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PLANNING AND EVALUATION

OFFICE OF  
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PATIENT-CENTERED OUTCOMES  
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## PROJECT REPORT

# Scoping Review Report

## Data Elements for Research on the Role of Social Determinants of Health in Coronavirus Disease 2019 Infection and Outcomes in the U.S.

Prepared for  
the Office of the Assistant Secretary for Planning and Evaluation (ASPE)  
at the U.S. Department of Health & Human Services

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## Department of Health and Human Services

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## Executive Summary

The rapid emergence of the novel Coronavirus Disease 2019 (COVID-19) pandemic spurred national concerns about the social determinants of health (SDOH) as risk factors for infection and their potential to negatively impact health outcomes beyond those experienced by the population in general. In the last two years, the research community has responded with an equally rapid proliferation of research findings in both preprint (non-peer reviewed) and peer-reviewed publications. This wide-ranging body of work revealed widely varying definitions, characteristics, and measures of association between SDOH and COVID-19 infection and outcomes, which affect our collective understanding of the magnitude of impact on the pandemic.

This variability highlighted the need to facilitate knowledge sharing across COVID-19 research projects and potentially other research areas. In 2021, the Office of the Assistant Secretary for Planning and Evaluation (ASPE) launched the Collaboration on Data for Evidence (CoDE), a forum for knowledge sharing and learning among projects focused on building data capacity for patient-centered outcomes research (PCOR) related to COVID-19. This collaboration is aligned with ASPE's charge, under delegation of authority by the Secretary of the U.S. Department of Health and Human Services (HHS), to coordinate across federal health programs data capacity building for PCOR through the Office of the Secretary's PCOR Trust Fund (OS-PCORTF).

A shared priority among projects participating in CoDE was the standardization of SDOH data elements for research, which spawned a community of practice (CoP) to undertake exploration of this data infrastructure topic.<sup>1</sup> This report provides findings of a scoping review conducted collaboratively by ASPE, the CoDE CoP, and the Health federally funded research and development center (Health FFRDC), operated by The MITRE Corporation, to identify SDOH that are risk factors for, or associated with outcomes of COVID-19, and to understand how SDOH data elements, definitions, characteristics, and measures were used across studies.

The scoping review was conducted in alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. The review covered peer-reviewed studies conducted in the United States and published from December 2019 to August 2021 that included a quantitative assessment of relationships between SDOH and COVID-19 infection or outcomes, such as testing, infection, hospitalization, and other COVID-19-related sequelae.<sup>2</sup> The SDOH data elements were mapped to the Healthy People SDOH framework made of domains put forth by the HHS Office of Disease Prevention and Health Promotion's Healthy People initiative. The joint Agency for Healthcare Research and Quality (AHRQ)-National Institutes of Health/National Institute of Diabetes and Digestive and Kidney Diseases' (NIH/NIDDK) Multiple Chronic Conditions Electronic Care Plan (MCC eCare Plan) framework, which includes data standards for SDOH, was also mapped to these domains.<sup>3</sup>

From 1,520 deduplicated abstracts identified, 27 full-text studies were included in the final analysis. A total of 132 SDOH data elements were identified from these studies, which were mapped to all five Healthy People SDOH framework made of domains put forth by the HHS Office of Disease Prevention and Health Promotion's Healthy People initiative. These domains include 20 of the 72 MCC eCare Plan data elements. The elements identified include both modifiable social determinants of health and non-modifiable factors such as race and ethnicity.<sup>4</sup>



The focus of this review was on modifiable factors, such as income and housing, that are the drivers of the outcome differences. However, non-modifiable factors were also of interest, not as causal factors for disparities but as factors subject to structural inequities that produce adverse health outcomes. For instance, race and ethnicity, while not SDOH data elements, were highlighted in the analysis because of their relevance to structural racism and systemic inequities that often result in adverse health outcomes and health disparities. In 16 out of 21 studies investigating the association, race and ethnicity were found to have statistically significant associations with COVID-19-related outcomes.

Among SDOH data elements, when investigating associations with COVID-19-related outcomes, substandard/inadequate housing was most often found to have significant associations (in five out of seven studies). Other SDOH data elements (English proficiency, health insurance coverage and type, health insurance inadequacy, housing insecurity/instability and homelessness, food insecurity, support network/social network, marital/spousal status, type of transportation used, criminal justice involvement/incarceration history, immigration status, and various socioeconomic status) were identified as having statistically significant associations with COVID-19-related outcomes, each in four or fewer papers. These SDOH data elements, as well as race and ethnicity, were statistically significantly associated with poorer outcomes related to COVID-19 testing, test positivity, cases, exposure, hospitalization, and mortality. Black race, Hispanic/Latino ethnicity, lower income, and housing challenges were consistently positive predictors and covariates of poor COVID-19-related outcomes across multiple studies. In addition, there was great variability in the definitions and measures of most SDOH data elements. Several notable exceptions to this general finding were studies that used well-defined and validated composite measures based on population data such as Area Deprivation Index, Social Vulnerability Index, Index of Concentration at the Extremes, and the Distressed Communities Index.

The findings of this scoping review support the need for continuing investigation of how SDOH affects COVID-19 infections and related outcomes. There are major gaps in the availability and application of the breadth of SDOH data elements proposed by MCC eCare Plan. In addition, there is substantial opportunity to improve the standardization of SDOH data elements that were used in relevant studies. Research in both of these areas would benefit both the COVID-19 response as well as many other health and public health priorities that rely on understanding SDOH.

This report provides insights on the importance of data standards development and implementation for SDOH. These insights will enhance the ongoing research in the CoDE COVID-19 portfolio and highlight gaps in knowledge that will benefit from additional attention. The findings also offer specific opportunities to improve the data infrastructure for PCOR which relies on SDOH.

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# 1 Introduction

## 1.1 Background

In the two years since the novel Coronavirus Disease 2019 (COVID-19) emerged, publications on COVID-19 have proliferated. Many of these publications focused on risk factors and associated outcomes.<sup>5,6,7,8</sup> Several publications discuss the implications of social inequalities in health for COVID-19 incidence and outcomes, citing historical evidence from previous pandemics or exploring possible associations between social determinants of health (SDOH) and COVID-19-related outcomes as new data emerge.<sup>9,10,11,12</sup> The rapid dissemination of research findings in both preprint (non-peer reviewed) and peer-reviewed publications revealed varying definitions, characteristics, and measures of association between SDOH and COVID-19 infection and related outcomes. This variability highlights the need for standardization of data elements<sup>3</sup> to facilitate knowledge sharing across COVID-19 research projects and investigation of data linkages to understand the impact of the pandemic.<sup>13</sup>

Established in 2010 by the Affordable Care Act, the Patient-Centered Outcomes Research Trust Fund (PCORTF) was created to help build and enable national data capacity and infrastructure and leverage existing clinical and federal data for the conduct of patient-centered outcomes research (PCOR). The PCORTF supports the efforts of the Patient-Centered Outcomes Research Institute (PCORI), Agency for Healthcare Research and Quality (AHRQ), and the Office of the Secretary of the U.S. Department of Health and Human Services (HHS) to conduct, disseminate, and expand capacity for PCOR and comparative effectiveness research.<sup>14</sup>

The Office of the Assistant Secretary for Planning and Evaluation (ASPE), under delegation of authority by the Secretary of HHS, coordinates across relevant federal health programs to build data capacity for patient-centered outcomes research (PCOR) through the Office of the Secretary's PCOR Trust Fund (OS-PCORTF). This coordination involves partnerships with agency leaders, scientists, research programs, and data stewards to develop and implement an extensive array of projects that expand data capacity for PCOR. In December 2019, Congress reauthorized the OS-PCORTF through 2029.

ASPE has supported the Secretary of HHS throughout the COVID-19 pandemic and recovery phases, providing an evidence-based agenda and analyses on population groups who are disproportionately impacted by COVID-19.<sup>15</sup>

In 2020, ASPE solicited projects to build data capacity and infrastructure for PCOR related to COVID-19. Seven multi-agency projects were selected for fiscal year (FY) 2021 funding. A summary of the projects can be found in the report *Building Data Capacity for Patient-Centered Outcomes Research (PCOR) for COVID-19: Highlights of Seven OS-PCORTF Funded Multiagency Data Initiatives*.<sup>1</sup>

In addition, ASPE implemented a new model of collaboration, the OS-PCORTF Collaboration on Data for Evidence (CoDE), to facilitate knowledge and expertise sharing across these FY21 COVID-19 projects. CoDE established two communities of practice (CoPs) to drive hands-on initiatives on standardization of

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<sup>a</sup> A data element is considered the basic unit of information, having a unique meaning and subcategories of distinct units or values. In computer terms, data elements are objects that can be collected, used, and/or stored in clinical information systems and application programs.

data elements for research on 1) SDOH data standards and 2) data linkages to describe lessons learned from OS-PCORTF Medicaid linkage projects. The CoP that focuses on SDOH data standards is composed of research scientists from the National Institutes of Health (NIH) and ASPE who have expertise and experience with SDOH and patient-centered outcomes. As research on COVID-19 risk and outcomes continued to grow, there was a need to understand SDOH data standardization at a more granular level such as which SDOH data elements were being used in COVID-19-related studies, as well as to understand how SDOH and COVID-19-related data elements were being defined, measured, and standardized across studies.

ASPE engaged the Health federally funded research and development center (Health FFRDC), operated by The MITRE Corporation, to collaborate with the CoDE SDOH data standards CoP and conduct a scoping review to identify SDOH that are risk factors for, or associated with outcomes of, COVID-19, and to understand definitions, characteristics, and measures of respective SDOH data elements. The method and process of a scoping review is similar to that of a systematic review yet differs in its purpose and aims. Systematic reviews aim to answer a specific research question, whereas a scoping review aims to assess and synthesize available research on a particular topic.<sup>16,17,18</sup> The methods for this scoping review can be found in Section 2.

This scoping review report informs the CoDE, other OS-PCORTF-funded projects, and the broader PCOR community on the state of SDOH data elements for research related to COVID-19. In addition, the results of this report may help ASPE to improve PCOR data capacity by suggesting common data elements for research related to COVID-19, informing data standards development and implementation, and highlighting gaps in knowledge that would benefit from additional research.

## 1.2 Research Purpose

The purpose of this scoping review was to understand how SDOH were used in studies exploring their potential associations with increased risk for COVID-19 infection and COVID-19-related outcomes, including SDOH data elements definitions, characteristics, and measures. To achieve these aims, the Health FFRDC project team collaborated with the CoDE CoP to develop a scoping review protocol and conduct the review. The research questions were:

- Which SDOH are associated with increased risk for COVID-19 infection?
- Which SDOH are associated with COVID-19-related outcomes?
  - COVID-19-related outcomes may include (but were not limited to) the following: Long COVID-19, hospitalization, intubation, ventilation, severe COVID-19 symptoms, intensive care unit admission, co-infection, complications, long recovery time, or death.

## 2 Methodology

To clarify concept and definition boundaries and to acknowledge the heterogenous nature of the topics of interest, a scoping review methodology was selected. This study was conducted between August and December 2021 in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist requirements.<sup>2</sup> The three-step procedure outlined below was implemented iteratively, so information gleaned from one step may have been informed by a previous step.

## 2.1 Step 1: Study Identification

### 2.1.1 Inclusion Criteria for the Scoping Review

Inclusion criteria used to select relevant studies include:

- Quantitative studies or mixed methods studies
- Human subjects
- Sample size of  $n \geq 10$
- English or English translation
- Conducted in the United States
- Published between December 1, 2019, and August 31, 2021
- Peer-reviewed sources, white papers, government reports, and industry reports
- At least one SDOH data element modeled as an independent variable, including SDOH data elements that are modeled in cross-sectional studies where directionality may not be indicated
- At least one COVID-19 data element of infection or outcome modeled as a dependent variable
- Data presented about the quantitative association between at least one SDOH and at least one COVID-19 infection or one COVID-19-related outcome
- Available measurement information about SDOH data elements
- Available measurement information about COVID-19 infection or COVID-19-related outcome data elements

Details on the inclusion criteria and the rationale for inclusion can be found in Appendix A.

### 2.1.2 Search Strategy

The Health FFRDC project team searched PubMed/MEDLINE and ScienceDirect.<sup>19,20</sup> PubMed/MEDLINE focuses on health-related research and offers highly functional syntax-based searches and filter mechanisms. ScienceDirect allows for a broader overview of a field, while still allowing for use of filters and Boolean terms, but does not allow for certain syntax-based searches (e.g., ScienceDirect does not support filtering for studies only in English, about the United States, or about humans). Therefore, in addition to the search terms used in PubMed/MEDLINE, the search was further narrowed using the manual filters. These filters specified results from December 1, 2019, to August 31, 2021, “Abstract” for text availability, “Humans” as the species, and “English” as the language. In ScienceDirect, the search was similarly refined with the same date range and to include research articles and short communications for the article type.

### 2.1.3 Defining COVID-19 and SDOH

Search terms for SDOH were based on prior work from the ASPE OS-PCORTF-funded project, “Understanding COVID-19 Trajectory and Outcomes in the Context of Multiple Chronic Conditions through Electronic Care Plan (MCC eCare Plan) Development.”<sup>21</sup> The MCC eCare Plan project is a joint agency effort led by AHRQ and NIH/National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The project seeks to build data capacity to conduct PCOR involving COVID-19 by expanding on standards-based, interoperable eCare plan tools designed to facilitate the collection, aggregation, and sharing of critical patient-centered data for adults with multiple chronic conditions across clinical and

research-based settings.<sup>21</sup> Of note, the MCC eCare Plan project has aligned its SDOH data elements with those of the Gravity Project, which convenes broad stakeholder groups in identifying and harmonizing social risk factor data standards for interoperable electronic health information exchange.<sup>21</sup> The search terms for this review were compared to previously published scoping reviews on SDOH and aligned with the HHS Office of Disease Prevention and Health Promotion's Healthy People SDOH framework.<sup>3,22,23,24,25,26,27,28,29</sup> Additional search terms were added based on feedback from the CoP. The complete set of search terms is in Appendix B.

Search terms for COVID-19 infection or COVID-19-related outcomes were drawn from work on existing ASPE projects, as well as from the working list of COVID-19 data elements published in February 2021 by the Food and Drug Administration:<sup>30</sup>

- Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection/COVID-19 diagnosis: objective assessment or self-report of positive COVID-19 test results, COVID-19 symptoms paired with known exposure
- COVID-19-related outcomes: Long COVID-19, hospitalization due to COVID-19, intubation due to COVID-19, ventilation due to COVID-19, severe COVID-19 symptoms, intensive care unit admission due to COVID-19, co-infection or new-onset comorbidity with COVID-19 and another disease, complications due to COVID-19 (including severe COVID-19 symptoms), long recovery time from COVID-19, death attributed to COVID-19<sup>30</sup>
  - Severe COVID-19 can be defined by the following:
    - Positive testing by standard reverse transcription—polymerase chain reaction (PCR) assay or an equivalent test
    - Symptoms suggestive of severe systemic illness with COVID-19, which could include:
      - Any symptom of moderate illness or shortness of breath at rest, or respiratory distress
      - Clinical signs indicative of severe systemic illness with COVID-19, such as respiratory rate  $\geq 30$  per minute, heart rate  $\geq 125$  per minute, SpO<sub>2</sub>  $\leq 93\%$  on room air at sea level or PaO<sub>2</sub>/FiO<sub>2</sub>  $< 300$
      - No criteria for critical severity

Additional filters were applied for the date range (December 1, 2019–August 31, 2021), language (English), country (United States), and species (human [MeSH<sup>b</sup>]) when possible. The search terms and filters were piloted using PubMed and ScienceDirect to troubleshoot any issues. Reviews of each preliminary search—including search date, search terms and filters used, narratives about adjustments made to original plan, number of studies identified, databases searched, and potential issues—were documented and shared with the CoP. After compiling the citations, duplicates were identified and removed. The COVID-19-related terms were searched as title and abstract keywords and included "coronavirus," "COVID-19," "COVID," "SARS-CoV-2," "PASC" (post-acute sequelae SARS-CoV-2 infection), and "PACS" (Post-Acute COVID-19 Syndrome).

