of Connecticut. Also sought to explore the myth of Black immunity to the virus	Connecticut, USA	Review	---	Poverty, limited access to health care, high-density neighborhoods and areas, education (graduation rates, degrees, etc.) greater disease burden, higher poverty rates, higher rates of jobs in service industries	COVID-19 may have devastating effects on vulnerable populations. America has a longstanding history of discrimination, creating potential negative public health outcomes as seen in the fight against HIV, influenza, and other infectious diseases. The call for action implores the reader to identify present disparities and address their effect on minority communities against COVID-19.

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Table 1. (Continued)

Reference first author	Purpose	Study/article location	Study type	Analytical method	SDoH indicators	Author's conclusion
⁴³ Green	Examined the relationship between the social determinants of health and COVID-19 infection outcomes	USA	Review	---	Race/ethnicity, gender, socioeconomic status, household composition and disability, housing type and transportation	Results suggest that vulnerable minority populations have been disproportionately impacted by COVID-19, as related to hospitalizations and mortality rates. Reflection on social and health policies implemented and their relatedness to SDoH are necessary to ensure health inequalities are mitigated moving forward.
⁵² Toussie	Analyzed chest radiograph severity in patients with COVID-19 at initial presentation to the emergency department	New York, USA	Retrospective Cohort	Multivariable Logistic Regression	Race/ethnicity, health status, gender, age, substance abuse history	Results suggest there were no statistically significant differences in primary health outcomes of COVID-19 patients according to race or ethnicity.
⁵³ Pappan	Explored the process of identifying patient SDoH and their associations with COVID-19 pandemic response	Pittsburgh, Pennsylvania	Retrospective Cohort	Statistical Analysis	Access to food, socioeconomic status, and access to health care, access to exercise, health status	Conclusion finds that identifying SDoH barriers via telemedicine can help to properly allocate resources to those who need it most, decreasing long-term effects of the pandemic.

Table 2. Components of our SDoH classification

Economic stability	Neighborhood and built environment	Health and health-care access	Social and community context
Employment	Housing quality and transportation	Comorbidity and mortality	Discrimination
Poverty	Air quality and environmental toxins	Access to health care	Civic participation
Education	Healthy food access	Health literacy	Social support

potentially at-risk counties in the United States with a greater percentile of the Centers for Disease Control and Prevention's (CDC's) Social Vulnerability Index (SVI) had higher incident cases (RR = 1.05; 95% prediction interval [PI]: 0.98, 1.12) and death rates (RR = 1.08; 95% PI: 1.00, 1.16) compared with those counties with a lower percentile of SVI.¹⁶ Many American Indian communities lived in multigenerational households that impacted physical distancing and other inequalities measures. Tribal geographic regions also recorded higher percentages of poverty and unemployment, as well as experienced lower levels of educational status and per capita income compared to the national averages.^{17,18} Some American Indian communities experienced poor running water, crowded living conditions, and lack of access to proper health care.^{17,18} Moreover, the pandemic negatively impacted immigrant and farming populations as Fielding-Miller et al. found that COVID-19 mortality risk to be significantly higher for non-urban farmworkers, and those living below the national poverty line (5.79 and 4.41 more deaths per percentage point increase, respectively).¹⁹ This study also found that the percentage of non-English speaking households in each county significantly influenced the COVID-19 mortality, with a notable increase in the number of reported deaths.¹⁹ In New York City, COVID-19 death rates were 2.0 times higher in poor neighborhoods versus wealthy neighborhoods.²⁰ Conversely, Texas census tracts with lower income levels experienced a reduced risk of COVID-19 infection incident rate (RR = 0.972; 95% confidence interval [CI], 0.953, 0.993).²¹ Rising unemployment and financial insecurity led to an increase in homelessness, which increased the risk of contracting COVID-19.²²

Education

Some studies found a link between the COVID-19 mortality rate and education. Regions with a high percentage of the population with college or associate degrees were found to have lower COVID-19 morbidity and mortality rates.^{9,23} Moreover, Bauer et al. found that the risk ratio for COVID-19 incidence was found to be higher in census tracts with a greater percentage of the population with limited English proficiency (RR = 1.015; 95% CI, 1.003, 1.028).²¹ Nonetheless, a higher percentage of no high school education (RR = 0.987; 95% CI, 0.976, 0.998) was protective and associated with a reduced COVID-19 risk with census tract subgroup aged 19 to 34 y.²¹

