A Scoping Review and Assessment of the Area-Level Composite Measures That Estimate Social Determinants of Health Across the United States

Thomas C. Hassett, PhD[1] (iD); Greta Stuhlsatz, PhD[2];
and John E. Snyder, MD, MS, MPH[1]

Abstract

Objectives: Evidence-informed population health initiatives often leverage data from various sources, such as epidemiologic surveillance data and administrative datasets. Recent interest has arisen in using area-level composite measures describing a community's social risks to inform the development and implementation of health policies, including payment reform initiatives. Our objective was to capture the breadth of available area-level composite measures that describe social determinants of health (SDH) and have potential for application in population health and policy work.

Methods: We conducted a scoping review of the scientific literature from 2010 to 2022 to identify multifactorial indices and rankings reflected in peer-reviewed literature that estimate SDH and that have publicly accessible data sources. We discovered several additional composite measures incidental to the scoping review process. Literature searches for each composite measure aimed to contextualize common applications in public health investigations.

Results: From 491 studies, we identified 31 composite measures and categorized them into 8 domains: environmental conditions and pollution, opportunity and infrastructure, deprivation and well-being, COVID-19, rurality, food insecurity, emergency response and community resilience, and health. Composite measures are applied most often as an independent variable associated with disparities, risk factors, and/or outcomes affecting individuals, populations, communities, and health systems.

Conclusions: Area-level composite measures describing SDH have been applied to wide-ranging population health work. Social risk indicators may enable policy makers, evaluators, and researchers to better assess community risks and needs, thereby facilitating the evidence-informed development, implementation, and study of initiatives that aim to improve population health.

Keywords

composite measures, social determinants of health, public health

Social determinants of health (SDH) are the physical, societal, and economic environments influencing the health, wellness, function, and quality of life of individuals and communities.[1] Decades of evidence indicate that structural factors such as poverty, educational and employment opportunities, housing, neighborhood conditions, and discrimination ultimately drive population health and markedly contribute to health disparities, chronic disease prevalence, and health outcomes such as life expectancy.[1-7] Among modifiable factors that affect an individual's length and quality of life, SDH are considered to be the strongest contributors.[8,9] Accordingly, public health strategies that aim to prevent disease, disability, and premature death often address SDH, an approach reinforced in the strategic plan of the US Department of Health and Human Services.[1,4,10]

Increasingly, evidence-informed approaches to population health policy seek to leverage knowledge gleaned from electronic health record data and aggregated administrative

[1] Office of Planning, Analysis, and Evaluation, Health Resources and Services Administration, US Department of Health and Human Services, Rockville, MD, USA
[2] Federal Office of Rural Health Policy, Health Resources and Services Administration, US Department of Health and Human Services, Rockville, MD, USA

Corresponding Author:
John E. Snyder, MD, MS, MPH, US Department of Health and Human Services, Health Resources and Services Administration, Office of Planning, Analysis, and Evaluation, 5600 Fishers Ln, 14N-120, Rockville, MD 20857, USA.
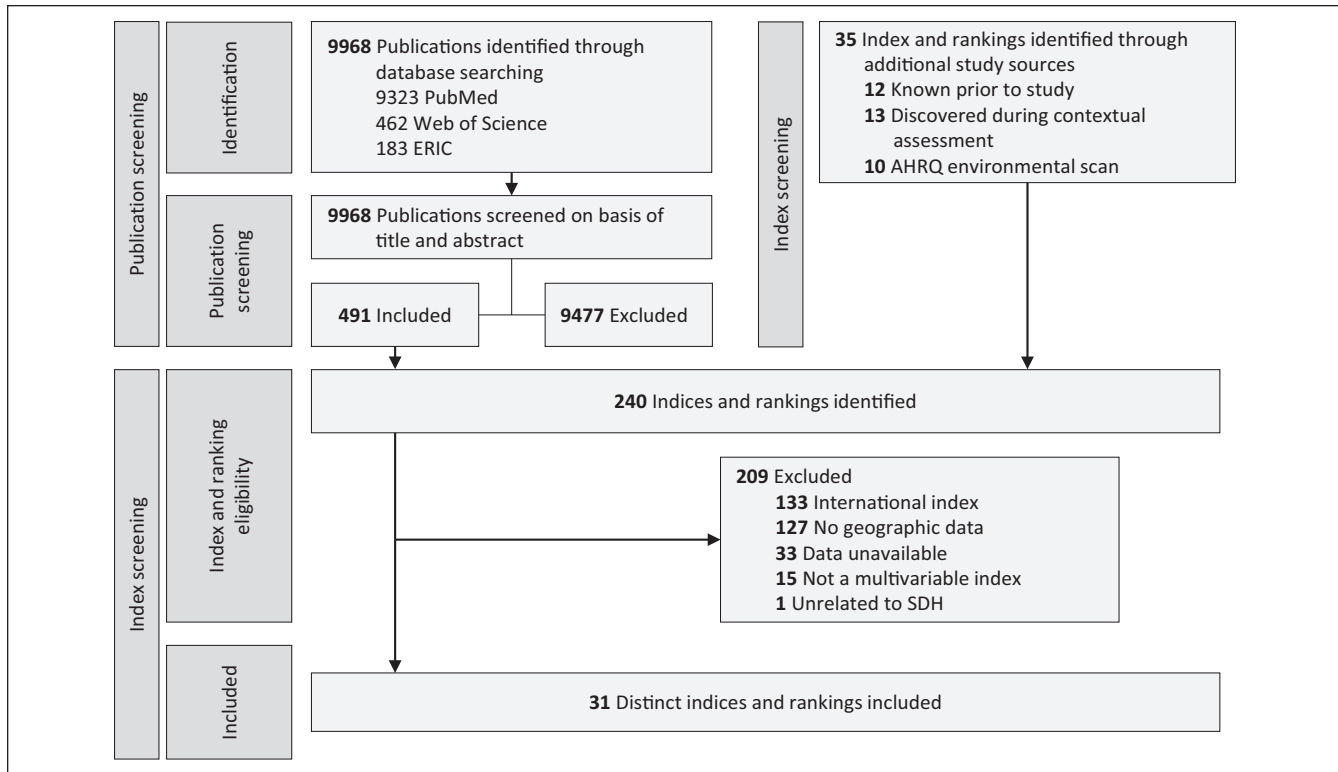Email: jsnyder@hrsa.gov

Publication screening

Identification

9968 Publications identified through database searching
9323 PubMed
462 Web of Science
183 ERIC

Index screening

35 Index and rankings identified through additional study sources
12 Known prior to study
13 Discovered during contextual assessment
10 AHRQ environmental scan

Publication screening

9968 Publications screened on basis of title and abstract

491 Included

9477 Excluded

Index screening

Index and ranking eligibility

240 Indices and rankings identified

209 Excluded
133 International index
127 No geographic data
33 Data unavailable
15 Not a multivariable index
1 Unrelated to SDH