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<sup>b</sup> MeSH (Medical Subject Headings) is the National Library of Medicine's controlled vocabulary thesaurus, used for indexing articles for the MEDLINE®/PubMed® database.

## 2.2 Step 2: Screening

Three reviewers from the Health FFRDC team evaluated the list of studies according to the inclusion criteria. First, one reviewer evaluated each study title and abstract to confirm that there were data elements for the independent variables under “social determinants of health” and dependent variables related to “COVID-19 clinical outcomes” and “COVID-19 infection” respectively. Second, two reviewers conducted full-text screening to confirm that they met the inclusion criteria. Disagreements between reviewers were resolved either by consensus or by conversation with a fourth party on the Health FFRDC team.

## 2.3 Step 3: Data Extraction and Analysis

### 2.3.1 Extraction

Data from studies were extracted into a database by one of these three reviewers. A second reviewer verified the completeness and accuracy of the data. Any discrepancies were either resolved by consensus or mediated by the fourth party referenced above. The data extracted included the elements described in Table 1. The detailed data extraction tables are included in the SDOH COVID-19 Scoping Review Data Extraction Workbook, which is described in Appendix C.

**Table 1. Study Domains and Data Elements Extracted**

Study Domains and Data Elements Extracted	
Study Domains	Study Data Elements
Study Overview	Study title Citation Lead author contact Study aims Study design Target audience Funding source
Study Population Characteristics	Sample size Population description included in study Race Ethnicity Sex Gender Age Income/socioeconomic status (SES) Education Comorbidities Immigration status Urban/rural U.S. geographic regions studied Additional countries included in study beyond the U.S.

Study Domains and Data Elements Extracted	
Study Domains	Study Data Elements
Study Methods	Data collection start date Data collection end date Study design Analysis methods
SDOH Data Elements	SDOH element name Definition Data source Measure and type
COVID-19 Data Elements	COVID-19 element name Definition Data source Measure and type
Measures of Association	Measure COVID-19 measure Statistic Main results Supporting figures/tables/exhibits SDOH measure (Y/N)

### 2.3.2 Mapping SDOH Data Elements

Literature on SDOH is broad, heterogenous, and has a long history. Therefore, the CoP used the Healthy People framework made of domains put forth by the HHS Office of Disease Prevention and Health Promotion’s Healthy People initiative that organizes SDOH constructs and their elements into five domains: 1) Economic Stability, 2) Education Access and Quality; 3) Health Care Access and Quality; 4) Neighborhood and Built Environment; and 5) Social and Community Context.

The data categories from the MCC eCare Plan project were mapped to these five domains to examine how SDOH data are harmonized across the different frameworks.<sup>21</sup> The mapping of these categories to domains is shown in Table 2. Of note, some MCC eCare Plan categories appear in more than one Healthy People domain.

**Table 2. Mapping of MCC eCare Plan Categories with Healthy People SDOH Framework Domains**

Mapping of MCC eCare Plan Categories with Healthy People SDOH Framework Domains	
Healthy People SDOH Framework Domains	MCC eCare Plan Categories
Economic Stability	Computer access, mobile technology access, disability payment status, disability payment type, food insecurity, housing insecurity/instability and homelessness, employment status, current/former occupation, job security, desire to be working, income, poverty/wealth, financial resource strain
Education Access and Quality	English proficiency, need for an interpreter, computer literacy, mobile technology literacy, education level

Mapping of MCC eCare Plan Categories with Healthy People SDOH Framework Domains	
Healthy People SDOH Framework Domains	MCC eCare Plan Categories
Health Care Access and Quality	Perceived barriers to communicating with health care team, health literacy, health numeracy, medication literacy, telehealth literacy, health insurance coverage and type, health insurance inadequacy, ability to pay for health care, usual source of care, travel time to usual source of care, barriers to health care and services, presence of emergency preparedness plan
Neighborhood and Built Environment	Internet access, access to clean drinking water, lives in food desert, lives in food swamp, substandard/inadequate housing, area deprivation, transportation barrier, type of transportation barrier, type of transportation used, exposure to environmental hazards, unsafe neighborhood, built environment not conducive to health
Social and Community Context	Experience of abuse, suspected abuse, at risk of abuse, domestic violence/intimate partner violence, Adverse Childhood Experiences (ACE), neglect, work productivity, support network/social network, caregiver characteristics, caregiver availability, social isolation, living situation, social role/activities or satisfaction, loneliness, marital/spousal status, dependents in home, caregiver role, caregiver burden, stress, recent life changes, experiences of discrimination, racism related vigilance, racial trauma/race-based traumatic stress, anger, lawsuit status, involved in legal actions/problems, criminal justice involvement/incarceration history, migratory grief and loss, immigration status

### 2.3.3 Analysis

Data analysis and synthesis focused on addressing the research questions of interest. Preliminary outputs of interest developed in the planning step were populated, reviewed, and revised in collaboration with the CoP to present findings effectively. The full-text manuscripts were revisited for additional extraction, as needed, if more questions about the data emerged.

This scoping review aimed to address two key research questions, listed in Section 1.2. To address the first research question, studies including SDOH associated with increased risk for COVID-19 infections were identified and their key characteristics described (Section 3.5).

To address the second research question, a two-step approach was used. First, COVID-19-related outcomes (and the studies that investigated them) were identified. Second, the SDOH associated with each COVID-19-related outcome were identified and the directionality of the statistically significant associations was presented visually using frequency charts (Figure 5 through Figure 10). Results were synthesized and reviewed for accuracy.

## 2.4 Literature Review Management Software

References were managed using Zotero, a reference management software that allows for duplicate identification and removal, bibliography generation, and cloud-based collaboration across operating systems.



Search results were exported from Zotero as a comma-separated values (CSV) file to Covidence to conduct screening and data extraction steps. The CSV file included data such as title, abstract, publication dates, authors, or source. Covidence is a web-based systematic review management platform that streamlines the tracking and production of rigorous reviews across the phases of abstract and full-text screening, data extraction, and outcomes and PRISMA-ScR reporting.<sup>31</sup>

### **3 Results**

Twenty-seven studies were included in the final scoping review (Figure 1). The findings are presented below. Statistical significance was defined as results having a probability value (p-value) of less than or equal to 0.05.

#### **3.1 PRISMA-ScR**

The initial literature search resulted in 1,957 studies. Deduplication yielded a sample of 1,520 studies. The titles and abstracts of these 1,520 studies were screened, and 1,477 studies were excluded for not meeting all inclusion criteria. Forty-three studies proceeded to full-text screening, after which a final set of only 27 studies were identified as meeting all criteria to be included in this review (see full citations listed in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C. All 27 studies were peer-reviewed articles from academic journals. The number of studies that were included and excluded, and reasons for exclusion, are in the PRISMA-ScR Flow Diagram below (Figure 1).<sup>2</sup>

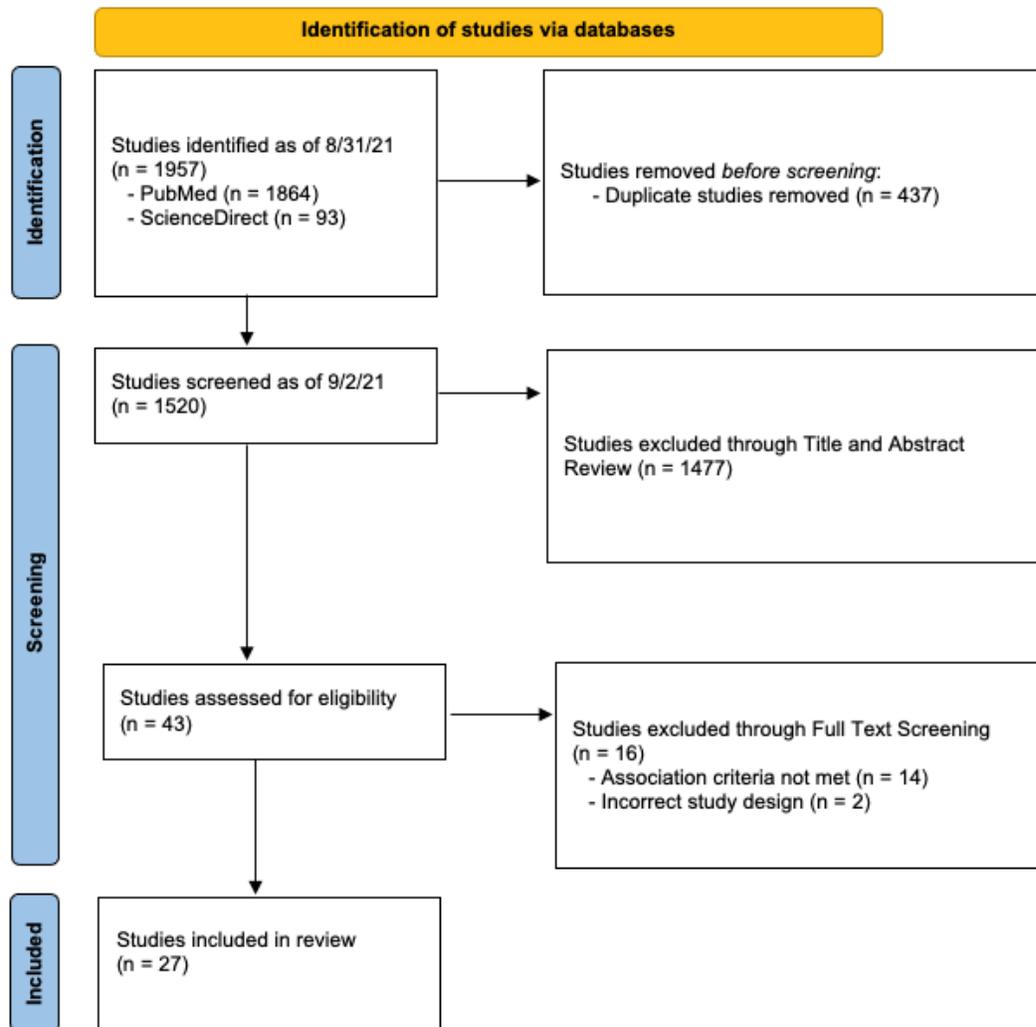


Figure 1. PRISMA-ScR Flow Diagram for Scoping Review

### 3.2 Study Population Characteristics

Population characteristics for each study were extracted. The majority of studies included various categories of race/ethnicity (n = 22). The most common categories included were Black or African American (n = 22), White (n = 18), and Hispanic or Latino (n = 18). American Indian, Alaska Native, Native Hawaiian, Asian, and Other Pacific Islander were grouped differently across studies, but were represented in some form in 20 of the 27 studies. One study categorized “American Indian” separately, while one combined “American Indian and Pacific Islander” and three combined “American Indian/Alaska Native.”<sup>32,33,34,35,36</sup> Nine studies categorized “Asian” separately, while four combined “Asian or Pacific Islander.”<sup>32,33,34,35,36,37,38,39,40,41,42,43,44</sup> Last, two studies combined “Native Hawaiian/Other Pacific Islander.”<sup>35,43</sup>

Nineteen studies included various categorizations of age.<sup>32,33,34,35,36,38,39,40,41,44,45,46,47,48,49,50,51,52,53</sup> For example, Toth et al. (2021) and Tummalapalli et al. (2021) included 18-55 years as a category,<sup>39,40</sup> whereas Dickenson et al. (2021) used 18-44 years<sup>41</sup> and Fitzpatrick et al. (2021) used 18-34.<sup>32</sup> Due to the variations in age categories, only the total number of studies that reported any age group is depicted in Table 3.

Biological sex was included in 13 studies.<sup>32,35,36,37,38,39,41,44,45,46,48,49,51</sup> Although two studies reported using “gender identity,” these papers actually reported sex identified at birth (male and female).<sup>39,41</sup> More information around the differences in categorization and definitions for each category can be found in Section 4. Descriptions of the populations for each study can be found in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C.

**Table 3. Summary of Study Population Characteristics<sup>c</sup>**

Summary of Study Population Characteristics	
Data Element	Number and Percent of Studies, n (%)
<b>Race/Ethnicity</b>	22 (81%)
Black or African American	22 (81%)
American Indian, Alaska Native, Native Hawaiian, Asian, Other Pacific Islander	17 (63%)
Hispanic or Latino	18 (67%)
White	18 (67%)
Not Hispanic or Latino	3 (11%)
Two or more races	2 (7%)
Arab	1 (4%)
Hispanic Black	1 (4%)
Hispanic White	1 (4%)
Other or unknown	--
<b>Sex (at birth)<sup>d</sup></b>	13 (48%)
Female	12 (44%)
Male	13 (48%)
<b>Gender identity</b>	0 (0%)
Female	--
Male	--
Non-binary or genderqueer	--
<b>Age</b>	19 (70%)
Various age categories ranging from <1 to 80+	19 (70%)

<sup>c</sup> Cells with dashes (“--”) indicate no results.

<sup>d</sup> Two studies labeled sex (at birth) as “gender.”

Summary of Study Population Characteristics	
Data Element	Number and Percent of Studies, n (%)
<b>Education</b>	5 (19%)
Up to high school	7 (26%)
Some post-secondary education	2 (7%)
College degree	3 (11%)
Graduate degree	2 (7%)
Unknown/refused	1 (4%)

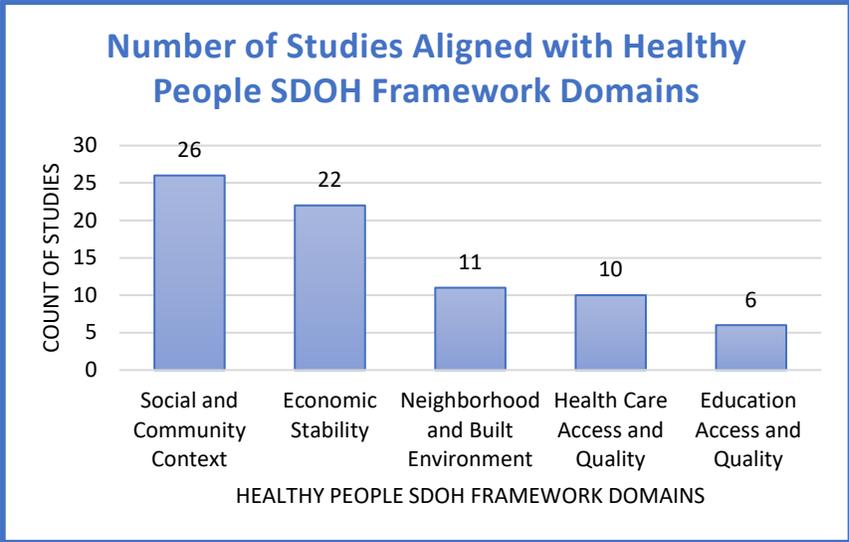
### 3.3 SDOH Data Categories, Domains, and Data Elements

#### 3.3.1 SDOH Data Categories and Healthy People SDOH Framework Domains

A total of 132 SDOH data elements were identified across all studies.