Neighborhood and Built Environment

Transportation and Housing Quality

Bai et al. focused on the commuting behavior of New York residents and found that counties with a high volume of bi-directional commuting patterns were spreading COVID-19 at higher rates

than other counties with a low volume of commuting patterns.²⁴ Counties with high inward commute scores were found to have the highest rates of COVID-19 infection, while counties with high outward commute scores had the lowest rates of infection but were thought to be the primary means of transmission.²⁴ Another study found that COVID-19 infections were more likely with housing (odds ratio [OR], 1.32; 95% CI, 1.16-1.5; $P < 0.0001$) and transportation insecurities (OR, 1.11; 95% CI, 1.02-1.23; $P = 0.03$).¹⁴ A similar trend found that housing and transportation disparities (adjusted IRR per 10 percentile increase: 1.05; 95% CI, 1.04 to 1.05; $P < 0.001$) predisposed to COVID-19 deaths.²⁵ Paul et al. reported that for every 5% increase in residential segregation among those who identified as Black or White, COVID-19 death rates increased by 3.4% (adjusted RR = 1.034; CrI = 1.019, 1.050).⁹ Also, the percentage of renters and racial minorities were found to be significantly associated with increased COVID-19 risk (RR = 1.014; 95% CI, 1.008, 1.020 and RR = 1.018; 95% CI, 1.005, 1.032) for people ≥ 65 y, respectively.²¹ Moreover, higher rates of COVID-19 positive cases were significantly correlated with areas with greater green space density, public transportation, median distance traveled, carpooling, male percentage, and percentage commuting by walking.²⁶

Air Quality and Environmental Toxins

Health disparities related to air quality and occupational hazards have been found to exist among minority communities for years. For instance, Tessum et al. found that racial-ethnic minorities disproportionately inhaled fine particulate matter (PM_{2.5}) air pollution from agriculture, coal, electric utilities, and residential wood combustion.²⁷ In this review, 1 study linked COVID-19 death rates to air pollution and found that any microgram per cubic meter ($\mu\text{g}/\text{m}^3$) increases in long-term average PM_{2.5} (particles with a diameter of ≤ 2.5 μm) exposure caused an 8% increase in COVID-19 mortality rate.²⁸ Moreover, Millett et al. found that higher PM_{2.5} scores were linked to poor social distancing practices in vulnerable communities. These findings highlight evidence that air quality and environmental toxins have contributed to increased morbidity and mortality.²⁹

Healthy Food Access

Additionally, the intersectionality between food insecurity, racial discrimination, and social class has exacerbated health disparities within marginalized communities. For instance, limited access to healthy foods and green vegetables, residential segregation, and zoning policies that disproportionately increase access to high density fast food establishments were linked to COVID-19 outcomes within these communities.³⁰⁻³²

Health and Health-Care Access

Comorbidity and Mortality

The prevalence of comorbidities in a population is often associated with their socio-economic disparities.³³ The SARS-CoV-2 has disproportionately impacted minority communities. Multiple studies have shown that counties with a higher density of African Americans had a higher percentage of COVID-19 cases and death rates^{29,34} and hospitalization rates.³⁵ Of particular significance, Kim and Bostwick found that areas with higher percentages of African American residents in Chicago were associated with higher SVI and COVID-19 risk factor scores. Areas comprised of $<5\%$ African American residents had a lower percentile of SVI ranging from -2.0639 to -0.8391 , whereas areas

comprised of $>75\%$ African American residents had a greater percentile of SVIs ranging from 0.9670 to 2.4588.³⁴ Moreover, regions with a greater prevalence of African American residents had significantly higher COVID-19 death rates, with autocorrelation between the percentage of African Americans and COVID mortality being 0.41 while merely -0.33 for the percentage of White residents.³⁴ As of April 2020, preliminary data indicated that 131 predominantly Black US counties recorded infectivity rate at 137.5/100,000 and the death rate at 6.3/100,000. These infectivity and death rates were 3- and 6-fold greater than those reported in White counties. A similar trend was recorded approximately a year later (by March 7, 2021) in another study where death rates were 178/100,000 among African Americans, 172/100,000 among American Indians/Alaska Natives, and 154/100,000 among the Hispanic population.³⁶ In contrast, COVID-related mortality rates among Whites (124/100,000) and Asians (95/100,000) were slightly lower.³⁶