Included

31 Distinct indices and rankings included

Figure 1. Scoping review approach used to identify area-level composite measures estimating 1 or more social determinants of health (SDH) domains in the scientific literature, 2010-2022. Publications were included if they made a direct reference to an index or ranking in either the title or abstract. Indices were included if they (1) were constructed from 2 or more input variables, (2) estimated 1 or more Healthy People 2030 SDH domains, (3) estimated discrete US geographic units at a subnational level (eg, counties, census tracts), and (4) had composite measure data that were made available for public use. Abbreviation: AHRQ, Agency for Healthcare Research and Quality.

datasets, such as those from disease surveillance activities, community assessments, and the US Census.[11-13] Public health professionals and researchers have also expressed interest in using area-level indices and rankings—used interchangeably herein with the term *composite measure*—to describe social risks during the development of health policies, including payment reform initiatives.[14,15] A composite measure is derived from compiling various individual data variables into a single quantitative index or ranking on the basis of an underlying statistical model, hence describing community characteristics in a more comprehensive, multidimensional manner than possible with single data elements alone.[16] For example, the Social Vulnerability Index is the product of 16 data variables, grouped across 4 themes (socioeconomic status, household characteristics, racial and ethnic minority status, and housing/transportation) that collectively help planners determine the levels of support that communities might need for emergency planning and response.[17]

As interest in and capacity to develop composite measures have increased, so too has the application of these resources to public health activities and their use in evidence-informed policy decision-making. While recent literature reviews have focused on identifying certain groupings of composite measures, such as those that describe population health outcomes, little information to date is available on those describing SDH.[18] The objectives of our study were to (1) identify publicly available multifactorial indices and rankings that are cited in the scientific literature and describe SDH, (2) characterize how these measures have historically been applied to work in population health, and (3) synthesize the collective findings into a single informational resource for use by policy makers, evaluators, and researchers.

Methods

Scoping Review Approach

We conducted a scoping review to identify area-level composite measures in the scientific literature that estimate 1 or more SDH domains (Figure 1). We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews guidelines from the Equator Network and established scoping review best practices.[19,20] Compared with other review methodologies, scoping reviews provide a comparatively flexible framework for gathering a range of evidence on emerging or understudied topics.[21-23] We developed a protocol for this scoping review and shared it among study authors and participants in a 5-member

literature review panel before the start of the review. The protocol was not registered.

We used PubMed, Web of Science, and Education Resources Information Center databases to identify relevant publications in the scientific literature released from 2010 through 2022.[24] We selected the starting year (2010) because this was the year that the Patient Protection and Affordable Care Act was passed, introducing mandatory national payment reforms seeking to shift Medicare toward value-based care payment models and leveraging data in new ways to drive affordability, value, accountability, and equity.[25] We used 2 criteria to identify relevant publications in the literature. First, the title of a publication had to contain either "index" or "ranking," thus reducing the total number of to-be-screened references and ensuring that captured publications prominently featured an index or ranking. Second, at least 1 of 28 keywords, generated using the 5 domains and related objectives in the Healthy People 2030 definition of SDH, had to be present in either the abstract or body of the publication (Supplemental Material).[1] We made minor keyword modifications as needed (eg, we converted "people with disabilities" to "disability"), with keywords automatically undergoing term-mapping procedures in databases such as PubMed to help capture keyword variations and closely related terms.[26]

Eligibility Criteria

We used both concept and context elements to determine the eligibility of publications during screening. We used concept elements to identify the principal focus and context elements to further specify the parameters of eligibility.[21] The primary concept used to determine eligibility was whether the identified publications contained a direct reference to an index or ranking in either the title or abstract, to capture studies in which the measure was core to the investigation. Then, we further evaluated identified indices and rankings for eligibility by using 4 context elements. First, we required a multivariate context, in which the index or ranking had to be constructed from 2 or more input variables. Second, we required an SDH context, in which the index or ranking had to estimate 1 or more Healthy People 2030 SDH domains.[1] Third, an index or ranking had to have a geographic context, providing an estimate for discrete US geographic units at a subnational level (eg, counties, census tracts). Finally, we required an availability context, where an index or ranking was required to have associated data available for download by potential users. This final context deemed composite measures for which the calculation formula was communicated but no source data were available as ineligible, because such measures are unlikely to be easily accessed for large-scale public health applications.

Screening Process

We determined the final list of each index and ranking included in this review through a multistep screening process. First, for each publication that met review criteria, the title and abstract were independently reviewed for eligibility by 2 people in a 5-member literature review panel. Publications with conflicting eligibility determinations between reviewers were rescreened and resolved through collaborative agreement by the 2 study leads (T.C.H., G.S.). We performed title and abstract screening as well as conflict resolution by using the web-based citation screening tool *abstrackr*.[27] Next, we rescreened eligible publications using their full text to identify the composite measure referenced in the publication. We generated a list of prospective indices and rankings from this second screening step.

Other Screening Approaches

We considered a number of additional, prospective composite measures for study eligibility when they were discovered in the text of scientific publications identified during the scoping review (outside the title/abstract), if they were known by 1 or more study authors prior to the review, or if they were listed in a publicly available environmental scan of SDH data sources from the Agency for Healthcare Research and Quality.[28] We applied the same context criteria used for the scoping review to these composite measures to determine their eligibility for inclusion in this study.

Contextual Assessment of Eligible Composite Measures

Following the scoping review, we reviewed the 5 most recent publications for eligible composite measures to contextualize their application in public health studies. Representative literature was limited to peer-reviewed publications in which composite measure data were applied in US-based public health initiatives and/or investigations.

The activities we conducted as part of this review met the criteria for excluded research according to the Code of Federal Regulations Title 45, Part 46, as our study does not involve human subjects. Thus, we did not seek institutional review board approval for this study.

Results

We retrieved 9968 publications from 3 electronic databases (Figure 1). The initial screening of title and abstract text yielded 491 publications that contained descriptions of indices and rankings. We identified 240 distinct indices and rankings from both accepted publications and additional study sources. We determined that 31 indices and rankings were eligible for inclusion after screening (Table 1). We reviewed this final list of composite measures for content and subsequently categorized them into 1 of 8 domains based on what it was designed to estimate or rank: environmental conditions and pollution, opportunity and infrastructure, deprivation and well-being, COVID-19, rurality, food

Table 1. Area-level composite measures identified in a scoping review of indices and rankings in peer-reviewed literature that estimate the social determinants of health and have publicly accessible data sources, by domains, 2010-2022