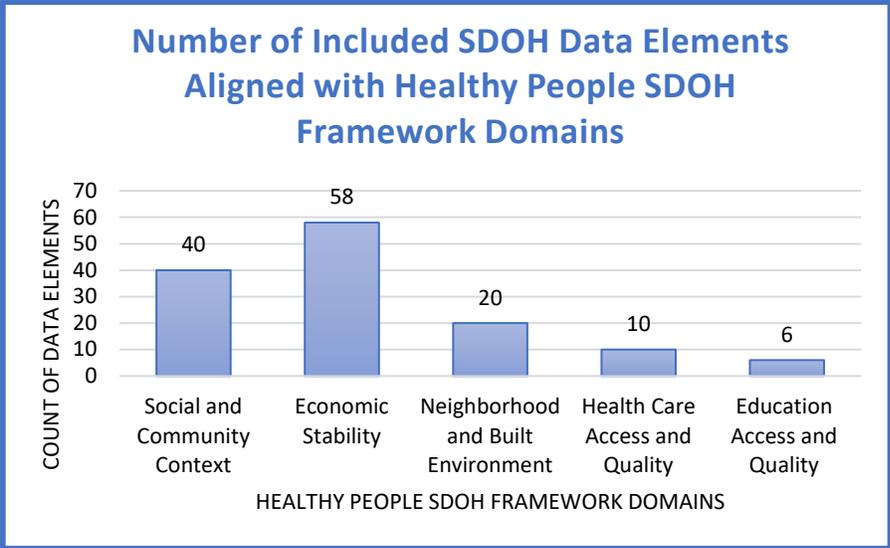
Several composite measures were identified that contained elements that fit into multiple categories. These include the Social Vulnerability Index (SVI), Rural-Urban Commuting Area (RUCA) codes, Area Deprivation Index (ADI), the Index of Concentration at the Extremes (ICE), and the Distressed Communities Index (DCI), all of which are calculated using population-level data for ZIP code or other geographic level.<sup>50,51,54,55</sup> These composite measures were categorized into the appropriate category based on the specific theme, domain, or component (e.g., SVI component, housing crowding, categorized as economic stability domain) in Figure 2 and Figure 3. The detailed list of SDOH elements is included in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C.

All the SDOH data elements identified were aligned with the five Healthy People SDOH framework domains: Social and Community Context; Economic Stability; Neighborhood and Built Environment; Health Care Access and Quality; and Education Access and Quality. The most common domain represented was Social and Community Context, with 26 studies reporting at least one of its data elements (Figure 2). The second most common domain was Economic Stability (n = 22). Far fewer studies included data elements from the remaining three domains.



**Figure 2. Number of Studies with at Least One SDOH Data Element Aligned with Healthy People SDOH Framework Domains**

The number of data elements differs by domain. Figure 3 below depicts the count of data elements by domain as they were identified throughout the selected 27 studies. The greatest number of SDOH data elements (58 data elements) aligned with Economic Stability (Figure 3). Forty data elements aligned with Social and Community Context. Only six data elements aligned with Education Access and Quality.



**Figure 3. Number of SDOH Data Elements Aligned with Healthy People SDOH Framework Domains<sup>e</sup>**

<sup>e</sup> The categories in Figure 3 sum to 134; however, the total number of elements is 132. Two elements spanned across two categories (Economic Stability and Neighborhood/Built Environment).

### 3.3.2 SDOH Data Elements and MCC eCare Plan Categories

Table 4 is organized according to the MCC eCare Plan categories and the corresponding studies that include SDOH data elements. The cells with dashes (“--”) in Table 4 indicate that no studies used a data element in that category. Details regarding statistical associations between SDOH and COVID-19 are presented in Section 3.5.

Among the 72 data elements in the MCC eCare Plan categories, only 20 were represented in the reviewed studies. The reviewed studies most commonly used SES-related (n = 22) and housing-related (n = 14) data elements.<sup>41</sup> SDOH data elements categorized under communication, neighborhood/environment, and food were studied less often. Only one study included an explicit measure in the racism/discrimination category.<sup>29</sup> Many of the elements were not represented in the literature. The abuse/neglect/upheaval category and the stress and anger category were not addressed in any of the studies.

Race/ethnicity was included in the MCC eCare Plan project as a person characteristic rather than as a SDOH. For the purposes of this scoping review, although the *a priori* plan was to follow this categorization, race/ethnicity was ultimately treated as a standalone category to provide additional context for health equity and insight into the relationships between structural racism, social determinants of health and COVID 19 and PASC outcomes. While race and ethnicity are in some cases correlated with SDOH and SES differences, they are not strictly speaking SDOH themselves and instead often reflect the health impacts of structural racism, as structural racism has contributed to substantial disparities in social determinants of health and health outcomes along racial and ethnic lines.<sup>56,57</sup> Thus, race/ethnicity data elements were maintained separately.

**Table 4. Summary of Studies Using SDOH Elements by MCC eCare Plan Categories<sup>f,g</sup>**

Summary of Studies Using SDOH Elements by MCC eCare Plan Categories <sup>f,g</sup>			
MCC eCare Plan Category (Number of Elements)	Studies Including SDOH Element, n (%)	Studies Analyzing Statistical Association with COVID-19, n (%)	Studies Identifying a Statistically Significant Association with COVID-19, n (%)
<b>Communication</b> (12 elements)	3 (11%)	3 (11%)	2 (7%)
English proficiency	3 (11%)	3 (11%)	2 (7%)
<b>Health Insurance &amp; Health Care Access</b> (8 elements)	10 (37%)	8 (30%)	5 (19%)
Health insurance coverage and type	5 (19%)	4 (15%)	4 (15%)
Health insurance inadequacy	5 (19%)	4 (15%)	1 (4%)
<b>Abuse/Neglect/Upheaval</b> (6 elements)	0 (0%)	0 (0%)	0 (0%)
<b>Food</b> (4 elements)	4 (15%)	3 (11%)	3 (11%)

<sup>f</sup> Cells with dashes (“--”) indicate no results.

<sup>g</sup> Several studies included more than one element.

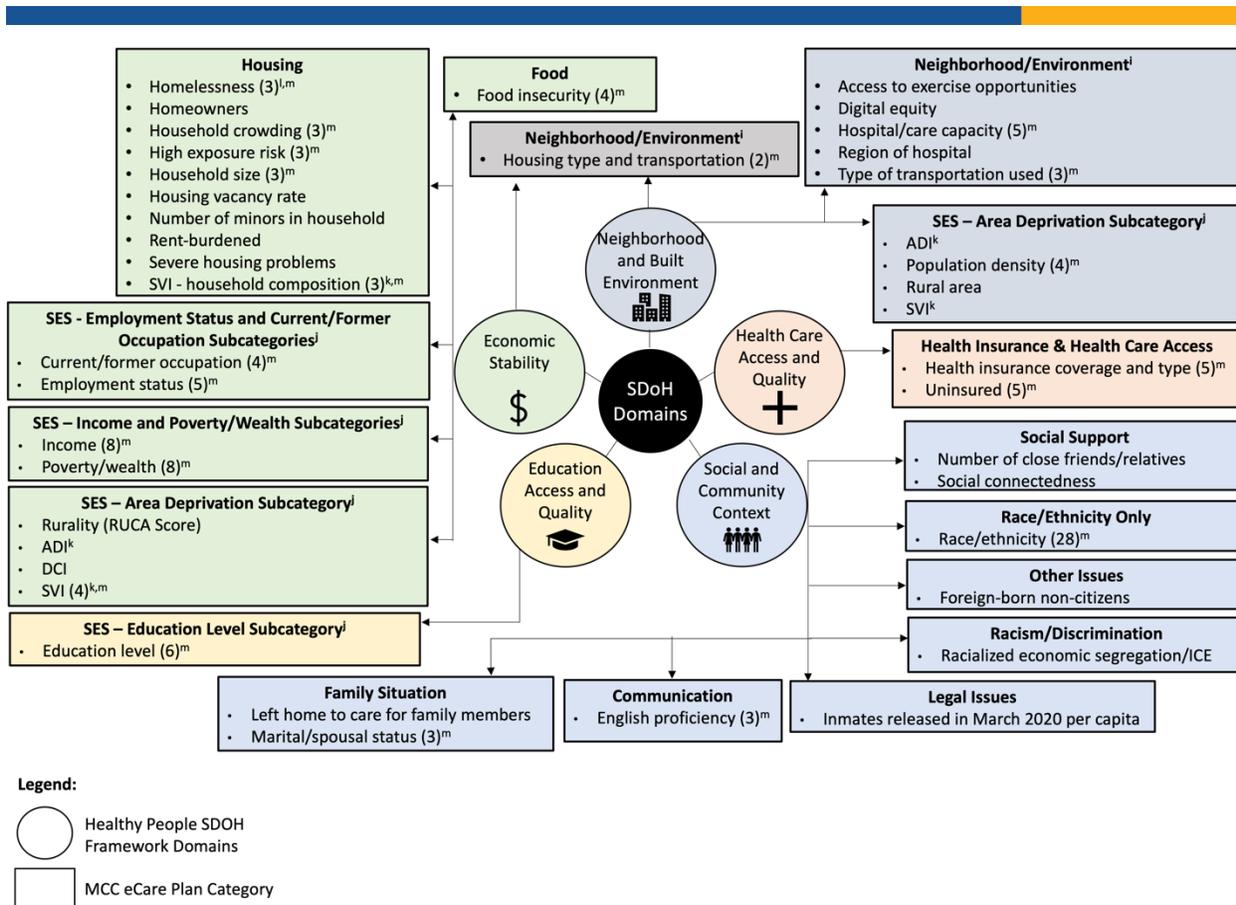
Summary of Studies Using SDOH Elements by MCC eCare Plan Categories <sup>f,g</sup>			
MCC eCare Plan Category (Number of Elements)	Studies Including SDOH Element, n (%)	Studies Analyzing Statistical Association with COVID-19, n (%)	Studies Identifying a Statistically Significant Association with COVID-19, n (%)
Food insecurity	4 (15%)	3 (11%)	3 (11%)
<b>Housing</b> (2 elements)	14 (52%)	10 (37%)	6(22%)
Housing insecurity/instability and homelessness	5 (19%)	5 (19%)	2 (7%)
Substandard/inadequate housing	9 (33%)	7 (26%)	5 (19%)
<b>SES (employment, education, income)</b> (10 elements)	22 (81%)	18 (67%)	13 (48%)
Employment status	5 (19%)	3 (11%)	2 (7%)
Current/former occupation	4 (15%)	3 (11%)	3 (11%)
Desire to be working	--	--	--
Education level	6 (22%)	5 (19%)	4 (15%)
Income	8 (30%)	6 (22%)	3 (11%)
Poverty/wealth	8 (30%)	8 (30%)	4 (15%)
Area deprivation	10 (37%)	6 (22%)	4 (15%)
<b>Social Support</b> (8 elements)	1 (4%)	1 (4%)	1 (4%)
Support network/social network	1 (4%)	1 (4%)	1 (4%)
<b>Family Situation</b> (4 elements)	4 (15%)	2 (7%)	2 (7%)
Marital/spousal status	3 (11%)	2 (7%)	2 (7%)
Caregiver role	1 (4%)	--	--
<b>Neighborhood/Environment</b> (6 elements)	8 (30%)	4 (15%)	2 (7%)
Type of transportation used	4 (15%)	2 (7%)	2 (7%)
Built environment not conducive to health	4 (15%)	2 (7%)	--
<b>Racism/Discrimination</b> (3 elements)	1 (4%)	1 (4%)	0 (0%)
Experiences of discrimination/prejudice	1 (4%)	1 (4%)	--
<b>Race/Ethnicity (not an MCC eCARE Plan category)<sup>h</sup></b> (1 element)	26 (96%)	21 (78%)	16 (59%)
<b>Stress and anger</b> (3 elements)	0 (0%)	0 (0%)	0 (0%)
<b>Legal Issues</b> (3 elements)	1 (4%)	1 (4%)	1 (4%)

<sup>h</sup> This is an addition to the MCC eCare Plan list of subcategories. It captures the studies that included data elements related to only race/ethnicity.

Summary of Studies Using SDOH Elements by MCC eCare Plan Categories <sup>f,g</sup>			
MCC eCare Plan Category (Number of Elements)	Studies Including SDOH Element, n (%)	Studies Analyzing Statistical Association with COVID-19, n (%)	Studies Identifying a Statistically Significant Association with COVID-19, n (%)
Criminal justice involvement/incarceration history	1 (4%)	1 (4%)	1 (4%)
<b>Other Issues</b> (3 elements)	1 (4%)	1 (4%)	1 (4%)
Immigration status	1 (4%)	1 (4%)	1 (4%)

### 3.3.3 SDOH Data Elements Mapped to Healthy People SDOH Framework Domains and MCC eCare Plan Categories

A map representing all the SDOH data elements across the 27 studies is shown in Figure 4. This map includes SDOH data elements, regardless of whether they were used in a statistical measure of association, to show the breadth of SDOH data. The SDOH data elements are organized by Healthy People SDOH framework domains and MCC eCare Plan categories. The central circles of the diagram are the Healthy People SDOH framework domains. The boxes are labeled with the MCC eCare Plan categories (bolded titles in each box) and color coded to match the Healthy People SDOH framework domain to which they correspond. The specific data elements from the studies are listed in the category box to which they map. Elements from one category are mapped to multiple domains: the housing type and transportation data elements correspond to both the neighborhood and built environment and economic stability domains. A detailed table with mappings from each study is provided in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C.



**Figure 4. SDOH Data Elements Mapped to Healthy People SDOH Framework Domains and MCC eCare Plan Categories <sup>i,j,k,l,m</sup>**

### 3.3.4 Variation in SDOH Definitions

Definitions of SDOH data elements (not restricted to those elements in a statistical calculation of association) varied substantially across studies. Detailed definitions of all data elements are provided in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C. For example, there were race/ethnicity data elements across the 27 studies, and their definitions and measurement methods varied greatly. Some studies used 2020 Centers for Medicare and Medicaid Services hospital

<sup>i</sup> There are two “Neighborhood/Environment” boxes because the “housing type and transportation” data element spans across the “Neighborhood and Built Environment” and the “Economic Stability” in the Healthy People SDOH framework domains. The latter box is shaded grey to differentiate it from the “Neighborhood/Environment” MCC eCare Plan category and elements associated only with “Neighborhood and Built Environment.”

<sup>j</sup> The SES (employment, education, income) MCC eCare Plan category maps to multiple Healthy People SDOH framework domains; therefore, the box titles incorporate the affiliated subcategory name from the MCC eCare Plan.

<sup>k</sup> ADI and SVI map to multiple MCC eCare Plan categories and therefore appear in multiple boxes.