Researchers found that underlying health inequalities and co-morbid health conditions increased susceptibility to COVID-19 infection and death.⁴⁵ For instance, increased COVID-19 mortality rates in urban (RR = 1.862; CrI = 1.704, 2.035) and rural (RR = 1.962; CrI = 1.783, 2.158) areas were linked to 5% increase in frequent mental distress.⁹ Also, Yancy³⁷ elaborated on the higher prevalence of health comorbidities (hypertension, diabetes, obesity, cardiovascular disease, and mental illness) and restricted access to health care among African Americans. Likewise, many American Indian and Alaskan Native communities experienced lower life expectancy and suffered higher death rates from comorbidities including liver disease, diabetes mellitus, and pneumonia when compared with other racial groups.¹⁷

Access to Health-Care and Health Literacy

The Indian Health Service (IHS), an operating division within the US Department of Health and Human Services, was reported to have inadequate health facilities offering intensive care, thus requiring medical transfers to other locations. In some Navajo communities, the intensive care unit (ICU) facilities were quite far from the residences thus requiring helicopter transportation.³⁸ Moreover, incomplete documentation of health records resulted in difficulty tracking hospitalization and mortality rates compelling some communities to keep records outside of the electronic health system.³⁹ Additionally, Native Americans are sometimes miscategorized or labeled as “others” in research studies thereby causing a lack of representation and complicating efforts to obtain pertinent information to address the health inequalities.³⁹ Increased COVID-19 morbidity/mortality have also occurred among susceptible elderly individuals who resided in rural areas with limited access to health care. Although Telehealth was reported to be relatively available, reliable high-speed Internet access remained a major challenge among rural populations. Given the importance of clear communication in health-care settings, language barriers also deterred accessing health-care needs.

Social and Community Context

Civic Participation and Discrimination

Although social distancing and the opportunity to work from home decrease exposure risk levels and are established as effective strategies to combating COVID-19, their implementation remain suboptimal among minority groups living in poverty, high-density neighborhoods, and multigenerational households.^{37,40,41} Specifically, Heath⁴² addressed how social distancing was a

daunting task for those unable to secure housing, eg, the homeless because they were compelled to share common spaces with other displaced individuals. These living conditions made it difficult to adhere to social distancing guidelines and maintain hygiene standards, thereby increasing susceptibility to COVID-19 spread.⁴²

Drivers of health disparities such as structural racial injustices as well as social, historical, and political discriminations have caused communities of color to be disproportionately impacted by the pandemic. This was underscored by initial data from the pandemic which indicated that African Americans and Hispanics experienced substantially higher hospitalization and death rates.^{13,43} In addition, prioritization of resources and shortage of beds, and ventilators placed the elderly in an extremely vulnerable situation given the overburdened health-care setting as they faced double discrimination.²¹ Gender imbalances were also exacerbated by the pandemic with women being more likely to give up their paid jobs to take on the responsibility of childcare following school closures.⁴³

Social Support

Some disadvantaged groups, eg, senior citizens, displaced individuals are less likely to access and harness social support systems and other informational resources with respect to transportation, health care, and companionship. Due to social distancing measures, some older adults encountered hardship stockpiling food supplies and other necessities.⁴² Also, the lack of community capacity and mobilization in deprived areas greatly impacted timely care and support for older patients and their affected families.²

Discussions and Future Directions

The COVID-19, which has led to a global pandemic, has disproportionately impacted groups and populations across the United States. Lately, the COVID-19 pandemic has exacerbated SDoH inequalities even though these have persisted throughout health systems for years. Concurrently, SDoH inequalities have increased susceptibility to COVID-19 outcomes. We summarized and categorized our findings into the 5 SDoH domains defined by the Healthy People 2030's taxonomy: (1) Economic Stability, (2) Education, (3) Neighborhood and Built Environment, (4) Health and Healthcare Access, and (5) Social and Community Context. Our review established that SDoH disparities were related to COVID-19 outcomes, ie, infectivity, hospitalization, and death rates.