Domain/index	Source	Description	Data format	Disaggregation	Data years
Environmental conditions and pollution					
Air Quality Index	US Environmental Protection Agency	A report of air quality for a particular area and reflects the relative presence of 5 major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide	Integer	County, core-based statistical areas	1980-2022
Environmental Justice Index	Agency for Toxic Substances and Disease Registry	Considers a combination of environmental, preexisting health, and social conditions to estimate communities at greatest risk for cumulative health effects from environmental impact	Decimal	Census tract	2022
Environmental Quality Index	US Environmental Protection Agency	Estimates overall environmental quality for communities, leveraging data across 5 domains: air, water, land, built, and sociodemographic	Decimal	County	2000-2005, 2006-2010
Opportunity and infrastructure					
American Dream Prosperity Index	The Legatum Institute and The Milken Center for Advancing the American Dream	A measure of community prosperity and the degree to which communities have effective institutions, an open economy, and empowered people	Decimal, ranking	County, state	2004-2022
Childhood Opportunity Index 2.0	Data Diversity Kids	Estimates the quality of resources and conditions (socioeconomic, health, environmental, and educational) in communities that are important for child development	Decimal	Census tract	2010, 2015
National Walkability Index	US Environmental Protection Agency	Provides estimates and rankings for community walkability across the United States	Decimal	Block group	2019
Ohio Children's Opportunity Index	Ohio Colleges of Medicine Government Resource Center and The Ohio State University	Leverages measures of neighborhood conditions and opportunities to estimate overall neighborhood opportunity for children across Ohio	Decimal	Census tract	2014, 2017
Ohio Opportunity Index	Ohio Colleges of Medicine Government Resource Center and The Ohio State University	Leverages measures of neighborhood conditions and opportunities to estimate overall neighborhood opportunity across Ohio	Decimal	Census tract	2016, 2018
The Opportunity Index	Child Trends and The Forum for Youth Investment's Opportunity Nation	Provides a multidimensional estimate of opportunity for communities, considering opportunity across economic, education, health, and community domains	Decimal	County, state	2011-2019
Race for Results Index	The Annie E. Casey Foundation	A measure of children's progress across communities and racial and ethnic groups on key educational, health, and economic milestones	Decimal	State, race, and ethnicity	2014, 2017
Social Capital Index	Social Capital Project	Estimates familial and community connectedness across communities	Decimal	County, state	2018

(Continued)

Table 1. (continued)

Domain/index	Source	Description	Data format	Disaggregation	Data years
Deprivation and well-being					
Area Deprivation Index	University of Wisconsin School of Medicine and Public Health	Estimates relative neighborhood socioeconomic disadvantage for communities; Area Deprivation Index rankings for each community relative to the nation and respective state are available	Integer	Census tract	2015, 2020
Distressed Community Index	Economic Innovation Group	A tool for measuring comparative economic well-being of communities, factoring in education, housing, occupational, income, and economic conditions in communities	Decimal	ZIP code, county	2015-2019
Multidimensional Deprivation Index	US Census Bureau	An expansive estimate of well-being that considers deprivation across 6 dimensions: standard of living, education, health, economic security, housing quality, and neighborhood quality	Decimal	County	2017
Neighborhood Deprivation Index	National Cancer Institute	Estimates community deprivation, factoring 4 dimensions of socioeconomic status: wealth and income, education, occupation, and housing conditions	Decimal	Census tract	2020
Social Deprivation Index	Robert Graham Center	A composite measure of area-level deprivation based on community characteristics related to education, poverty, housing, employment, and transportation	Decimal	Census tract, county, primary care shortage areas, ZIP code tabulation areas	2012-2019
COVID-19					
COVID-19 Community Vulnerability Index	Surgo Ventures	An estimate of a community's resilience to the health, economic, and social consequences of COVID-19 in the absence of appropriate response and support	Percentile	County	2020
COVID-19 Pandemic Vulnerability Index	National Institute of Environmental Health Sciences	An estimate of community vulnerability developed from inputs related to virus transmission and outcomes and conditions that may predispose communities to have adverse outcomes	Decimal	County	2020-2022
COVID-19 Vaccine Coverage Index	Surgo Ventures	A measure of the expected difficulty a community may face in achieving rapid, widespread COVID-19 vaccine coverage	Decimal	County, state	2021
Rurality					
Index of Relative Rurality	Purdue University	A continuous, threshold-free, unit-free measure of rurality	Decimal	County	2000, 2010
Food insecurity					
Map the Meal Gap	Feeding America	Estimates food insecurity for the overall population and children at multiple geographic levels	Decimal	State, county, congressional district	2011-2022
Emergency response and community resilience					
Baseline Resilience Indicators for Communities	University of South Carolina–Hazards & Vulnerability Research Institute	An estimate of community disaster resilience, factoring social, economic, community capital, institutional, infrastructural, and environmental county characteristics	Decimal	County	2015, 2010

(Continued)

Table 1. (continued)

Domain/index	Source	Description	Data format	Disaggregation	Data years
Community Resilience Estimates	US Census Bureau	Measures neighborhood risk to disasters, including COVID-19, by leveraging restricted census microdata, which are otherwise absent in other estimates of resilience	Decimal	Census tract, county	2018, 2019
Minority Health Social Vulnerability Index	Office of Minority Health	An expansion of the Social Vulnerability Index in areas related to racial and ethnic minority status and language and also considers inputs associated with COVID-19 outcomes	Decimal	County	2021
National Health Security Preparedness Index	Robert Wood Johnson Foundation and University of Kentucky	A broad measure of the health protections in place in each state that are needed to keep people safe in the face of large-scale public health threats	Decimal	National, state	2003-2021
National Risk Index	Federal Emergency Management Agency	A measure of the community risk to 18 natural disasters; the measure considers historic economic losses due to natural disasters as well as social and community factors that may influence the extent to which disasters affect communities	Percentile	Census tract, county	2020-2023
Social Vulnerability Index	Agency for Toxic Substances and Disease Registry	An estimate of community vulnerability to disasters (natural, disease, human-made)	Percentile	County, congressional district	2000, 2010, 2014, 2016, 2018
Social Vulnerability to Environmental Hazards Index	University of South Carolina	An estimate of community social vulnerability to environmental hazards	Decimal	County	2014
Health					
California Healthy Places Index	Public Health Alliance of Southern California	Provides an estimate of health and the social conditions that drive health for areas in California	Decimal	Census tract, county, ZIP code, and others	2022 (HPI 3.0)
County Health Rankings and Roadmaps	University of Wisconsin Population Health Institute & Robert Wood Johnson Foundation	Estimates and ranks county health and well-being based on factors related to health behaviors, clinical care, social and economic factors, and physical environment	Ranking	County	2010-2022
Healthiest Communities Ranking	US News & World Report	A ranking of counties and county equivalents based on inputs relating to population health, equity, education, economy, housing, food and nutrition, environment, public safety, community vitality, and infrastructure	Ranking	State, county	2022

insecurity, emergency response and community resilience, and health. Although each composite measure was assigned to a single domain, in some cases composite measures could be reasonably categorized under multiple domains.