<sup>l</sup> Similar elements that had only minor wording differences were clustered together (e.g., “homelessness” included the data elements “homelessness status,” “unsheltered homelessness,” and “any history of homelessness”).<sup>33,43,60</sup>

<sup>m</sup> The number of elements clustered are indicated in parenthesis after the element name.

claims data and limited analysis to Black and White; others used the 2013-2018 American Community Survey categories of Latino, Black, White, and Other.<sup>45,47</sup> One study by Fitzpatrick et al. (2021) used electronic health record (EHR) data to categorize American Indian, while another study by Nguyen et al. (2021) used a combined category of American Indian and Alaska Native.<sup>32,52</sup>

Definitions of education data elements, another common demographic characteristic in many studies, also varied across six studies. Dickinson et al. (2021) used survey responses to categorize education into high school or lower, some college, college degree, and graduate degree, while Tsai et al. (2021) used some college or less, associate or bachelor's degree, advanced degree, and student status.<sup>41,58</sup> Vassallo et al. (2021) used highest education level categorized as  $\leq$  8th grade; some high school; no diploma; high school graduate; some college/tech school; associate degree; bachelor's degree; graduate degree; unknown/refused.<sup>36</sup> Figueroa et al. (2020) and Hawkins et al. (2020) included only education status below high school, defined as less than high school education and adults 25 years or older without a school degree.<sup>47,50</sup> Velayati et al. (2021) included "some post-secondary education" as defined by the Hopkins Resource Center.<sup>53</sup>

Similarly, definitions varied greatly for the less frequent SDOH data elements. For example, four studies evaluated food insecurity data elements. These elements included receiving food assistance/ Supplemental Nutrition Assistance Program benefits (n = 2), patients who screened positive for food insecurity during the COVID-19 testing intake process (n = 1), and percent food insecure by census tract (n = 1).<sup>37,43,46,54</sup>

Definitions for the housing insecurity/instability and homelessness data elements across five studies varied.<sup>33,37,43,50,58</sup> Irwin et al. (2021) defined homelessness as individuals who lack housing or resources to isolate themselves, while Tsai et al. (2021) defined it as someone who did not have a stable nighttime residence (such as staying on streets, in shelters, cars, etc.).<sup>43,58</sup> Irwin et al. (2021) referred to housing insecurity as rent-burdened, and defined it as households spending more than 30% of their annual pretax income on rent, compared to households with severe housing problems obtained from the 2020 County Health Rankings.<sup>43</sup>

Household crowding data elements were defined across five studies. Three of these studies used a similar definition of having more than one person per room (excluding bathrooms and kitchens).<sup>34,40,41</sup> However, Samuels-Kalow et al. (2021) and Tummalapalli et al. (2021) used the SVI, which contains a household composition measure.<sup>37,40</sup>

Health insurance inadequacy data elements were addressed across five studies. Gaglioti et al. (2021), Hawkins et al. (2020), Nguyen et al. (2021), Samuels-Kalow et al. (2021), and Velayati et al. (2021) all measured uninsured populations, but used differing metrics and sources.<sup>34,37,50,52,53</sup> Gaglioti et al. (2021) used the percent uninsured by census tract from the U.S. Census Bureau 2010-2019.<sup>34</sup> Hawkins et al. (2020) defined uninsured as the rate of uninsured individuals under age 65 based on the American Community Survey 5-year Estimates.<sup>50</sup> Samuels-Kalow et al. (2021) used the U.S. Census Bureau 2018 American Community Survey 5-year estimates.<sup>37</sup> Nguyen et al. (2021) obtained the percent of adults uninsured from the 2020 County Health Rankings.<sup>52</sup> Velayati et al. (2021) used the Johns Hopkins Coronavirus Resource Center for the percentage uninsured in Alabama.<sup>53</sup>

Area deprivation was addressed in some form in 10 studies. Hendricks et al. (2021) utilized 2010 RUCA codes based on the 2010 decennial Census and 2006-2010 American Community Survey.<sup>54</sup> Nguyen et al. (2021) calculated the percent of the population living in a rural area.<sup>52</sup> Hawkins et al. (2020) used the Distressed Communities Index (DCI) composite score to identify the population in distressed ZIP codes.<sup>50</sup> Two studies, Hendricks et al. (2021) and Khanna et al. (2021), used state ADI, a comprehensive, composite measure based on Census data.<sup>51,54</sup> Three studies included SVI measurements based on Census Bureau rankings.<sup>37,40,43</sup> Four studies used a calculation of population density that was consistent across studies, but with variations in geographic boundaries.<sup>34,48,52,59</sup>

### 3.3.5 COVID-19 Data Categories and Data Elements

The COVID-19 data elements were grouped into the following categories: testing, test positivity, cases, exposure, hospitalization, and mortality. Table 5 shows a summary of COVID-19 elements that were found to have statistically significant associations with SDOH. In most studies, the COVID-19 test positivity and testing categories included PCR testing and antibody testing; however, three studies included an unspecified type of COVID-19 test.<sup>35,46,58</sup> The COVID-19 testing category elements were measured as raw counts of COVID-19 tests performed. Population rates of testing calculated from raw test counts were used to estimate testing rates. Three assessed associations between SDOH and testing, and all three found significant associations. Similarly, 10 out of 11 studies assessing associations between SDOH and test positivity found significant associations.<sup>32,35,36,41,46,48,51,54,58,60</sup>

The COVID-19 cases category included COVID-19 reported cases, COVID-19 confirmed cases, COVID-19 presumed or suspected cases, self-reported COVID-19 cases, confirmed/presumed COVID-19 cases, and acute respiratory distress syndrome. Case counts included cases reported to local or state health departments, cases extracted from EHRs or laboratory records, and case counts extracted from other accessible databases. Addressing the first research question regarding which SDOH are associated with increased risk for COVID-19 infection, statistically significant associations between SDOH and COVID-19 cases were identified in all 11 studies investigating the link.<sup>29,34,37,40,42,43,44,47,50,52,59</sup> One out of two studies investigated and found (Goyal et al. [2020]) a statistically significant association between SDOH and COVID-19 exposure.<sup>49</sup>

The outcomes category included COVID-19 hospitalization and mortality. Addressing the second research question regarding which SDOH are associated with COVID-19-related outcomes, nearly half (12) of the 27 studies investigating the link found significant associations between SDOH and COVID-19 related outcomes. Statistically significant associations between SDOH and hospitalization were identified in all five studies that investigated this link.<sup>33,34,43,52,60</sup> Hospitalization outcomes included counts of hospitalization records with positive COVID-19 tests, hospitalization rates, counts of intensive care unit (ICU) stays, and emergency department visits for COVID-19. Nine out of 12 studies that investigated the links between SDOH and COVID-19 mortality found statistically significant associations.<sup>29,38,39,42,43,45,50,52,53</sup> The mortality category included general death counts, population mortality rates calculated from reported death counts, and death during or closely following hospitalization. While several studies reported on other clinical complications, such as mechanical ventilation and time to intubation, none found a significant statistical association with SDOH.<sup>38,48</sup>

**Table 5. Summary of COVID-19 Data Elements Associated with SDOH**

Summary of COVID-19 Data Elements Associated with SDOH	
COVID-19 Elements	Number and Percent of Studies, n (%)
COVID-19 Testing	3 (11%)
COVID-19 Test Positivity	10 (37%)
COVID-19 Cases	11 (41%)
COVID-19 Exposure	1 (4%)
COVID-19-Related Outcomes	12 (44%) <sup>n</sup>
COVID-19-Related Outcomes - Hospitalization	5 (19%)
COVID-19-Related Outcomes - Mortality	9 (33%)

### 3.4 Study Designs

Over half of the studies were cross-sectional (n = 15, 56%), and the remainder (n = 12, 44%) were cohort studies, with only one, Vassallo et al (2021), using a prospective cohort design.<sup>36</sup> The sample sizes of studies ranged from 159 to 38,329,281.<sup>42,52</sup> Vassallo et al. (2021) conducted a prospective surveillance study in order to effectively screen unvaccinated donors for SARS-CoV-2 antibodies to identify potential COVID-19 convalescent plasma donors.<sup>36</sup> Between June and December 2020, researchers tested 523,068 unique patient samples for SARS-CoV-2 antibodies and noted a demonstrable increase in overall seroprevalence, from 1.4% in June to 11.2% in December. Further, researchers observed higher reactivity rates statistically associated in those with middle school or lesser education, patients under 18 years old, and Hispanic patients.

Studies used different methods to analyze potential relationships between SDOH predictors or confounders and COVID-19-related outcomes (Table 6). Most studies applied a multivariate regression method. One study used a multivariable generalized estimating equation model including health care facility-level clustering to identify risk factors for mortality.<sup>39</sup> Another study applied a Bayesian hierarchical model to identify statistical associations of covariates at the census tract level with testing and positivity.<sup>41</sup> Gaglioti et al. (2021) used two methods to analyze associations: a linear regression using COVID-19 case rate as an outcome and a negative binomial regression using COVID-19 death numbers as the outcome variable.<sup>34</sup> Details of the study designs, analytic methods, and statistics calculated are in the SDOH COVID-19 Scoping Review Data Extraction Workbook, which is described in Appendix C.

<sup>n</sup> Studies included multiple COVID-19 elements, so totals are not summative.

**Table 6. Summary of Statistical Analysis Applied to Association of SDOH and COVID-19-Related Outcomes**

Summary of Statistical Analysis Applied to Association of SDOH and COVID-19-Related Outcomes	
Statistical Method	Number of Studies <sup>o</sup>
Regression	20
Logistic regression (2 univariate, 11 multivariate)	13
Linear regression (all multivariate)	5
Negative binomial regression (1 also in linear regression)	2
Only descriptive statistics and ratios <sup>p</sup>	6
Bayesian hierarchical model	1
Generalized estimating equation	1

### 3.5 SDOH Statistically Associated with COVID-19

Among studies reporting statistically significant associations of SDOH with COVID-19-related outcomes, most reported positive effects, meaning the SDOH was associated with an increase in the outcome. Figure 5 through Figure 10 show the percentage of studies (“frequency”) that found statistical associations with a COVID-19 infection or outcome, and whether the association is positive, negative, or mixed. Although SDOH can be risk factors or protective factors, most, but not all, SDOH elements identified in this review were risk factors associated with worse outcomes.<sup>33</sup> Black race and Hispanic/Latino ethnicity (and combined data elements) were positively associated with COVID-19-related outcomes of test positivity, exposure, cases, mortality, and hospitalization across all studies. However, there were mixed statistical associations with other races. Lower median income, a population-level measure, was consistently positively associated with outcomes including test positivity, exposure, cases, mortality, and hospitalization.<sup>33,34,43,48,49,50</sup> In one of these studies, higher income was also associated with hospitalization.<sup>33</sup>

Education showed mixed statistical associations with test positivity. Vassallo et al. (2021) tested for antibodies to SARS-CoV-2 to identify potential COVID-19 convalescent plasma donors and found higher odds of antibody reactivity among high school graduates and those with an eighth grade education level or less when compared to those with a graduate degree.<sup>36</sup> However, Tsai et al. (2021), using survey data, found that having an advanced degree was associated with test positivity.<sup>58</sup> Hawkins et al. (2020) quantified the statistical associations between SES and COVID-19-related cases and mortality in the United States using DCI.<sup>50</sup> The authors found that adults without a high school degree were among those with the strongest statistical association with both higher cases and higher fatalities per 100,000 persons.<sup>50</sup>

Several composite measures and their components were associated with COVID-19-related outcomes. Section 3.3.1 provides additional detail around the composite measures identified in this review. Khanna et al. (2021) found a positive statistical association of Black populations in highly deprived areas (using

<sup>o</sup> Studies reported use of more than one statistic.

<sup>p</sup> Examples include rate ratios, risk ratios, and incidence ratios.



ADI) and test positivity.<sup>51</sup> Chen et al. (2021) found a positive statistical association of racialized economic segregation measured by ICE with test positivity and cases, but mixed effects with mortality.<sup>29</sup> Samuels-Kalow et al. (2021) investigated SVI overall and the four subcategories and found all to be positively associated with mortality.<sup>37</sup>

Tummalapalli et al. (2021) studied racial/ethnic disparities in COVID-19 incidence among patients on hemodialysis in New York City, including evaluating whether SVI explained racial/ethnic differences in COVID-19 incidence.<sup>40</sup> Among non-Hispanic White patients, housing crowding was associated with increases in mortality. Azar et al. (2020) measured potential disparities in hospital admission and mortality among COVID-19 patients at a large integrated health system in northern California.<sup>33</sup> Azar et al. (2020) found that patients who tested positive for COVID-19 and resided in ZIP codes in the top two median household income quartiles were less likely to be admitted to the hospital for COVID-19 than patients residing in the lowest income quartile.<sup>33</sup>

The above results answer both questions of this scoping review, what SDOH are associated with increased risk for COVID-19 infection and what SDOH data elements are associated with COVID-19-related outcomes. Details of statistical associations reported in each study are supplied in the SDOH COVID-19 Scoping Review Data Extraction Workbook, described in Appendix C.

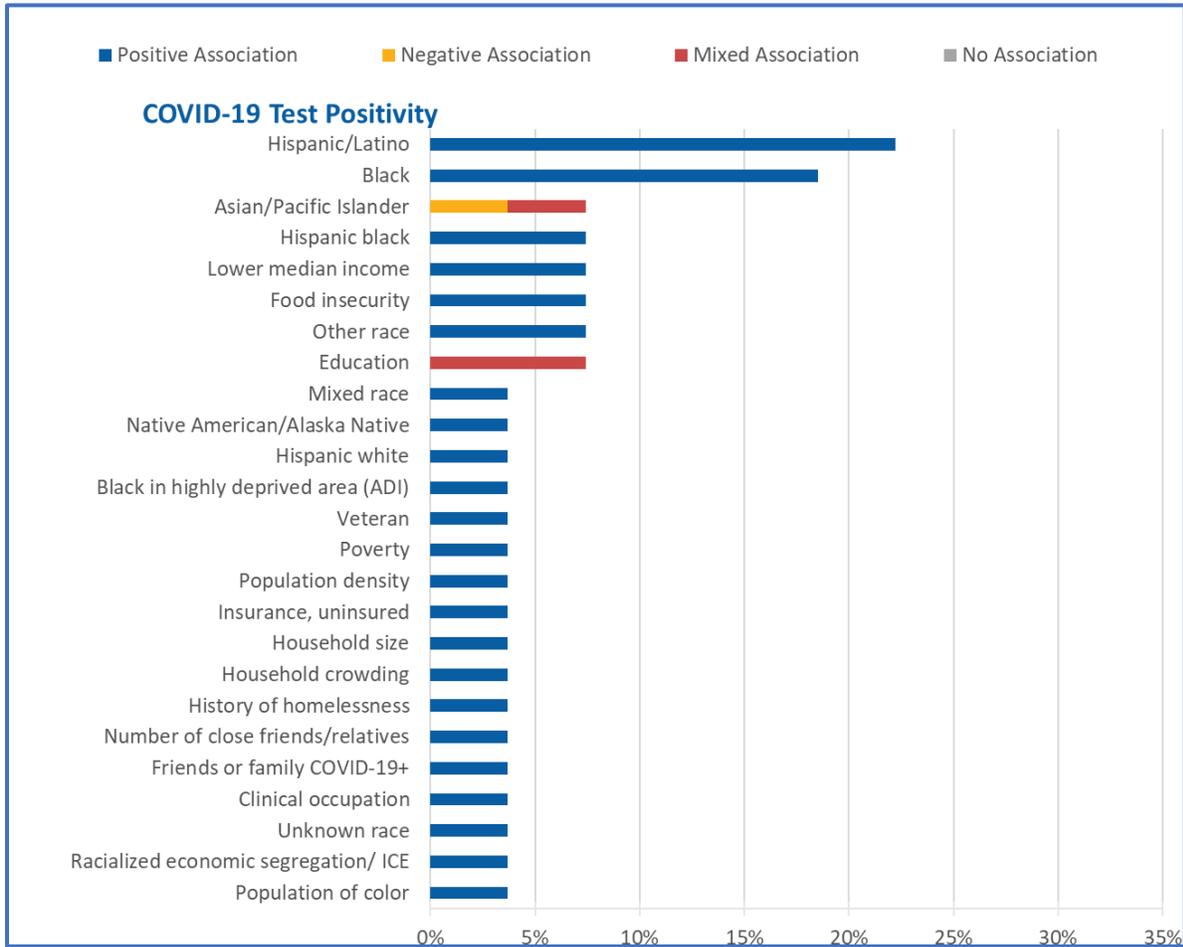


Figure 5. SDOH Frequency and Direction of Association on Reported COVID-19 Test Positivity as a Percentage of Studies