In addition to identifying SDoH disparities associated with COVID-19 outcomes, this study proposes that SDoH be incorporated into intervention strategies that address pandemic recovery and response (see Table 3). Investigating communities with public health surveillance and intervention strategies that address policies, health care systems, and society level determinants should be part of the solution process.⁴⁰ Moreover, "Moving forward, as the lessons of COVID-19 are considered, SDoH must be included as part of pandemic research priorities, public health goals, and policy implementation."⁴⁴ To plan and implement interventions for COVID-19 pandemic recovery and response, it is important to recognize and consider SDoH risk factors and vulnerabilities that may vary among different communities and populations. However, this process will require an in-depth understanding of minority communities to promote health equality for all its individuals. Maslow's framework model proposed 5 hierarchies of needs: "physiology", "safety", "social", "esteem",

Table 3. SDoH recommendations to address COVID-19 outcome disparities

Recommended action	Description
Economic instability	Resources for economic assistance, access to social services (ie, local food banks, loans), training/education on job seeking and skills acquisition
Education and language	Resources for language translation, eg, document translation, telephone interpretation, service in multiple languages; education (ie, free community college); scholarships; financial aid
Neighborhood and built environment	Health policies and intervention strategies that are focused on addressing barriers in counties with a higher percentile of Social Vulnerability Index, with particular attention to structural inequities, eg, access to healthy foods, housing, health care
Health and health-care access	Health interventions that are adapted within local contexts, eg, culturally adapted mental health services; point-of-care testing and vaccinations within community health centers. Mitigation policies that address racism/discrimination and disruptions to health-care delivery as well as address barriers to health literacy and telemedicine diffusion.
Social and Community Context	Support services for hard-to-reach groups through community partnerships

and "self-actualization" which promote diversity in policy and health decision-making that are in the best interest of communities.⁴⁵ Moreover, Jani⁴⁶ also recommended a heuristic approach to optimize the expenditure of limited resources and minimize the painful road to recovery following the pandemic. Meneses-Navarro et al.⁴⁷ suggested that the government's implementation of socio-culturally appropriate communication strategies include evidence-based best practices, due to mistrust of the government and health-care systems among minority communities. They emphasized that inequalities and barriers to health-care access should be eliminated for ground/air transportation and free health services during the COVID-19 pandemic.

Integrating SDoH indicators into intervention strategies should positively impact policies and decision-making regarding current/future pandemic preparedness and response. To a certain extent, preparedness ensures that "a degree of thought and resources are dedicated to generating the knowledge and materials needed for response to and recovery from actualized disasters."⁴⁵ The inclusion of SDoH indicators into health-care systems and planning, designing, and implementation of intervention strategies facilitate a more holistic and systematic approach to mitigating the adverse impact of the ongoing crisis, particularly for the hardest-to-reach and most vulnerable population. Also, importantly, this approach ensures that specific societal needs are met and health education/promotion efforts adequately informed. While clusters of SDoH risk factors may coexist in certain individuals and communities, it is imperative that these are distinctly identified and adequately addressed. Moreover, artificial intelligence, epidemiological analyses/investigations (eg, ecological regression analyses, etc.), and other innovative disease surveillance methods are essential to rapidly access, understand, and effectively address the emerging big data sets from the ever-evolving COVID-19 health crises.

Our findings should be considered in light of some limitations. Our study was confined to only 2 database searches, as a result, it is

possible that other significant studies not currently published in these databases were overlooked. Despite this limitation, our study identified SDoH disparities that exacerbate the ongoing public health threat particularly among vulnerable populations, and proposed the integration of SDoH into recovery efforts and pandemic preparedness. In addition, our study forms the basis for more extensive, in-depth systematic reviews and studies to gain insights on the short and long-term impacts of COVID-19 among minority communities.

Our future work is currently focused on implementing an Urban Population Health Observatory (UPHO)⁴⁸ that would generate actionable intelligence to improve COVID-19 surveillance. *Actionable Intelligence* investigates the causal pathways or effects between drivers (eg, SDoH indicators) and outcomes (eg, COVID-19 positive cases, COVID-19 morbidity, and mortality) and will involve the following processes: (1) collect and integrate data from multi-dimensional sources, (2) classify collected data into drivers and outcomes, (3) incorporate data science techniques to calculate measurable indicators from raw variables, and (4) examine the extent to which interventions are identified or developed to mitigate drivers that lead to the undesired outcomes. The design and development of a systematic surveillance platform that embeds SDoH indicators can improve equity in the distribution of quality health care and services, eg, vaccinations, inform policy/health decision-making from health officials, eg, on safety for re-openings, as well as address shortages of medical supplies to alleviate the health and economic crisis.⁴⁹⁻⁵¹

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