Environmental Conditions and Pollution

The review yielded 3 indices reflecting the quality of environmental conditions in communities across the United States: Air Quality Index, Environmental Justice Index, and Environmental Quality Index.[29-31]

Opportunity and Infrastructure

Eight indices focused on infrastructure and opportunities in communities: American Dream Prosperity Index (formerly the US Prosperity Index), Childhood Opportunity Index 2.0, National Walkability Index, Ohio Children's Opportunity

Index, Ohio Opportunity Index, the Opportunity Index, Race for Results Index, and the Social Capital Index.[32-39] The Childhood Opportunity Gap is the calculated difference in Childhood Opportunity Index scores between metropolitan areas, and although it is not an independent index, it may also be useful for disparity-related comparison studies, mapping, and policy work.[40]

Deprivation and Well-Being

Five indices provided estimates related to disadvantage and well-being across domains (eg, education, industry) in communities: Area Deprivation Index, Distressed Community Index, Multidimensional Deprivation Index, Neighborhood Deprivation Index, and Social Deprivation Index.[41-46]

COVID-19

Three indices provided estimates related to COVID-19 outcomes, vulnerability, and vaccine coverage in communities: COVID-19 Community Vulnerability Index, COVID-19 Pandemic Vulnerability Index, and COVID-19 Vaccine Coverage Index.[47-49]

Rurality

The Index of Relative Rurality was the only index found that focused on the rural status of communities.[50]

Food Insecurity

Map the Meal Gap was the only identified index that focused on food insecurity across communities.[51]

Emergency Response and Community Resilience

Seven indices provided estimates for community resilience to disasters and the protections in place in communities to address crises: Social Vulnerability Index, Baseline Resilience Indicators for Communities, Community Resilience Estimates, Minority Health Social Vulnerability Index, National Health Security Preparedness Index, Social Vulnerability to Environmental Hazards Index, and National Risk Index.[52-58]

Health

Three indices and rankings provided estimates on the overall health and well-being of communities across the United States: California Healthy Places Index, County Health Rankings and Roadmaps, and Healthiest Communities Ranking.[59-61]

Themes and Applications

We reviewed and categorized input data variables comprising each index and ranking. We selected the 18 most common thematic input constructs appearing in distinct indices and rankings to identify conceptual similarities and potential redundancies for indices and rankings that might be used concurrently in future population health applications (Table 2). Furthermore, examples of how composite measures have been used in recent US-based public health investigations are also presented, based on their identification in recent peer-reviewed publications (Table 3). These measures have been applied in a broad array of epidemiologic studies, clinical trials, correlational analyses, case studies, and descriptive analyses, with varied application in the study of diseases, people, neighborhoods, and health systems (Figure 2). Collectively, the composite measures identified in this review appeared most often to be used as an independent variable associated with disparities, risk factors, and/or outcomes affecting individuals, populations, communities, and health systems. However, they also have been used to assess community-level needs, risks, and readiness; for planning policies, population health initiatives, and emergency response; to assess issues related to health insurance status or having specific payors; to assess laws and costs/expenditures; and to guide or study the allocation of public resources.

Discussion

In 1971, Julian Tudor Hart opened his seminal publication on the so-called inverse care law by noting, "The availability of good medical care tends to vary inversely with the need for it in the population served."[163] More than 50 years later, the public health world continues to try to better understand and mitigate social risks to prevent disease, disability, and premature mortality. Data are a critical resource for policy makers and researchers aiming to assess the milieu of SDH in communities, develop successful public health interventions for them, and evaluate the value and impact of such initiatives.[11-13]

Composite measures depict multidimensional population characteristics in a more complex, comprehensive manner than their source data, while still maintaining the same underlying information.[16] Often, well-understood relationships exist between the discrete SDH variables found in composite measures (eg, poverty, housing access, childhood opportunity).[164] Furthermore, the social risks they describe often co-occur in the same geographic areas and work in unison to exert their effects on health outcomes.[165,166] Therefore, composite measures are well-suited for describing broad population characteristics, allowing for comparisons within and among communities, and providing accessible evidence for policy makers to apply to their decision-making.[18] Limited evidence

Table 2. Thematic constructs of the data variables comprising each social determinants of health SDH composite measure identified in a scoping review of indices and rankings in peer-reviewed literature that estimate SDH and have publicly accessible data sources[a]

	Economic stability					Neighborhood and built environment					Education access and quality		Social and community context			Health care access and quality		
	Employment	Poverty	Income	Wealth	Housing	Transportation	Pollution	Crime	Food	Internet	Education	Family	Demographic characteristics	Language	Vote	Health insurance	Health	Health workforce
Environmental conditions and pollution																		
Air Quality Index							×											
Environmental Justice Index	×	×		×	×		×				×	×	×	×		×	×	
Environmental Quality Index	×	×	×	×	×		×	×	×	×	×	×		×	×	×	×	×
Opportunity and infrastructure																		
American Dream Prosperity Index	×	×	×		×		×	×	×	×	×					×	×	
Childhood Opportunity Index 2.0	×	×		×	×		×	×	×		×	×				×	×	
National Walkability Index					×	×			×									
Ohio Children's Opportunity Index	×	×		×	×		×	×	×		×	×				×		
Ohio Opportunity Index			×		×				×		×							
The Opportunity Index	×	×	×		×		×	×	×	×	×				×	×	×	×
Race for Results		×					×		×		×	×		×	×			
Social Capital Index										×		×			×			
Deprivation and well-being																		
Area Deprivation Index	×	×	×	×	×	×					×	×						
Distressed Communities Index	×	×	×		×	×					×							
Multidimensional Deprivation Index	×		×		×	×		×			×					×	×	
Neighborhood Deprivation Index		×	×	×	×	×					×	×						
Social Deprivation Index	×	×		×	×	×			×		×	×				×	×	
COVID-19																		
COVID-19 Community Vulnerability Index	×												×			×	×	×
COVID-19 Pandemic Vulnerability Index						×	×						×			×	×	×
COVID-19 Vaccine Coverage Index	×	×	×			×				×	×		×	×		×	×	×
Rurality																		
Index of Relative Rurality				×														
Food insecurity																		
Map the Meal Gap	×	×	×	×									×					
Emergency response and community resilience																		
Baseline Resilience Indicators for Communities	×		×	×	×	×			×	×	×		×	×	×	×	×	×
Community Resilience Estimates	×	×			×	×				×		×	×	×	×	×	×	
Minority Health Social Vulnerability Index	×	×	×		×	×				×	×	×	×	×	×	×	×	×
The National Health Security Preparedness Index	×					×		×		×				×	×			
National Risk Index	×	×	×	×	×	×			×	×	×	×	×	×	×	×		
Social Vulnerability Index	×	×	×		×	×				×	×	×	×	×				
Social Vulnerability to Environmental Hazards Index	×	×	×	×	×	×	×			×	×	×	×	×		×		×
Health																		
California Healthy Places Index	×	×	×	×	×	×	×	×	×		×	×				×	×	×
County Health Rankings and Roadmaps	×	×	×	×	×	×	×	×	×		×	×				×	×	×
Healthiest Communities Index	×	×	×	×	×	×	×	×	×	×	×				×		×	×

Abbreviation: SDH, social determinant of health.

[a] The 18 most common themes, according to appearance in distinct indices, are shown.