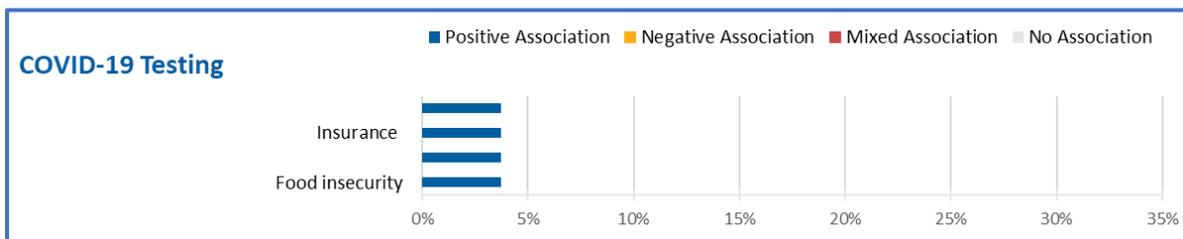


Figure 6. SDOH Frequency and Direction of Association on Reported COVID-19 Testing as a Percentage of Studies

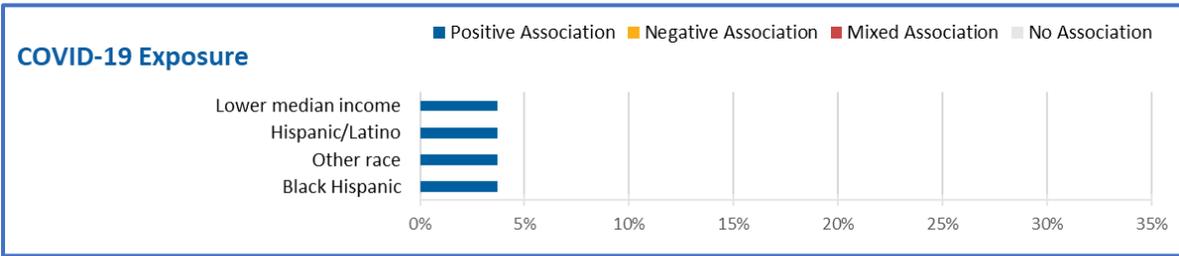


Figure 7. SDOH Frequency and Direction of Association on Reported COVID-19 Exposure as a Percentage of Studies

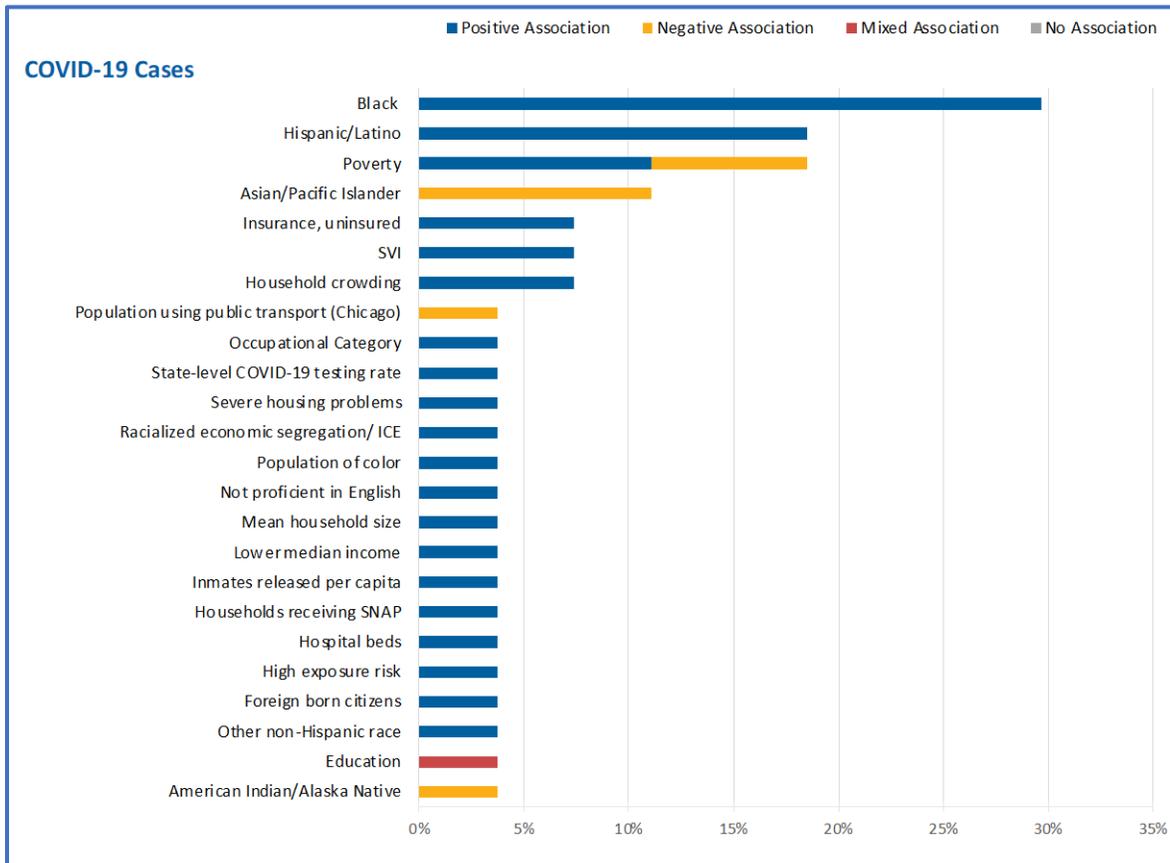
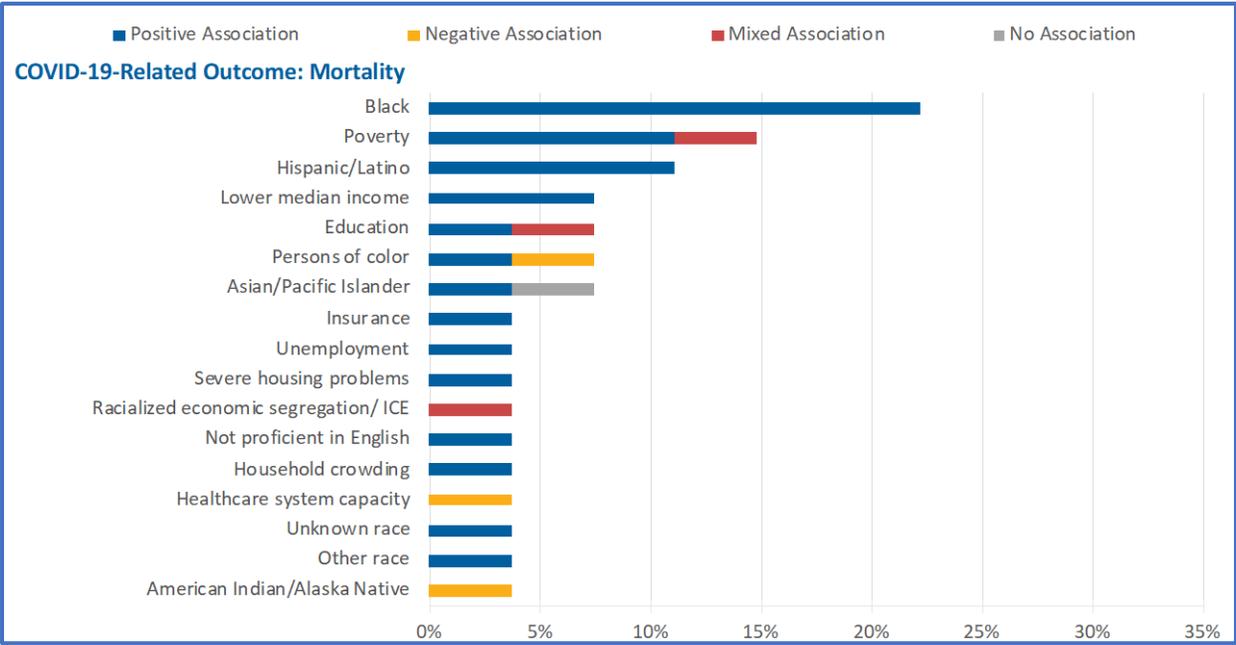
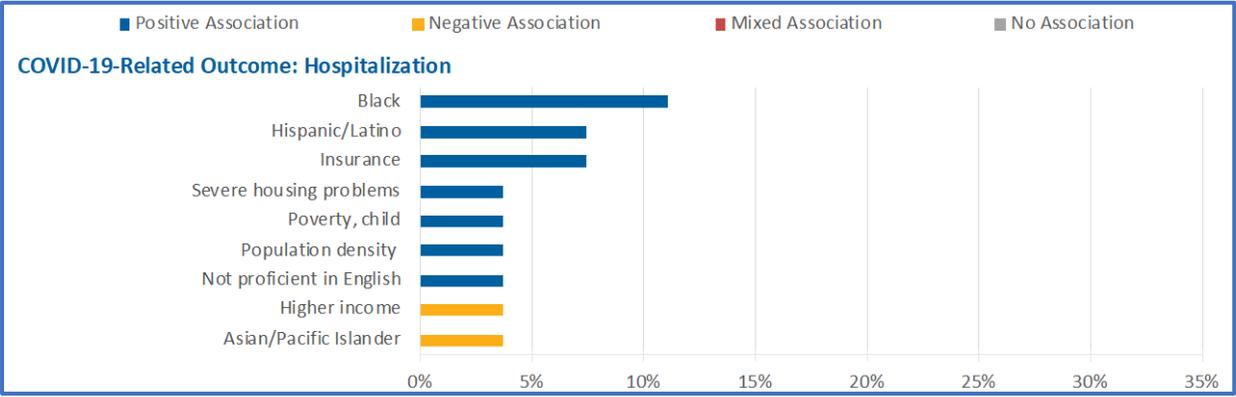


Figure 8. SDOH Frequency and Direction of Association on Reported COVID-19 Cases as a Percentage of Studies



**Figure 9. SDOH Frequency and Direction of Association on Reported COVID-19-Related Outcome: Mortality as a Percentage of Studies**



**Figure 10. SDOH Frequency and Direction of Association on Reported COVID-19-Related Outcome: Hospitalization as a Percentage of Studies**

**3.5.1 U.S. Geographic Regions Associated with COVID-19**

U.S. geographic regions and urban/rural settings were specified in all 27 studies and are described in Table 7. Geographic region descriptions were included in 23 studies solely to specify the study setting.

Four studies included geographic region descriptions as a predictor for the analysis of statistical associations with COVID-19-related outcomes, and of these, three studies found statistically significant associations.<sup>36,44,46,58</sup> Oda et al. (2021) found that those employed at health care facilities in the South

and Northeast were at a higher risk for COVID-19 infection than those employed at health care facilities in the West.<sup>44</sup> Tsai et al. (2021) found that participants residing in the Midwest region had significantly higher odds of being untested for COVID-19 compared with participants in the Northeast region, but found no statistical associations between other U.S. geographic regions and testing status or infection.<sup>58</sup> Vassallo et al. (2021) found significant differences between COVID-19 antibody seroreactivity across different regional blood collection centers in the West, Midwest, and South U.S. regions.<sup>36</sup> The study found a wide range of degrees in antibody response among 11 of 18 regional collection sites across the country.<sup>36</sup> When compared to the Phoenix regional collection center as the reference group, samples from the West, Midwest, and South U.S. regions had significantly lower levels of binding antibodies (i.e., signal-to-cutoff values<sup>q</sup>).<sup>36</sup> The only other COVID-19-related outcome that was studied for statistical associations with region, but was not found to be significantly associated, was the number of COVID-19 tests completed by patients in a study focusing on ZIP codes in Rhode Island.<sup>46</sup>

Urban/rural setting was used as a descriptor of setting in 21 studies and as a predictor in the analysis of statistical associations with COVID-19-related outcomes in three studies.<sup>32,54,52</sup> Of the three studies that analyzed statistical associations between urban and rural settings and COVID-19-related outcomes, two studies found significant associations.<sup>32,54</sup> Hendricks et al. (2021) found lower COVID-19 testing rates among individuals living in rural areas (assessed by a high 2010 RUCA score).<sup>54</sup> Fitzpatrick et al. (2021) reported that urban dwellers had significantly higher seroprevalence of SARS-CoV-2 IgG than non-urban dwellers.<sup>32</sup> COVID-19 case rates, hospitalization rates, and death rate were studied for statistical associations with urban/rural setting, but were not found to be significantly associated.<sup>55</sup>

**Table 7. Geographic Regions and Urban/Rural Settings<sup>r</sup>**

<b>Geographic Regions and Urban/Rural Settings</b>			
<b>Data Element</b>	<b>Studies, n (%)</b>	<b>Studies Analyzing a Statistical Association with COVID-19, n (%)</b>	<b>Studies Identifying a Statistically Significant Association with COVID-19, n (%)</b>
<b>U.S. Geographic Region</b>	27 (100%)	4 (15%)	3 (11%)
Northeast	7 (26%)	1 (4%)	--
Midwest	4 (15%)	--	--
South	5 (19%)	--	--
West	3 (11%)	--	--
All Regions Included	8 (30%)	3 (11%)	3 (11%)
<b>Urban/Rural</b>	27 (100%)	3 (11%)	2 (7%)
Urban	10 (37%)	--	--
Rural	2 (7%)	1 (4%)	1 (4%)

<sup>q</sup> Vassallo et al. (2021) describe the signal-to-cutoff ratio as a measure for screening blood donors that “correlates with the presence of binding antibody across the [Ortho VITROS Immunodiagnostic Products Anti-SARS-CoV-2 Total Ig (αCoV2Ig)] test’s high dynamic range”.<sup>38</sup>

<sup>r</sup> Cells with dashes (“--”) indicate no results.