Table 3. Select applications of the area-level composite measures to US-based peer-reviewed public health investigations[a] identified in a scoping review of indices and rankings in peer-reviewed literature that estimate SDH and have publicly accessible data sources

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/population location)	Application for area-level composite measure	Study summary
Environmental conditions and pollution						
Air Quality Index (AQI)	Rosser et al: Air Quality Index and Childhood Asthma: A Pilot Randomized Clinical Trial Intervention[62]	Clinical trial	Pediatric patients at University of Pittsburgh Medical Center Children's Hospital of Pittsburgh (Pittsburgh, PA)	US counties (a subset of US counties served by a single hospital in Pittsburgh)	Area-level composite measure used as a clinical intervention to guide patient care approaches	This investigation looked at whether adding the AQI to pediatric patients' asthma action plans (for children to check the AQI before any outdoor activity) reduced exacerbations, improved asthma control, or affected quality of life. It found some evidence that the intervention improved asthma control but may be associated with reduced outdoor activity levels.
	Altman et al: Associations Between Outdoor Air Pollutants and Non-viral Asthma Exacerbations and Airway Inflammatory Responses in Children and Adolescents Living in Urban Areas in the USA: A Retrospective Secondary Analysis[63]	Epidemiologic study	Children aged 6-17 years living in urban areas with exacerbation-prone asthma enrolled in a prospective observational cohort study	US counties (a subset of US counties with study participants, located in 9 US cities: Boston, MA; Chicago, IL; Cincinnati, OH; Dallas, TX; Denver, CO; Detroit, MI; New York, NY; Saint Louis, MO; and Washington, DC)	Area-level composite measure was studied as an independent variable potentially associated with a health outcome in the study population	This investigation examined the associations between regional air pollutant concentrations (using AQI and other independent variables) and incidence of respiratory illnesses, lung function, and upper airway transcriptional signatures in a population sample of children with asthma and focusing on asthma exacerbations occurring in the absence of viral infection. Findings suggest that air pollution is a risk factor for asthma exacerbations in children living in urban areas.
	McLeod et al: The Effect of Sustained Poor Air Quality on EMS Call Volume and Characteristics: A Time-Stratified Case-Crossover Study[64]	Epidemiologic study	California county-level population with data in the California American Medical Response database, representing the largest private ambulance provider in California	US counties (a subset of US counties located in California that were included in the primary source data)	Area-level composite measure studied as an independent variable with potential association with a population health outcome, having implications for the distribution of public health resources	This investigation examined the public health implications of wildfires and air pollution by demonstrating an association between AQI and the characteristics and volume of calls to emergency medical services (EMS), suggesting that the AQI may be helpful for more efficient deployment of EMS resources.
	Reyes-Angel et al: Parental Knowledge and Usage of Air Quality in Childhood Asthma Management[65]	Clinical study	Forty parents (or legal guardians) of children with persistent asthma at the University of Pittsburgh Medical Center Children's Hospital of Pittsburgh (Pittsburgh, PA)	US counties (a subset of US counties served by a single hospital in Pittsburgh)	Area-level composite measure used as an independent variable having a potential association with a health outcome in the study population	This investigation examined the awareness among parents/guardians of children with asthma about the application of the AQI to pediatric patients' asthma action plans. Although there was awareness about the AQI and air pollution was a known asthma trigger for their children, only 20% of parents/guardians in the study sample checked the AQI on the AirNow app or website, suggesting a need for health care providers to reinforce using this information.
	Myers and Kriebel: If Smoking Were Eliminated, Which US Counties Would Still Have High Rates of Smoking-Related Cancers?[66]	Epidemiologic study	County populations	US counties (a subset of 257 metropolitan US counties with data in the Surveillance, Epidemiology, and End Results [SEER] program database)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation sought to assess the county-level effect of smoking elimination and environmental indices (including the AQI and Environmental Quality Index) on the rates of smoking-related cancers. One finding, suggesting that air pollution may be a primary explanation for observed post–smoking elimination cancer rates, suggests a public health need to prioritize pollution control along with tobacco control, particularly in metropolitan counties with high levels of air pollution.
Environmental Justice Index (EJI)	Turek-Hankins et al: Risk Screening Methods for Extreme Heat: Implications for Equity-Oriented Adaptation[67]	Case study	California census tract–level population	US census tracts (in California)	Area-level composite measure used to compare community-level needs and use this information to guide the distribution of public resources	This case study investigation sought to evaluate the utility of the EJI, the Social Vulnerability Index, and the Heat-Health Action Index in assessing an equity-oriented program to help communities in California adapt to climate change. The relative vulnerability to climate change faced by various communities—and vulnerabilities to various risks (eg, heat, water resources)—varied depending on the measure used. The choice of vulnerability index thus has important nuances to consider in planning.
	Jiao et al: Application of Citizen Science Risk Communication Tools in a Vulnerable Urban Community[68]	Case study	Population in a single community, the Stambaugh-Elwood community in Columbus, OH	US census tracts (in Ohio)	Area-level composite measure used to evaluate risks and need in a community-based environmental study with public health implications	This investigation of a single community (the Stambaugh-Elwood community in Columbus) served as an opportunity to demonstrate that community-led coalitions can be effective in addressing environmental concerns, when done collaboratively with academic and state agency partners. The EJI was used to examine and describe the environmental risks for this community, along with other approaches (eg, soil sampling).
Environmental Quality Index (EQI)	Shaikh et al: Association Between the Environmental Quality Index and Textbook Outcomes Among Medicare Beneficiaries Undergoing Surgery for Colorectal Cancer (CRC)[69]	Clinical study	Medicare patients diagnosed with CRC in the SEER–Medicare database	US counties (a subset of the US counties covered by the database used in the study, representing about 26% of US population)	Area-level composite measure used as an independent variable with potential associations with clinical outcomes in the study population	This retrospective, longitudinal investigation examined the association between certain factors (eg, EQI and race) and the likelihood of achieving expected (ie, textbook) outcomes after the surgical treatment of CRC in Medicare patients. Those who lived in counties with high EQI scores or who identified as Black were less likely to achieve textbook outcomes.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/population location)	Application for area-level composite measure	Study summary
	Myers and Kriebel: If Smoking Were Eliminated, Which US Counties Would Still Have High Rates of Smoking-Related Cancers?[66]	Epidemiologic study	US county-level populations	US counties (a subset of 257 metropolitan US counties with data in the SEER program database)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation sought to assess the county-level effect of smoking elimination and environmental indices (including AQI and EQI) on the rates of smoking-related cancers. One finding, suggesting that air pollution may be a primary explanation for observed post–smoking elimination cancer rates, suggests a public health need to prioritize pollution control along with tobacco control, particularly in metropolitan counties with high levels of air pollution.
	McAlexander et al: Latent Growth Trajectories of County-Level Diabetes Prevalence in the United States, 2004-2017, and Associations With Overall Environmental Quality[70]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation examined how environmental factors might contribute to type 2 diabetes risk by studying the association between EQI values overall and for each of the 5 domain indices (air, water, land, sociodemographic, and built) with diabetes prevalence in various urban/rural-classified areas. Among other findings, an association was observed between poor air EQI scores and diabetes prevalence in rural counties.
	Jagai et al: Diabetes Control Is Associated With Environmental Quality in the USA[71]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation examined how environmental factors might contribute to type 2 diabetes control by studying the association between county-level EQI values and age-adjusted rates of prevalence for various levels of diabetes control. Findings demonstrated that diabetes control rates worsen in parallel with declines in environmental quality, along with rural/urban, sociodemographic, and built environment factors, suggesting a need for environmental improvements in policy and clinical interventions.
	Nance et al: Increased Risk of Eosinophilic Esophagitis With Poor Environmental Quality as Measured by the Environmental Quality Index[72]	Case-control epidemiologic study	US county-level population with and without eosinophilic esophagitis (as identified in a pathology database)	US counties (national study)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation examined how environmental exposures may contribute to eosinophilic esophagitis by examining how EQI scores may be associated with the prevalence of this disease. Poor EQI scores in the water domain were associated with increased odds of eosinophilic esophagitis, suggesting that environmental exposures might contribute to pathogenesis of this condition.
	Vigneswaran et al: Association Between Environmental Quality and Prostate Cancer Stage at Diagnosis[73]	Epidemiologic study	US county-level populations	US counties (a subset of 257 metropolitan US counties with data in the SEER program database)	Area-level composite measure studied as an independent variable having a potential association with a health outcome in the study population	This investigation examined how environmental exposures may contribute to prostate cancer by examining how EQI scores may be associated with prevalence of this disease. Poor EQI values overall and for each of the 5 domain indices (air, water, land, sociodemographic, and built) were found to be associated with having metastatic (advanced stage) disease at the time of diagnosis, suggesting a need to determine whether specific, modifiable environmental factors might contribute to development of more aggressive forms of prostate cancer.
Opportunity and infrastructure						
American Dream Prosperity Index (ADPI; formerly known as the US Prosperity Index)	Acosta: Linking Nevada to Doughnut Economics[74]	Case study	State population	US states (Nevada)	Area-level composite measure was studied as one of several indicators to compare the studied geographic area with other geographic areas	This investigation explores the interconnected social and ecological factors at play in Nevada as a means of contextualizing factors relevant for planning and presenting them in a "doughnut economics" model, a visualization framework for examining interconnected complex systems that puts social needs such as housing in the center and ecological factors such as climate change on the outside. Among the data sources used to describe the state, the author notes that Nevada ranks 37th among other states in the US Prosperity Index rankings. The author recommends further developing the Nevada doughnut economics model, noting its potential use in policy making and applications for other states.
	Haber: Montana's Hard Right Turn[75]	Case study	State population	US states (Montana)	Area-level composite measure was used to contextualize study findings and to compare the studied geographic area with others	This investigation explores the political context and effects of 2021 budgetary and legislative actions in Montana on public policy, noting an overall rightward political shift with variable effects and implications. The findings are contextualized in part by noting that Montana ranks 32nd in the US Prosperity Index rankings and previously was ranked 29th. The author notes that the influx of federal COVID-19 funding to the state may have helped to prevent larger budget cuts than what might otherwise have been implemented.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
Childhood Opportunity Index 2.0 (COI)	Sarnthiyakul et al: Neighborhood Deprivation and Childhood Opportunity Indices Are Associated With Violent Injury Among Children in Los Angeles County[76]	Epidemiologic study	Children living in Los Angeles County who were entered in the Los Angeles County Trauma and Emergency Medicine Information System registry with violent mechanisms of injury, including gunshot, stabbing, or assault	US counties (Los Angeles County)	Area-level composite measure was studied as an independent variable potentially associated with a health outcome in the study population	This investigation examined how living in ZIP codes across Los Angeles with high levels of disadvantage (using the Area Disadvantage Index) and low levels of opportunity (using the COI) might be associated with the risks of experiencing violent injury (including gunshot, stabbing, or assault) for children. Given the associations found, further study of relevant neighborhood factors and targeted interventions were recommended.
	Shen et al: Pediatric Instant Noodle Burns: A Ten-Year Single Center Retrospective Study[77]	Epidemiologic study	Children hospitalized for scald burns at University of Chicago Burn Center (Chicago, IL)	US census tracts (a subset of US census tracts served by a single hospital in Chicago, IL)	Area-level composite measure was studied as an independent variable potentially associated with a health outcome in the study population	This investigation examined how living in ZIP codes across the Chicago area with lower average COI score might be associated with the risks of children experiencing a scald burn from instant noodles, one of the more common causes of such burns. Instant noodle burns were found to be disproportionately seen in Black/African American patients and in patients with low COI scores. Given the associations found, consideration of focused burn prevention efforts for these populations was recommended.
	Newman et al: Impact of Poverty and Neighborhood Opportunity on Outcomes for Children Treated With CD19-Directed CAR T-cell Therapy[78]	Epidemiologic study	Children with acute lymphoblastic leukemia at The Children's Hospital of Philadelphia	US census tracts (a subset of US census tracts served by a single hospital in Philadelphia, PA)	Area-level composite measure studied as an independent variable having a potential association with health care access and a health outcome in the study population	This investigation examined how children living in poverty experience excessive rates of relapse and death from newly diagnosed acute lymphoblastic leukemia by studying how COI scores were associated with the use of chimeric antigen receptor T-cell therapy in relapsed/refractory disease. Patients unexposed to household poverty or living in neighborhoods with low opportunity scores were more likely to receive this therapy in the setting of high disease burden than other patients, even though outcomes for those receiving this treatment were equitable regardless of socioeconomic status, suggesting a need to examine access disparities more closely.
	Wojcik et al: Rare Diseases, Common Barriers: Disparities in Pediatric Clinical Genetics Outcomes[79]	Epidemiologic study	Individuals receiving outpatient genetics referrals to a pediatric academic tertiary care center (Boston Children's Hospital)	US census tracts (a subset of US census tracts served by a single hospital outpatient center in Boston, MA)	Area-level composite measure as an independent variable having a potential association with health care access and a health outcome in the study population	This investigation examined how living in lower-resourced (vs higher resourced) neighborhoods (as assessed with the COI), limited English proficiency, and having public health insurance may be associated with the yield of diagnostic genetic evaluations in the outpatient setting for children with rare diseases. The study found that initiation of genetics care was more of a barrier than finding a genetic diagnosis (once care was established), suggesting a need to examine disparities in access to clinical genetics evaluations more closely.
	Najjar et al: Geospatial Analysis of Social Determinants of Health Identifies Neighborhood Hot Spots Associated With Pediatric Intensive Care Use for Acute Respiratory Failure Requiring Mechanical Ventilation[80]	Epidemiologic study	Pediatric patients at 2 urban freestanding children's hospital pediatric intensive care units (Children's Healthcare of Atlanta's Egleston campus and Scottish Rite campus)	US census tracts (a subset of US census tracts served by 2 hospitals in Atlanta, GA)	Area-level composite measure studied as an independent variable having a potential association with health care access and a health outcome in the study population	This investigation examined how living in areas of high social vulnerability and low child opportunity were associated with pediatric intensive care unit admissions for acute respiratory failure that required the use of invasive mechanical ventilation. Results suggested the need for interventions addressing social risks to decrease neighborhood-related disparities.