Geographic Regions and Urban/Rural Settings			
Data Element	Studies, n (%)	Studies Analyzing a Statistical Association with COVID-19, n (%)	Studies Identifying a Statistically Significant Association with COVID-19, n (%)
Both	15 (56%)	2 (7%)	1 (4%)

### 3.5.2 Comorbidities

Comorbidities were reported in nine of 27 (33%) studies, either as a descriptor of the study population, as an inclusion or exclusion criterion, or as a predictor in the analysis of statistical associations with COVID-19 infection or COVID-19-related outcomes.<sup>33,35,38,40,45,48,50,52,53</sup> Table 8 summarizes the number of studies that report on each comorbidity, and highlights those studies that included comorbidities as a factor in a risk assessment model of SDOH and COVID-19 infections or related outcomes. Overall, five studies included a comorbidity in such a risk assessment model related to COVID-19 infections or related outcomes (e.g., case rate, hospital admission, hospitalization rate, invasive mechanical ventilation, death rate, in-hospital mortality, and 28-day mortality).<sup>33,38,40,50,52</sup> Among these five studies, the most frequently included comorbidities were diabetes in four studies<sup>33,40,50,52</sup> and chronic obstructive pulmonary disease (COPD) in three studies.<sup>33,38,50</sup> Statistically significant associations were found in three of these studies, ranging in sample size from 159 to 14,036 individuals, with two studies for diabetes,<sup>33,52</sup> and one study including multiple comorbidities that were significant: self-reported fair or poor health, coronary artery disease, congestive heart failure, chronic kidney injury, and chronic kidney disease.<sup>38</sup>

Nguyen et al. (2021) found positive associations between diabetes and COVID-19-related hospitalization rate as well as with death rate.<sup>52</sup> The same study also reported a negative association between self-reported fair or poor health and COVID-19-related case rate, as well as death rates.<sup>52</sup> Obesity was the only other comorbidity included in these risk assessment models, but no statistically significant associations were found between obesity and COVID-19-related case rate, hospitalization rate, nor death rate.<sup>52</sup>

Azar et al. (2020) was the second study which found a positive association between diabetes and COVID-19-related hospital admission.<sup>33</sup> Congestive heart failure was also positively associated with COVID-19-related hospital admissions.<sup>33</sup> Hypertension, depression, cardiovascular disease, cancer, COPD, and asthma were included in the risk assessment model, but no statistically significant associations were found between these comorbidities and COVID-19-related hospital admission.<sup>33</sup>

Lazar et al. (2021) reported positive associations between chronic kidney disease and COVID-19-related invasive mechanical ventilation.<sup>38</sup> The same study also reported a positive association between chronic kidney injury and in-hospital mortality and 28-day mortality.<sup>38</sup> Coronary artery disease was also positively associated with COVID-19-related in-hospital mortality in the same model.<sup>38</sup> Congestive heart failure, coronary artery disease, and COPD were also included in these risk assessment models, however no statistically significant associations were found between these comorbidities and COVID-19-related in-hospital or 28-day mortality.<sup>38</sup>

Tummalapalli et al. (2021) found no statistically significant associations between diabetes, cancer malignancy, glomerulonephritis, HIV, hypertension, post-transplant outcomes, other/unknown

comorbidities, and cystic kidney disease and COVID-19 cases among patients on hemodialysis.<sup>40</sup> Hawkins et al. (2020) found no statistically significant associations between diabetes, COPD, chronic kidney disease, heart disease, and obesity and COVID-19 case rate or death rate.<sup>50</sup>

**Table 8. Comorbidities<sup>s,t,38</sup>**

Comorbidities				
Comorbidity	Studies Including Comorbidities, n (%)	Comorbidities in SDOH and COVID-19 Infection and Outcome Risk Assessment Models		
		Number of Studies, n (%)	Studies with Significant Association, n (%)	Direction of Association
Acquired immunodeficiency syndrome (AIDS)	1 (4%)	--	--	--
Alcohol use disorder	2 (7%)	--	--	--
Anemia	3 (11%)	--	--	--
Any condition	2 (7%)	--	--	--
Asthma	2 (7%)	1 (4%)	--	--
Cancer	5 (19%)	2 (7%)	--	--
Cardiovascular disease	1 (4%)	--	--	--
Cerebrovascular disease defined by Charlson Comorbidity Index	1 (4%)	--	--	--
Chronic kidney disease	5 (19%)	2 (7%)	1 (4%)	Positive
Chronic kidney injury	1 (4%)	1 (4%)	1 (4%)	Positive
Chronic obstructive pulmonary disease	6 (22%)	3 (11%)	--	--
Cirrhosis	1 (4%)	--	--	--
Coagulopathy	1 (4%)	--	--	--
Congestive heart failure	3 (11%)	2 (7%)	1 (4%)	Positive

<sup>s</sup> Cells with dashes (“--”) indicate no results.

<sup>t</sup> The number in each row refers to how many studies include the comorbidity. Studies include multiple comorbidities, such that total of each column is not the number of studies.

Comorbidities				
Comorbidity	Studies Including Comorbidities, n (%)	Comorbidities in SDOH and COVID-19 Infection and Outcome Risk Assessment Models		
		Number of Studies, n (%)	Studies with Significant Association, n (%)	Direction of Association
Coronary artery disease	1 (4%)	1 (4%)	1 (4%)	Positive
Deep vein thrombosis history	1 (4%)	--	--	--
Depression	3 (11%)	1 (4%)	--	--
Diabetes	8 (29%)	4 (22%)	2 (7%)	Positive
Fair or poor health	2 (7%)	1 (4%)	1 (4%)	Negative
Fluid and electrolyte disorder	2 (7%)	--	--	--
Glomerulonephritis	1 (4%)	1 (4%)	--	--
Heart conditions (congestive heart failure, cardiac arrhythmias, and/or valvular disease) defined by Elixhauser Comorbidity Index	1 (4%)	--	--	--
Heart disease	2 (7%)	1 (4%)	--	--
HIV	1 (4%)	1 (4%)	--	--
Hypertension	5 (19%)	2 (7%)	--	--
Hypothyroidism	1 (4%)	--	--	--
Lung disease (pulmonary circulation disorders and/or chronic pulmonary disease) defined by Elixhauser Comorbidity Index	1 (4%)	--	--	--
Neurologic disorder	1 (4%)	--	--	--

Comorbidities				
		Comorbidities in SDOH and COVID-19 Infection and Outcome Risk Assessment Models		
Comorbidity	Studies Including Comorbidities, n (%)	Number of Studies, n (%)	Studies with Significant Association, n (%)	Direction of Association
Obesity	6 (22%)	2 (7%)	--	--
Obstructive sleep apnea/obesity hypoventilation syndrome	1 (4%)	--	--	--
Other or unknown	2 (7%)	1 (4%)	--	--
Paralysis	1 (4%)	--	--	--
Peripheral vascular disease	1 (4%)	--	--	--
Post-transplant	1 (4%)	1 (4%)	--	--
Psychosis	1 (4%)	--	--	--
Renal disease	2 (7%)	1 (4%)	--	--
Renal failure	1 (4%)	--	--	--
Rheumatoid arthritis	1 (4%)	--	--	--
Sickle cell disease or thalassemia (deficiency anemia) defined by Elixhauser Comorbidity Index	1 (4%)	--	--	--
Smoking	1 (4%)	1 (4%)	--	--
Solid tumor without metastasis	1 (4%)	--	--	--
Substance use disorder	1 (4%)	--	--	--
Valvular disorder	1 (4%)	--	--	--
Weight Loss	1 (4%)	--	--	--

## 4 Discussion and Implications

### 4.1 Summary of Findings

A review of relevant literature found a variety of SDOH significantly associated with increased COVID-19 testing, test positivity, cases, exposure, mortality, and hospitalization.

The SDOH data reported in the reviewed literature are representative of the five domains of Healthy People SDOH framework. Data related to the domain of Neighborhood and Built Environment emerged as an area of particular interest, with the highest number of data elements ( $n = 42$ ) defined across 16 studies. It is notable that composite measures such as SVI and ADI were mapped to the SES-area deprivation category in the MCC eCare Plan in both this domain and the Economic Stability domain.

The use of composite measures offers the benefits of clear definitions of data elements and consistent measurement. These composite measures were used in only two studies, but both found positive statistical associations with COVID-19-related outcomes, one with test positivity and one with mortality.<sup>40,51</sup> The domain with the fewest data elements was Education Access and Quality.

SDOH data elements used in reviewed studies align with many MCC eCare Plan categories, such as food, housing, and neighborhood/environment. For example, severe housing problems,<sup>u</sup> crowding, homelessness, and lower income were associated with several COVID-19-related outcomes in a number of studies.<sup>34,40,50,47,52,58</sup> While definitions differ across these studies, this domain appears as an emerging area of interest in SDOH research.

However, most MCC eCare Plan data elements were not assessed in the reviewed literature. For example, within the communication category, the only element represented is English proficiency. No studies addressed the other elements of health literacy, technology literacy, or technology access. There were no studies with data elements in two broader categories, abuse/neglect/upheaval and stress and anger.

Our focus was on modifiable factors, such as income and housing, that are the drivers of the outcome differences; however, we were also interested in non-modifiable factors, which are themselves not causal factors for disparities but are subject to structural inequities that produce adverse health outcomes. For instance, Black race and Hispanic/Latino ethnicity were consistently associated with worse COVID-19-related outcomes across multiple studies, while there were varying associations for other races depending on the COVID-19-related outcome.

There are numerous gaps in the use of SDOH proposed by the MCC eCare Plan. There is little standardization of definitions and consistency in measures among the data elements used. Among the elements reported, there is much room to improve the definitions and differentiation of similarly named elements. The use of composite measures at the ZIP code level is promising. It may be useful to determine how to adjust these types of measures to account for neighborhood-level differences. There is ample opportunity to advance standardization, operationalization, and measurement of existing SDOH data elements and new elements that do not exist today.

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<sup>u</sup> Severe housing problems were defined in the Nguyen et al. (2021) study as having at least one of four characteristics: lack of complete kitchen, lack of plumbing, overcrowding, and unbearable housing cost burden.

## 4.2 Scoping Review Limitations

Several limitations to the scoping review approach were addressed in the methodology employed. First, although typically conducted in full systematic reviews, a formal evaluation of the *quality of evidence* in each study and *quantitative synthesis* of findings was not possible given the time frame for the review. To address this, the Health FFRDC project team limited the search to two databases focused on studies with quantitative data. Second, the fast pace at which the COVID-19 pandemic evolved limited the breadth of research available. The scope of the search was broadened beyond traditional academic journal articles to include government and industry reports to attempt to capture as much knowledge as possible. However, none of these reports were identified. Third, the scoping review included only studies conducted in the United States, and therefore results may not be generalizable outside of the United States. Finally, because the independent variable represented an extremely broad field with a variety of operational and theoretical frameworks actively in use, it is unlikely that these search terms would comprehensively capture all available literature on all SDOH data elements. To address this limitation, multiple structured searches were conducted, rather than a single search, to ensure the most relevant literature was included.

The review covered less than two years of publications from the time COVID-19 was first identified. The results will most likely change as more research is completed and published. Thousands of studies have been published related to COVID-19 and SDOH in the last two years, making evidence synthesis challenging. The urgent need for information motivated rapid pre-publication of results and speedy peer review by many journals. The goal of rapid dissemination of research was laudable. However, standardization of concepts, terminology, and data sources was not possible in this short period. Challenges included the changing definition of the COVID-19 as a condition, changing information about signs and symptoms, variable quality and availability of testing, and variation in data collection and reporting. For example, initial guidance on reporting COVID-19-related conditions, signs, and symptoms was released on February 20, 2020.<sup>61</sup> The official International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnosis code for COVID-19 was not adopted until October 1, 2020, and more codes were added on January 1, 2021.<sup>62,63</sup> Data collected prior to this date may have relied on identification of signs and symptoms of COVID-19 that were also evolving. In addition, tests for infection varied, with some organizations using emergency use-authorized testing.<sup>61</sup>

Studies included in this scoping review relied on data sources for SDOH that were readily available, such as local health systems' EHRs, national cohort surveys, or publicly available geo-coded indices, with limited standardization and harmonization. The standardization of data in EHRs is known to be a challenge.<sup>64</sup> National cohort surveys have the benefit of consistency of data over time. Yet, data are not harmonized across these data sets. The treatment of core demographic data necessary for uncovering relationships between SDOH and COVID-19 was highly varied. For example, data on race were universally included in studies and were commonly associated with negative health outcomes related to COVID-19. However, studies differed substantially in how racial categories were defined, aggregated, and combined with ethnicity. Including consistent and standardized race and ethnicity data is important to identifying and understanding their related structural inequities that may lead to adverse health outcomes.

Additionally, it is important to note that while sex at birth was reported in 13 studies, no studies reported on gender identity. Two studies used the terms sex and gender interchangeably, referring to sex at birth (male/female) as gender (Dickinson and Toth).<sup>39,41</sup> The Gender Harmony Project has called for improved standards to ensure accurate representation of clinical sex and gender interoperability, suggesting the use of five data elements that should be included in an individual's information model: Gender Identity, Sex For Clinical Use, Recorded Sex or Gender, Name to Use, and Pronouns.<sup>39,41,65</sup>

### 4.3 Implications for Current OS-PCORTF Funded COVID-19 Initiatives

In 2021, the OS-PCORTF funded seven new projects to strengthen the data infrastructure for conducting PCOR on COVID-19, during and after the pandemic. A summary of the projects can be found in the report *Building Data Capacity for Patient-Centered Outcomes Research (PCOR) for COVID-19: Highlights of Seven OS-PCORTF Funded Multiagency Data Initiatives*.<sup>1</sup>

The projects that are currently in progress sought to expand the use of existing data or linked federal and state data sources and address four priorities: leveraging health data and methods, social and medical risk factors, therapeutics and vaccines, and technology and the pandemic. The findings of the scoping review are particularly relevant to inform the integration of data on SDOH and community services to understand the impact of COVID-19 on health equity, and the health of populations at higher health risk.

The scoping review highlighted the reliance on readily accessible data sources containing SDOH and COVID-19 data elements including EHRs, population data sets, and survey information regardless of their standardization status. In addition, the papers in this review reveal the importance of real-world data “...to quickly capture, aggregate, update, and analyze high-quality data for PCOR and surveillance” that emerged concurrent with the pandemic itself.<sup>1</sup> Existing data sources from federal agencies such as the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI), Housing and Urban Development data, Centers for Medicare and Medicaid Services (CMS) claims data, as well as local data from EHRs and health information exchanges, are important for understanding disparities and effectiveness of interventions. However, they may not include standardized SDOH data elements for comparability and linkages across that could be the possible reason for finding only very limited (a few) examples in the scoping review where these data were linked.

The scoping review identified several other critical gaps that align with and support the priorities of the portfolio. The lack of standardization of basic demographic categories, such as age and education, hampers comparison across studies. Similarly, the lack of specification of definitions and measures across most SDOH hampers generation of evidence and analysis of the strength of evidence across studies. In addition, the lack of representation of most of the MCC eCare Plan subcategories of potential SDOH points to major gaps in both availability of data and consensus in the research community about which SDOH data elements are important.

Specific implications from the findings of the scoping review for the portfolio of seven projects are provided in Table 9.<sup>66</sup>

**Table 9. Implications by Project**

<b>Implications by Project</b>		
<b>OS-PCORTF Funded COVID-19 Initiatives Project Title (Lead Agency)</b>	<b>Project Description</b>	<b>Implications from the Scoping Review</b>
Building Infrastructure and Evidence for COVID-19 Related Research, Using Integrated Data from NCHS Data Linkage Program (CDC/National Center for Health Statistics [NCHS])	Create publicly available synthetic data integrating SDOH (health care access, education, income, housing, and urbanicity) to enable research to assess associations between individual risk factors, health behaviors, and SDOH and pre-COVID-19 respiratory-related health care-seeking behavior and treatments, patterns of care, and outcomes.	Highlights examples of papers with the definitions and measures of SDOH data elements of health care access, education, income, housing, and urbanicity and their association with COVID-19, particularly income and housing.
Using Machine Learning Techniques to Enable HIE to Support COVID-19-Focused PCOR (ONC)	Develop patient-centered outcomes models with special emphasis on the inclusion of social determinant risk factors, behavioral/mental health factors, and other factors unique to people with chronic conditions.	Indicates that comorbidities from EHRs were collected and in a small number of papers were associated with COVID-19 infection and outcomes. Most of the SDOH risk factors lead to poorer COVID-19-related outcomes.
A National COVID-19 Longitudinal Research Database Linked to CMS Data (NIH)	Evaluate disparities by looking at community characteristics using geocoding approaches and information on air quality and housing, and capture care and outcomes of vulnerable populations such as patients on dialysis, nursing home residents, and low-income individuals. The project will also examine functional health status, frailty, and mental health disorders.	Among promising SDOH data elements are the use of population-level composite measures (e.g., SVI and ADI) that incorporate natural and physical environment, including population density, housing, transportation.
CURE ID: Aggregating and Analyzing COVID-19 Treatments from EHRs and Registries Globally (Food and Drug Administration)	Analyze outcomes for different repurposed treatment regimens and treatment options to determine their impact on subpopulations, particularly vulnerable populations such as pregnant women and neonates, and subpopulations defined by geography, health insurance status, income, race/ethnicity, and medical conditions.	Several examples of papers show the use of geography, health insurance status, income, race/ethnicity, and medical conditions (e.g., comorbidities) in association with COVID-19-related outcomes. The definitions and measures of these data elements may be useful in application to analyses of populations at risk for health disparities and poor medical outcomes.