National Walkability Index (NWI)	Acolin et al: Gentrification, Mobility, and Exposure to Contextual Social Determinants of Health[81]	Epidemiologic study	Residents of central cities for the 100 largest metropolitan regions in the United States	US census block groups and US census tracts (a subset of US census block groups for Area Deprivation Index, Air Pollution, and NWI data) and US census tracts (for medically underserved areas and contextual control data in the central cities for the 100 largest metropolitan regions in the United States)	Area-level composite measure was studied as an independent variable potentially associated with a health outcome in the study population	This investigation examined how gentrification may contribute to health disparities through changes in exposure to contextual social determinants of health (SDH) using 4 study measures: designation as a medically underserved area, Area Deprivation Index scores, measures of air pollution, and NWI scores. Among the study's findings is the result that original residents within gentrifying tracts had a 1.9-percentile decrease in NWI scores, on average, as a result of mobility patterns stemming from gentrification, suggesting that gentrification has potential population health effects.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Field et al: Association of Community Walkability and Glycemic Control Among Pregnant Individuals With Pregestational Diabetes Mellitus[82]	Epidemiologic study	Residents of low- and moderate-income neighborhoods served by a tertiary care center (The Ohio State University)	US census tracts (in Ohio)	Area-level composite measure was studied as an independent variable potentially associated with a clinical health outcome	This investigation examined how individuals with pregestational diabetes mellitus living in areas with high walkability (using NWI scores) may have better glycemic control in both early and late pregnancy. Results suggested the need for considering community-level interventions to improve glycemic control in pregnancy.
	Lin et al: An External Exposome-Wide Association Study of Opioid Use Disorder Diagnosed During Pregnancy in Florida[83]	Epidemiologic study	Individuals in a statewide database that links individual-level birth and electronic health records (EHRs)	US census block groups (in Florida)	Area-level composite measure was studied as an independent variable potentially associated with a clinical health outcome	This investigation examined how individuals with pregestational diabetes mellitus living in areas with low levels of food access, high levels of vacant land, and high levels of walkability (using NWI scores) may be associated with the diagnosis of opioid use disorder during pregnancy. Results suggested the need for further study and for potentially developing screening tools both for SDH factors and substance use.
	Makhlouf et al: Neighborhood Walkability and Cardiovascular Risk in the United States[84]	Epidemiologic study	US census tract–level populations	US census tracts (national study)	Area-level composite measure was studied as an independent variable potentially associated with a clinical health outcome	This investigation examined how living in areas of high walkability (using NWI scores) may be associated with a lower prevalence of cardiovascular disease and its risk factors. The study results suggest that the observed relationship between walkability and cardiovascular disease is in part independent and in part mediated by traditional risk factors such as high cholesterol, high blood pressure, and diabetes.
	Liao et al: Joint Associations Between Neighborhood Walkability, Greenness, and Particulate Air Pollution on Cardiovascular Mortality Among Adults With a History of Stroke or Acute Myocardial Infarction[85]	Epidemiologic study	Individuals with cardiovascular disease and its risk factors (a documented medical history of acute myocardial infarction and/ or stroke) in the Kaiser Permanente Northern California EHR system	US census tracts (a subset of US census tracts in Northern California that had data in the Centers for Disease Control and Prevention [CDC] Places and NWI databases)	Area-level composite measure was studied as an independent variable potentially associated with a clinical health outcome	This investigation examined how fine particulate matter and living in areas of high walkability (using NWI scores) and greenness (using the Normalized Differentiated Vegetation Index) may be associated with the prevalence of cardiovascular disease. Results suggest that high greenness levels may protect against mortality for adults with cardiovascular disease and that the association of fine particulate matter with cardiovascular mortality risk may be somewhat affected by neighborhood walkability levels.
Ohio Children's Opportunity Index (OCOI)	Fareed et al: Construction of the Ohio Children's Opportunity Index[86]	Public health policy development	US census tract–level populations in Ohio	US census tracts (in Ohio)	Area-level composite measure was developed to guide public policy decision-making	This study details the development of an area-level composite measure, the OCOI (with 8 domains: family stability, infant health, children's health, access, education, housing, environment, and criminal justice). The index, whose values were demonstrated to have a relationship with values from the national-level COI, was shown to serve as a significant predictor of a health outcome (average life expectancy at birth) and race (proportion of the population identifying as a member of a racial or ethnic minority population). The index aims to provide a clear and concise tool able to inform policy decisions concerning care delivery that affect children's health. The authors also present case studies to demonstrate the dashboard's value in identifying neighborhoods with high levels of need.
	Jonnalagadda et al: Developing Dashboards to Address Children's Health Disparities in Ohio[39]	Public health policy development	US census tract–level populations in Ohio	US census tracts (in Ohio)	Area-level composite measure was developed to guide public policy decision-making	This study details the development of a dashboard with an area-level composite measure, the OCOI (with 8 domains: family stability, infant health, children's health, access, education, housing, environment, and criminal justice). The index, which is associated with health and demographic outcomes (average life expectancy at birth and proportion of the population identifying as a member of a racial or ethnic minority population), aims to provide a clear and concise tool able to inform policy decisions concerning care delivery that affect children's health. The authors also present case studies to demonstrate the dashboard's value in identifying neighborhoods with high levels of need.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
Ohio Opportunity Index (OOI)	Fareed et al: Visualizing Opportunity Index Data Using a Dashboard Application: A Tool to Communicate Infant Mortality–Based Area Deprivation Index Information[37]	Public health policy development	US census tract–level populations in Ohio	US census tracts (in Ohio)	Area-level composite measure was developed to guide public policy decision-making	This study details the development of an area-level composite measure, the OOI (with 7 domains: transportation, education, employment, housing, health, access to services, and crime) and an associated Opportunity Index Dashboard. The index aims to provide a clear and concise tool able to inform policy decisions concerning care delivery. The authors note the differences between the OOI and the national-level OI, with the latter having fewer data variables related to transportation, health, housing, crime, and care access.
The Opportunity Index (OI)	Lucero et al: Politics, Preparedness, or Resources Examining State Responsiveness to the COVID-19 Pandemic[38]	Epidemiologic study	US state-level populations	US states (national study)	Area-level composite measure was studied as an independent variable potentially associated with public policy decision-making	This investigation examined how state policy decisions concerning reopening after lockdowns because of the COVID-19 pandemic may be related to certain state characteristics. Associations were found between reopening policies and the governor's political party, the state's political culture, level of public health preparedness, the cumulative number of pandemic-related deaths per 100 000 people, and OI score.
Race for Results Index	Yusef et al: Florida's Historically Black Colleges and Universities Address Racial Disparities Within the Criminal Justice System Using Results-Based Accountability[87]	Public policy development	Florida state population	US states (a subset of southern US states, but primarily focusing on Florida)	Area-level composite measure was used to contextualize need	This study describes the Florida Historically Black Colleges and Universities Expanding the Bench Project, a consortium-based effort aiming to use the Results-Based Accountability framework to successfully educate and train faculty and students on performance management in several fields: criminal justice, sociology, social work, education, psychology, and (STEM) science, technology, engineering, and mathematics. The authors contextualize the need for this initiative using a few methods, including by using Race for Results scores. The authors note that criminal justice policies and practices, paired with living conditions, may lead to both overrepresentation of Black/African American people in justice systems (court and police interactions) and underrepresentation in the workforce for these systems.