Implications by Project		
OS-PCORTF Funded COVID-19 Initiatives Project Title (Lead Agency)	Project Description	Implications from the Scoping Review
Dataset on Intellectual and Developmental Disabilities: Linking Data to Enhance Person-Centered Outcomes Research (ASPE)	Create a publicly available data set linking survey and administrative data to enable the study of relationships between patient-centered outcomes and long-term services and supports for individuals with intellectual disabilities/ developmental disabilities (ID/DD).	The definitions and measures of SDOH data elements may be useful in application to analyses relevant to individuals with ID/DD.
Multistate EMS and Medicaid Dataset (MEMD): A Linked Dataset for Patient-Centered Outcomes (ASPE)	Assess outcomes of Medicaid beneficiaries who engage with emergency medical services (EMS), using data to identify variations in care delivery related to SDOH and understand outcomes of individuals experiencing behavioral health emergencies (e.g., opioid overdose) before and during the pandemic.	The definitions and measures of community conditions (e.g., poverty, race/ethnicity) in exemplar papers may be useful in application to analyses. There were no examples of paper that linked Medicaid and EMS data, highlighting the importance of addressing this gap.
Understanding COVID-19 Trajectory and Outcomes in the Context of MCC Through e-Care Plan Development (AHRQ/NIDDK)	Expand standards-based e-Care plan tools to facilitate aggregation and sharing of person-centered planning data, including health concerns, SDOH, complex constellations of COVID-19 sequelae, and behavioral health concerns, across disparate systems for people living with MCC, their caregivers, and their care teams.	Most SDOH proposed in this MCC e-Care plan project are not represented in papers included in the scoping review. This highlights the importance of data standardization for the breadth of SDOH and sharing of findings with initiatives like the Gravity Project to improve risk factor collection for vulnerable populations through the balloted and developed FHIR® implementation guides.

The rapidly evolving COVID-19 environment further emphasized the need for timely and consistent, standardized data collection for research. The findings in this report around SDOH and COVID-19 data elements highlight what data sources and elements are being used for research and identify variations in definitions that can be used to inform many of the FY21 OS-PCORTF-funded projects as well as future solicitations.<sup>1</sup>

#### 4.4 Future Needs in SDOH and COVID-19 Research

This scoping review provides more granular evidence compared to existing reports and calls for the standardization of SDOH data across health care, public health, and research. A 2020 concept paper from the National Alliance to Impact the Social Determinants of Health (NASDOH) listed standardization



of SDOH data collection and storage as a prevailing challenge in capturing and transmitting SDOH information. The National Academies of Science, Engineering, and Medicine (NASEM) also published a report with a specific focus on building data capacity for PCOR in 2021, which further emphasized the need for standardizing SDOH data collection and storage.<sup>67</sup> This report highlighted the importance of SDOH data in the United States Core Data for Interoperability core data set, and suggested data standards that should be adopted to exchange SDOH information between consumers and service providers.<sup>68</sup> Similarly, a 2021 report by ASPE HP highlighted the need for standardizing terminology and measurement, including “aligning approaches to data collection to help make comparisons across interventions that target similar social determinants.”<sup>69</sup>

A 2019 report by the Center for Open Data Enterprise recommended that HHS develop an SDOH strategy, with one of the three critical goals focusing on defining and standardizing SDOH data. This would involve “improving and aligning open-source assessment tools, adopting data standards and definitions, and developing a data governance body.”<sup>70</sup> Watkins et al. (2020) reviewed considerations around translating SDOH to standardized clinical entities such that they may be used in health care settings. The authors highlight the importance of developing a robust ontology of SDOH terminology codes, as well as utilizing the Health Level Seven (HL7) Fast Healthcare Interoperability Resources (FHIR) standard. Important considerations outlined in their review include 1) existing efforts around developing FHIR profiles for SDOH, such as those by the Gravity Project; 2) leveraging the FHIR Questionnaire resource for interoperable SDOH collection; and 3) reconciling terminology overlaps for representing SDOH.<sup>71,72</sup> In June 2021, the Office of the National Coordinator for Health Information Technology (ONC) awarded a cooperative agreement to HL7 to prioritize and expedite the development and deployment of gap and opportunity areas for SDOH standards.<sup>64</sup>

While there was not an adequate number of highly comparable studies to better synthesize evidence addressing specific questions of interest, the scoping review results indicate that the intersection of SDOH and COVID-19 is a growing area of research. Further, applying the Healthy People SDOH framework domains and the MCC eCare Plan categories of SDOH provided a useful framework for identifying gaps in current data sets, highlighting opportunities to contribute to a comprehensive set of SDOH elements and standardization of these elements across data sets.

## 5 Conclusion

This scoping review sought to identify SDOH that are risk factors for, or associated with outcomes of, COVID-19, and understand the definitions, characteristics, and measures of SDOH data elements as they were used in studies analyzing any statistical associations with the risk for COVID-19 infection and COVID-19-related outcomes in the United States. In general, a variety of adverse SDOH were significantly associated with increased COVID-19 testing, test positivity, cases, exposure, mortality, and hospitalization.

Overall, the results of this scoping review inform increasing efforts to raise awareness of the importance of SDOH standardization, which will subsequently enhance the use of these data elements in PCOR and in other research related to health care and public health needs. Future research might explore how this work will advance OS-PCORTF goals, opportunities for SDOH and COVID research, and implications for OS-PCORTF work on data infrastructure. As research on SDOH progresses, the field may also consider



how best to apply newer methods of analysis appropriate to the complex and varied data sets that contain SDOH. Such endeavors will not only contribute to the understanding of SDOH and COVID-19, but also may benefit future research on the relationship of SDOH to other health conditions, interventions for PCOR, and public health priorities.

## Abbreviations and Acronyms

<b>Term</b>	<b>Definition</b>
<b>ACE</b>	Adverse Childhood Experiences
<b>ADI</b>	Area Deprivation Index
<b>AHRQ</b>	Agency for Healthcare Research and Quality
<b>AIDS</b>	Acquired Immunodeficiency Syndrome
<b>ASPE</b>	Assistant Secretary for Planning and Evaluation
<b>ASPE HP</b>	ASPE Office of Health Policy
<b>CDC</b>	Centers for Disease Control and Prevention
<b>CKD</b>	Chronic Kidney Disease
<b>CMS</b>	Centers for Medicare and Medicaid Services
<b>CoDE</b>	Collaboration on Data for Evidence
<b>CoP</b>	Community of Practice
<b>COVID-19</b>	Coronavirus Disease 2019
<b>CSV</b>	Comma-Separated Values
<b>DESS</b>	Data Element and Standards Set
<b>DCI</b>	Distressed Communities Index
<b>eCare</b>	Electronic Care Plan
<b>EMS</b>	Emergency Medical Services
<b>FFRDC</b>	Federally Funded Research and Development Center
<b>FHIR</b>	Fast Healthcare Interoperability Resources
<b>FY</b>	Fiscal Year
<b>HHS</b>	U.S. Department of Health and Human Services
<b>HL7</b>	Health Level Seven
<b>HP</b>	Office of Health Policy
<b>ICD-10-CM</b>	International Classification of Diseases, Tenth Revision, Clinical Modification
<b>ICE</b>	Index of Concentration at the Extremes
<b>ICU</b>	Intensive Care Unit
<b>ID/DD</b>	Intellectual Disabilities/Developmental Disabilities
<b>MCC</b>	Multiple Chronic Conditions
<b>MeSH</b>	Medical Subject Headings
<b>NASDOH</b>	National Alliance to Impact the Social Determinants of Health
<b>NASEM</b>	National Academies of Science, Engineering and Medicine
<b>NCHS</b>	National Center for Health Statistics
<b>NIDDK</b>	National Institute of Diabetes and Digestive and Kidney Diseases

<b>Term</b>	<b>Definition</b>
<b>NIH</b>	National Institutes of Health
<b>ONC</b>	Office of the National Coordinator for Health Information Technology
<b>OS</b>	Office of the Secretary
<b>OS-PCORTF</b>	Office of the Secretary Patient-Centered Outcomes Research Trust Fund
<b>PACS</b>	Post-Acute COVID-19 Syndrome
<b>PASC</b>	Post-Acute Sequelae SARS-CoV-2 Infection
<b>PCOR</b>	Patient-Centered Outcomes Research
<b>PCORI</b>	Patient-Centered Outcomes Research Institute
<b>PCORTF</b>	Patient-Centered Outcomes Research Trust Fund
<b>PCR</b>	Polymerase Chain Reaction
<b>PRISMA-ScR</b>	Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews
<b>RUCA</b>	Rural-Urban Commuting Area
<b>SARS-CoV-2</b>	Severe Acute Respiratory Syndrome Coronavirus 2
<b>SDOH</b>	Social Determinants of Health
<b>SES</b>	Socioeconomic Status
<b>SVI</b>	Social Vulnerability Index

## Appendix A. Inclusion Criteria for Scoping Review

Inclusion criteria used to select studies relevant for this scoping review are presented below.

**Table 10. Inclusion Criteria and Rationale**

Inclusion Criteria and Rationale	
Inclusion Criteria	Rationale
Quantitative studies or mixed methods studies	The study aimed to identify quantitative data elements of interest to be included in other data sets to improve data interoperability and cohesion across projects. Although reviews and qualitative studies provide critical information about the scope of a field, they will not provide evidence about which specific and measurable SDOH data elements are associated with COVID-19.
Human subjects	Only studies with human subjects' data were included to ensure that data about SDOH were incorporated.
Sample size of $n \geq 10$	Case studies and studies with very small sample sizes ( $n < 10$ ) were excluded to ensure that results were quantifiable.
English or English translation Conducted in the United States	Although non-English-language literature and research conducted outside of the United States were available, associations between SDOH and COVID-19-related outcomes may differ significantly across countries and cultures. Given that this review was focused on addressing these factors in the United States, studies were included only if they were conducted in English (or had an English translation available) and if they were conducted in the United States.
Published any time after December 2019	The first known case of COVID-19 was identified in Wuhan, China, in December 2019. Without filtering by date, filters and search terms may have picked up studies about other coronavirus strains published prior to the COVID-19 pandemic, and which may have had different antecedents. Manuscripts posted by authors as preprints may show up in results because of the posting date. However, preprints are pre-publication drafts and therefore are excluded.
Peer-reviewed sources, white papers, government reports, and industry reports	Non-peer-reviewed sources may not undergo the same levels of rigorous peer review as the other sources listed in the inclusion criteria. Dissertations, theses, journalism, and editorials were excluded for this reason.
At least one SDOH element modeled as an independent variable, including SDOH elements that are modeled in cross-sectional studies where directionality may not be indicated	The research question of interest and the current understanding of the effects SDOH on health outcomes suggest that SDOH provide the foundation and background for health, well-being, and disease. Given that the first case of COVID-19 was not identified until December 2019, these foundational SDOH should have been measured either at the same time or prior to measurement of COVID-19 infection or outcomes. Many studies used retrospective reports of SDOH. These studies were included if they modeled their data as if SDOH were an independent variable and COVID-19 were a dependent variable, or as if directionality between SDOH and COVID-19 were not specified.

Inclusion Criteria and Rationale	
Inclusion Criteria	Rationale
At least one COVID-19 element of infection or outcome modeled as a dependent variable, including COVID-19 elements that are modeled in cross-sectional studies where directionality may not be indicated	The research question of interest and the current understanding of the effects SDOH on health outcomes suggest that SDOH provide the foundation and background for health, well-being, and disease. Given that the first case of COVID-19 was not identified until December 2019, these foundational SDOH should have been measured either at the same time or prior to measurement of COVID-19 infection or outcomes. Many studies used retrospective reports of SDOH. These studies were included if they modeled their data as if SDOH was an independent variable and COVID-19 was a dependent variable, or as if directionality between SDOH and COVID-19 was not specified.
Data presented about the quantitative association between at least one SDOH and at least one COVID-19 infection or COVID-19-related outcome	Studies that investigated SDOH and COVID-19 but did not present quantitative data about associations between these constructs had limited use for the quantitative review and were excluded to address the first two research questions.
Measurement information about elements of SDOH available	The primary objective for the review was to gain a better understanding of the data elements of SDOH and COVID-19. Without sufficient information to understand how these constructs were measured, a study would have limited use for the review and was therefore excluded.
Measurement information about elements of COVID-19 infection or outcome available	The primary objective for the review was to gain a better understanding of the data elements of SDOH and COVID-19. Without sufficient information to understand how these constructs were measured, a study would have limited use for the review and was therefore excluded.

## Appendix B. Search Terms for Social Determinants of Health

The search terms according to the MCC eCare Data elements are the table below.

**Table 11. Search Terms for Social Determinants of Health**

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
<b>Communication</b>		"health communication" OR "health care communication" OR "healthcare communication"
English proficiency	Indication of ability to proficiently communicate in English.	"English proficien** <sup>xxii</sup>
Need for an interpreter	Indication of the person's need for interpreter services to communicate with health care staff.	("healthcare" OR "health care" OR "clinical care" OR "medical care" OR "care") AND "interpreter"
Perceived barriers to communicating with health care team	Identification of the person's perceived barriers to communicating with health care team.	("healthcare" OR "health care") AND "communication"
Health literacy	Determination of the patient's ability to understand and communicate health related information, as well as fill out forms.	"health literacy"
Health numeracy	Determination of the patient's ability to understand numerical health-related information.	"health numeracy"
Medication literacy	Determination of the degree to which the person can obtain, comprehend, communicate, calculate, and process patient-specific information about their medications to make informed medication and health decisions to use their medications safely and effectively.	"medication literacy"
Computer literacy	Determination of the degree to which the person is able to use computers and related technology to access, interpret, and share information.	"computer literacy" OR "technology literacy" OR "tech literacy"
Mobile technology literacy	Determination of the degree to which the person is able to use mobile technology (i.e., smartphones, tablets) to access, interpret, and share information.	"mobile technology literacy" OR "mobile literacy"

<sup>xxii</sup>Asterisks serve as the truncation symbol for standard search engines. They are used at the root of a search term in place of letters to help broaden a search. For example, "proficien\*\*" would yield search results for "proficient" and "proficiency."

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
Telehealth literacy	Determination of the person's competency and comfort using telehealth (e.g., secure messaging, video consultations) to engage in health care.	"telehealth literacy"
Internet access	Determination of whether the patient has access to information over the internet by computer or smartphone.	("internet" OR "broadband") AND "access*"
Computer access	Determination of whether the person has access to a computer and how (e.g., personal computer, public library).	("computer" OR "mobile" OR "tech*") AND "access*"
Mobile technology access	Determination of whether the person has access to mobile technology (i.e., smartphone, tablet) and how (e.g., personal computer, public library).	
<b>Health Insurance and Health Care Access</b>		<b>"health insurance" OR "healthcare access" OR "health care access"</b>
Health insurance coverage and type	Determination of whether the patient has or does not have health insurance coverage, and the type of coverage.	"health insurance coverage" OR "type of health insurance" OR "health insurance type" OR "health care coverage" OR "healthcare coverage"
Health insurance inadequacy	Suggestion that the person's health coverage is not adequate in terms of their ability to pay for health needs and out-of-pocket costs.	"adequate health insurance" OR "health insurance adequacy" OR "inadequate health insurance" OR "health insurance inadequacy" OR "underinsured" OR "underinsurance"
Ability to pay for health care	Assessment of the person's ability to pay for health care, including medical, dental, vision.	("healthcare" OR "health care" OR "medication" OR "treatment" OR "medical device" OR "dental" OR "dentist" OR "vision" OR "clinical care" OR "medical care" OR "care") AND ("pay" OR "afford*")
Usual source of care	Determination of the person's usual source of care, including no usual source, emergency department, primary care provider, or specialist.	"access to primary care" OR "access to healthcare" OR "access to health care" OR "source of healthcare" OR "source of health care" OR "source of care"

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
Travel time to usual source of care	Determination of the amount of time it takes for a person to reach their usual source of care.	("healthcare" OR "health care" OR "primary care" OR "medical care" OR "clinical care") AND ("travel" OR "transport*") AND "time"
Barriers to healthcare & services	Identification of barriers the person experiences that make it difficult to access or receive care (e.g., distance to care, unavailability of appointments at doctor's office, long wait times at doctor's office, or lack of transportation).	("healthcare" OR "health care" OR "clinical care" OR "medical care" OR "care") AND "access*" AND "barrier"
Disability payment status	Indication of whether the person is receiving disability payments (Y/N).	"disability payment" OR "disability support" OR "workers comp*" OR "disability insurance" OR "disability income" OR "income protection" OR "Supplemental Security Income" OR "disability benefits"
Disability payment type	Description of the type of disability the person is receiving (i.e., Worker's Compensation, Social Security Disability Insurance, Other).	
<b>Abuse/Neglect/Upheaval</b>		<b>Search terms covered in sections below</b>
Experience of abuse	Determination of whether, when, and how often the patient has experienced/is experiencing physical, emotional, or sexual abuse.	"abuse" OR "neglect" OR "domestic violence" OR "intimate partner violence" OR "IPV" OR "adverse childhood experience*" OR "ACE"
Suspected Abuse	Indication that the person may be experiencing abuse/abuse is suspected.	
At risk of abuse	Indication or finding that the person may be at risk of experiencing abuse.	
Domestic violence/Intimate partner violence	Indication that the person has experienced domestic violence/intimate partner violence.	
Adverse Childhood Experiences (ACE)	Person's experience of adverse childhood experiences.	
Neglect	Indication of whether the person has experienced neglect.	

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
<b>Food</b>		<b>Search terms covered in sections below</b>
Food insecurity	Determination of whether and degree to which the person experiences limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways.	"food secur*" OR "food insecur*" OR "right to food" OR "adequate food" OR "right to healthy food" OR "right to nutrition" OR "lack of food" OR "food scarcity" OR "food deprivation" OR "WIC" OR "supplemental nutrition program" OR "food sovereign"
Access to clean drinking water	Determination of whether and degree to which the person experiences limited or uncertain availability of clean drinking water.	"water" AND ("availab*" OR "access")
Lives in food desert	Determination that the person lives in a food desert, defined by poor access to grocery stores, farmers markets, and other sources of nutritious food.	"food desert" OR "food swamp" OR "access to food" OR "access to healthy food" OR "access to nutritious food" OR "access to nutrition" OR "access to affordable food"
Lives in food swamp	Determination that the person lives in a food swamp, defined by an overabundance of access to processed, high caloric density, snacks, and fast foods.	"food swamp"
<b>Housing</b>		<b>Search terms covered in sections below</b>
Housing insecurity/instability and homelessness	Determination of whether the person has limited or uncertain access to stable, safe, adequate, and affordable housing. If homeless, indication of whether sheltered or unsheltered.	"housing secur*" OR "housing insecur*" OR "homeless*" OR "unhouse*" OR "housing instability" OR "housing stability" OR "stable housing" OR "access to housing"
Substandard/inadequate housing	Determination that the person is living in housing with severe physical problems (e.g., lack of running water or electricity, lack of key fixtures, like a bathtub or shower, exposed wiring, structural deficiencies).	"housing adequacy" OR "adequate housing" OR "substandard housing" OR "community housing organization" OR "housing application*" OR "inadequate housing" OR "housing inadequacy"

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
SES (employment, education, income)		"socio-economic status" OR "SES" OR "socioeconomic status" OR "socio economic status" OR "economic status"
Employment status	Determination of employment status (employed, unemployed, retired) of the patient.	"employment status" OR "employed" OR "unemployed" OR "retire*" <p>"employment status" OR "unemployment status" OR "retire*" OR "last time working" OR "out of work"</p> <p>Note: "employed" picks up a lot of abstracts with "we employed XYZ technique for sequencing"</p>
Current/Former Occupation	Description of the person's current or former occupation.	"occupation*" OR "field of work" OR "job type" OR "job class*"
Job security	Assessment of the likelihood of the patient to lose job or be laid off, and determination of ease of re-employment.	"job security" OR "job insecurity" OR "secure job" OR "insecure job" OR "layoff" OR "laid off" OR "lose job" OR "lost job" OR "temporary employment" OR "out of work" OR "temporary work" OR "temp work"
Work productivity	The person's ability to remain productive at work relating to their physical and mental health.	"work productivity" OR "productive at work"
Desire to be working	Indication of whether the person wants to be working.	"desire to work" OR "job seeking" OR "seeking work"
Education level	Determination of the highest level of education achieved by the patient.	"education* level" OR "highest education" OR "highest degree" OR "education* status"
Income	Documentation of the patient's most recent household income level or income level category.	"income"
Poverty/wealth	Documentation of the patient's economic status in terms of living in wealth or poverty.	"poverty" OR "wealth"
Area deprivation	Documentation of the advantage level of the patient's neighborhood.	"area deprivation" OR "neighborhood deprivation" OR "area poverty" OR "neighborhood poverty"

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
Financial resource strain	Ability to pay for basic necessities such as food, housing, medical care.	"financial resource strain" OR "financial strain" OR "resource strain" OR "financial hardship" OR "material hardship"
<b>Social Support</b>		<b>"social support" OR "social connection"</b>
Support network/social network	Assessment of the adequacy of the patient's social support systems.	"support network" OR "social network" OR "community health service" OR "social care" OR "social service"
Caregiver characteristics	Defines the ability and willingness of the caregiver to assist and support the patient in following the plan of care and medication regimen.	"caregiver quality" OR "caregiver characteristics"
Caregiver availability	Indicates whether the person has any unpaid/non-professional caregiver in local area.	"caregiver availability" OR "access to caregivers" OR "caregiver access*"
Social isolation	Determination of whether the person has social interactions with family, friends, or colleagues or experiences social isolation.	"social isolation"
Living situation	Determination of whether the person lives alone, with family, with friends, in congregate living.	"living situation"
Social role/activities	Degree to which the person is able to participate in social roles and activity.	"social role*" OR "social activities" OR "social activity"  "social role satisfaction" OR "social satisfaction" OR "social role"
Social roles satisfaction	Person's satisfaction with their social role.	
Loneliness	Determination of whether the person is experiencing feelings of loneliness.	"lonely" OR "loneliness"
<b>Family Situation</b>		<b>"family situation"</b>
Marital/spousal status	Documentation of whether the patient has a spouse or domestic partner.	"marital status" OR "spousal status"
Dependents in home	The type and number of adult or child dependents the person has living at home.	"household size" OR "size of household" OR "dependents in home" OR "children in home"
Caregiver role	Description of caregiving role(s) the persons plays to family members/friends (e.g., young children, disabled children, parents, spouse).	"caregiver role" OR "caregiver responsibility*" OR "caregiver burden"

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
Caregiver burden	Assessment of whether/the amount of burden the person experiences as a result of managing the health care of children, parents, other family members, or friends.	
<b>Neighborhood/Environment</b>		<b>"built environment" OR "neighborhood"</b>
Transportation barrier	Assessment of the patient's ability to access transportation to reach health-related resources.	"transport*" AND ("challeng*" OR "barrier*" OR "limitation")
Type of transportation barrier	Identification of the type of transportation barrier the person experiences (e.g., long travel distances, lack of vehicle, transportation cost, inadequate infrastructure, and adverse policies affecting travel).	
Type of transportation used	Identification of the type of transportation the person uses.	"type of transport*"
Exposure to environmental hazards	Potential exposure to hazards in the person's environment, including work, school, and home.	"environmental hazard" OR "environmental risk" OR "pollution" OR "environmental contaminant" AND "expos*"
Unsafe neighborhood	Indication that the person lives in a neighborhood where they are exposed to violence, crime, or a lack of sense of safety.	"neighborhood" OR "community" AND ("safe*" OR "unsafe" OR "crime" OR "violence")
Built environment not conducive to health	Indication that the built environment in the person's neighborhood does not support or impedes health. The built environment includes the physical makeup of where we live, learn, work, and play—our homes, schools, businesses, streets and sidewalks, open spaces, and transportation options. The built environment can influence overall community health and individual behaviors such as physical activity and healthy eating.	"built environment"
<b>Stress, Discrimination and Anger</b>		<b>Search terms covered in sections below</b>
Stress	Determination of the person's perceived stress level.	"stress*" OR "distress"
Recent life changes	Identification of potentially stressful life changes in person's life.	("life event" OR "life change") AND ("recent")
Experiences of discrimination/prejudice	Determination of the person's perceived experiences of/exposure to discrimination/prejudice.	"racis*" OR "prejudic*" OR "discriminat*"

Search Terms for Social Determinants of Health		
Data Element	Data Element Definition	Search Terms
Racism related vigilance	Assessment of the degree to which the person experiences racism-related vigilance.	
Racial trauma/race-based traumatic stress	Determination of whether/the extent to which the person has experienced mental and emotional injury caused by direct or vicarious encounters with racial bias and ethnic discrimination, racism, and hate crimes.	"racial trauma" OR "race-based traumatic stress"
Anger	Assessment of the person's level of anger.	"anger" OR "angry"
<b>Legal Issues</b>		<b>Search terms covered in sections below</b>
Lawsuit status	Indication of whether the person is involved in a lawsuit relating to their health condition(s).	"health" AND ("lawsuit" OR "legal problem*")
Involved in legal actions/problems	Indication of whether the person is involved in legal actions or is experiencing legal problems.	("lawsuit" OR "legal problem*") AND "involve*"
Criminal justice involvement/incarceration history	Assessment of the person's criminal justice involvement, including history of incarceration.	"criminal justice involvement" OR "incarceration" OR "imprisonment"
<b>Other Issues</b>		<b>Search terms covered in sections below</b>
Presence of emergency preparedness plan	Indication of whether the person has developed an emergency preparedness plan.	"emergency preparedness plan"
Migratory grief and loss	Assessment of the level of grief the person experiences associated with immigration.	"migratory grief" OR "migratory loss"
Immigration status	Assessment of the person's status with immigrating to their current country of residence.	""immigrat*" status" OR ""citizen*" status"
Social determinants	General search term.	"social risk*" OR "SDOH" OR "social need*" OR "social determinant*" OR "basic need*" OR "nonclinical determinant*"

## Appendix C. Full-Text Data Extraction

The descriptions of each worksheet in the SDOH COVID-19 Scoping Review Data Extraction Workbook are detailed below.

### App C. Extraction Data

All raw data extracted from the 27 studies. Each row includes all information extracted from one study.

#### Table 3. Pop Characteristics

The population characteristics across all 27 studies. Categories include race/ethnicity, sex (at birth), gender, age, and education and were based on previous discussions with the CoP and the Healthy People SDOH framework domains. Studies with data elements in each category were grouped into sub-categories based on similarities (e.g., White, female, etc.). The data table lists the number and percent of studies that are included each category in their study population. The sheet includes the current Table 3 included in the report and the previous version where all cells (n and percent) were separated. The table on the right side of the sheet (labeled “WORKING Version”) provides the detailed list of studies and the population characteristic elements included.

#### Fig 2-3. SDOH Study Alignment

Bar charts of 1) the number of studies aligned with Healthy People SDOH framework domains and 2) the number of SDOH data elements aligned with Healthy People SDOH framework domains.

#### Table 4. Summary of SDOH

The SDOH data elements included in all 27 studies. Categories follow the MCC eCare Plan categories and include communication, health insurance and health care access, abuse/neglect/upheaval, food, housing, SES (employment, education, income), social support, family situation, neighborhood/environment, racism/discrimination, race/ethnicity, stress and anger, legal issues, and other issues. Studies were grouped into these categories and their corresponding sub-categories. The table lists the number and percent of studies that included each SDOH element category, the number and percent of studies that studied the SDOH element category in statistical association with COVID-19, and the number and percent of studies that identified a statistically significant association between the SDOH element category and COVID-19. The sheet includes the current Table 4 included in the report and the previous version where all cells (n and percent) were separated.

#### SDOH Mapping

All SDOH data elements identified across the 27 studies. Most studies included more than one SDOH data element. The “SDOH element name” includes the data elements as they were reported in their respective studies, verbatim. These data elements were organized by an intermediate category (e.g., “Race/Ethnicity”), which were then mapped to the Healthy People SDOH framework domains, as well as the MCC eCare Plan categories and subcategories.

## Table 5. C-19 DE Assoc w SDOH

The COVID-19-related outcome data elements across the 27 studies, not limited to those found to be associated with SDOH. The table on the left lists the number and percent of studies that include each COVID-19 element category. Categories were determined by grouping similar COVID-19 elements, which are shown in detail on the right side of the sheet (in the table labeled “WORKING Version”).

## Table 6. Analysis Methods

Analysis methods used across the 27 studies. The data table lists the various statistical analyses applied to the association of SDOH and COVID-19-related outcomes, and the number of studies for each. The right side of the sheet (in the table labeled “WORKING Version”) shows the detailed list of studies and analysis methods.

## Sect 3.6 SDOH Associations Data

All SDOH data elements that were studied for statistical association with COVID-19-related outcomes, mapped to the Healthy People SDOH framework domains, as well as the MCC eCare Plan categories and subcategories. This sheet also includes the statistical analyses used to study the association and the numerical results derived. Statistically significant results have been marked with a double asterisk (\*\*). These cells can be found by using the CTRL+F feature and typing “~\*\*” into the search box, or by filtering column L, “Statistically Significant Result (Y/N).” These cells have been bolded for ease of viewing.

## Fig 5-10. Sig Assoc Summary

The directional relationship of SDOH elements associated with COVID-19-related outcomes. The data table lists the various SDOH elements, the study reporting the associated COVID-19-related outcome (COVID-19 Test Positivity, COVID-19 Testing, COVID-19 Exposure, COVID-19 Cases, COVID-19-Related Outcome: Mortality, and COVID-19-Related Outcome: Hospitalization), and the relationship of the statistical association (positive, negative, or mixed). The data table on the left (labeled “WORKING Version”) shows the detailed list of studies and their SDOH and COVID-19 associated relationships. The graphs on the right are the depictions of the statistical associations included in the report.

## Table 7. Geographic Regions

The geographic region and urban/rural populations across the 27 studies and whether they were studied in a statistical association with COVID-19 or not. Categories are based on the U.S. Census Bureau regional categories. If a study did not explicitly determine a U.S. region, the reviewers selected the region in which the state, county, etc., was located (e.g., Rhode Island was categorized as Northeast). The table in the middle lists the number and percent of geographic regions and urban/rural classifications overall, the number and percent of geographic regions and urban/rural classifications studied in a statistical association with COVID-19, and the number and percent of geographic regions and urban/rural classifications that identified a statistically significant association between the geographic region and COVID-19. The sheet includes the current Table 7 in the report and the previous version where all cells (n and percent) were separated. The table on the right side of the sheet (labeled

“WORKING Version”) provides the detailed list of studies and their geographic regions and urban/rural populations.

### **Table 8. Comorbidities**

All comorbidities included across the 27 studies and whether they were studied in a statistical association with COVID-19 or not. The table lists the number and percent of studies that included each comorbidity, the number and percent of studies that studied the comorbidity in a statistical association with COVID-19, and the number and percent of studies that identified a statistically significant association between the comorbidity and COVID-19. The sheet includes the current Table 7 in the report and the previous version where all cells (n and percent) were separated. The table on the right side of the sheet (labeled “WORKING Version”) provides the detailed list of studies and the comorbidity elements.

### **MCC eCare Plan DESS**

The Multiple Chronic Conditions eCare Plan Data Element and Standards Set (MCC eCare Plan DESS) provided by the CoP on 8/5/2021. This was used as a guide during SDOH data element mapping.

### **Acronyms**

A list of the acronyms and their corresponding definitions from the Scoping Review Data Extraction file.

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