Social Capital Index (SCI)	Sun and Bisesti: Political Economy of the COVID-19 Pandemic: How State Policies Shape County-Level Disparities in COVID-19 Deaths[88]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SCI scores and other factors may be associated with county-level COVID-19 mortality. The results highlight how state and local policies, as well as other factors, can affect COVID-19 mortality rates.
	McCann and Szaflarski: Differences in County-Level Cardiovascular Disease Mortality Rates Due to Damage Caused by Hurricane Matthew and the Moderating Effect of Social Capital: A Natural Experiment[89]	Epidemiologic study	Populations living in US counties affected by Hurricane Matthew	US counties (a subset of US counties affected by Hurricane Matthew)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how social capital (using the SCI) may moderate the relationship between damage from Hurricane Matthew and cardiovascular mortality rates. The premise for this study was based on previous research that found an association between high levels of social capital and lower cardiovascular mortality rates. Although the study found an increase in cardiovascular mortality rates for the 18 mo after Hurricane Matthew in counties known to be affected by this hurricane, a role for social capital in this phenomenon was not established. The authors suggest that improving social capital measurement and additional studies on hurricane damage and cardiovascular mortality are warranted.
	Fraser et al: Social Capital's Impact on COVID-19 Outcomes at Local Levels[90]	Epidemiologic study	Populations at the county, census tract, ZIP code, and county subdivision levels	US counties, US census tracts, US ZIP codes, and US county subdivisions (national study)	Area-level composite measure was studied as an independent variable potentially associated with a population health outcome, which may be useful in guiding public policy development	This investigation examined how SCI and SVI scores may be associated with the incidence of COVID-19 in case studies in Massachusetts, Wisconsin, Illinois, and New York City. The results suggest that social capital was a predictor of COVID-19 outbreaks and, thus, could serve as a predictive tool for mitigating the spread of COVID-19.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Ferwana and Varshney: Social Capital Dimensions Are Differentially Associated With COVID-19 Vaccinations, Masks, and Physical Distancing[91]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable potentially associated with a population health outcome, which may be useful in guiding public policy development	This investigation examined how SCI scores may be associated with the adoption of protective behaviors during the COVID-19 pandemic, such as social distancing, wearing face masks, and vaccinating. The results suggest that social capital should be considered during pandemic control planning.
	Owusu-Edusei et al: County-Level Social Capital and Bacterial Sexually Transmitted Infections in the United States[92]	Epidemiologic study	US county-level populations	US counties (a subset of US counties located in the 48 contiguous US states)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the association between county-level SCI scores and rates of commonly reported sexually transmitted infections (STIs) (chlamydia, gonorrhea, and syphilis). A stepwise relationship was observed, suggesting that SCI scores could be used for designing and implementing effective interventions for STI control and prevention.
Deprivation and well-being						
Area Deprivation Index (ADI)	Renaud et al: Addressing Health-Related Social Needs Via Community Resources: Lessons From Accountable Health Communities[93]	Epidemiologic study	Medicare and Medicaid beneficiaries	US ZIP codes (a subset of US ZIP codes with Medicare and Medicaid beneficiaries in a national-level study)	Area-level composite measure was used to adjust the analytic model for contextual factors related to social risks	This investigation examined the Accountable Health Communities model from the Center for Medicare and Medicaid Innovation, to assess whether identifying and addressing the health-related social needs of Medicare and Medicaid beneficiaries ultimately helped them meet their needs. For this work, the investigators surveyed a group of model beneficiaries meeting specific criteria: 1 or more health-related social needs and 2 or more emergency department visits in the preceding year. ADI scores and other data were used to adjust the analytic model for contextual factors related to social risks. The study results suggested that there were difficulties in connecting beneficiaries to community services and that resources were often insufficient to meet beneficiaries' needs when these connections were in fact made. The study authors note that there are likely opportunities to strengthen access and integration of health care and social services into the Accountable Health Communities model.
	Purrington et al: The Role of Area-Level Socioeconomic Disadvantage in Racial Disparities in Cancer Incidence in Metropolitan Detroit[94]	Epidemiologic study	Populations at the public use microdata areas (PUMA) level in metropolitan Detroit, MI	US PUMAs (a subset of US PUMAs in the metropolitan Detroit area)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how ADI scores may be associated with the incidence of breast cancer, prostate cancer, lung cancer, and colorectal cancer. The results suggest that area-level socioeconomic disadvantage is associated with the risk of common cancers and that this likely plays a role in race-related differences observed for cancer incidence.
	Dubin et al: Race Associated With Increased Complication Rates After Total Knee Arthroplasty[95]	Epidemiologic study	Patients at a single tertiary referral center (Sinai Hospital of Baltimore)	US census block group neighborhood level (a subset of US census block groups served by a single hospital in Baltimore, MD)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how race and ADI scores may be associated with the rate of complications after total knee arthroplasty. While Black race was demonstrated to be a risk factor, ADI was not, suggesting that race in particular may be an important consideration.
	Ellsperman et al: The Impact of Social Determinants of Health on Vestibular Schwannoma Management: A Single Institution Review[96]	Epidemiologic study	Patients at a single tertiary referral center (University of Michigan)	US census block group (a subset of US census block groups served by a single hospital in Ann Arbor, MI)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how ADI scores may be associated with tumor grade for vestibular schwannoma, with grade being important for how this tumor is clinically managed. Patients with higher disadvantage levels based on ADI scores were more likely to present with a higher tumor grade. In addition, age, ADI score, and tumor grade were all associated with ultimate treatment recommendations.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Sullivan et al: Neighborhood Deprivation and Association With Neonatal Intensive Care Unit Mortality and Morbidity for Extremely Premature Infants[97]	Epidemiologic study	Non-Hispanic Black and non-Hispanic White premature infants born at and admitted to 1 of 4 level IV neonatal intensive care units: University of Virginia (Charlottesville, VA), University of Alabama at Birmingham (Birmingham, AL), Washington University in St Louis (St Louis, MO), and Columbia University (New York, NY)	US census block group (a subset of US census block groups served by 4 hospitals in the Northeast, Mid-Atlantic, Midwest, and South)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how ADI scores may be associated with hospital outcomes among premature infants. After adjustment for multiple covariates, the results suggest that ADI was a risk factor for mortality and morbidity.
Distressed Community Index (DCI)	Akinyemi et al: Exploring the Relationship Between Community-Level Economic Deprivation and HIV Infection Among Hospital Admissions in Washington, DC[98]	Epidemiologic study	Individuals in the Washington, DC, State Inpatient Database	US ZIP codes (in Washington, DC)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how DCI scores may be associated with prevalence of HIV infection among hospital admissions. The observed association between increased levels of economic distress and the prevalence of HIV among hospital admissions suggested a need to consider the SDH when planning and implementing targeted interventions for HIV prevention and management, especially in communities with elevated levels of economic distress.
	Read et al: Causal Analysis of Socioeconomic Influence on Cost of Care: The Emergency General Surgery Model[99]	Epidemiologic study	Adult patients in the Florida Agency for Health Care Administration Ambulatory Patient inpatient dataset who underwent an emergency general surgery procedure	US ZIP codes (in Florida)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how DCI scores may be associated with the cost of emergency general surgery. Costs were determined to be associated with discharge status, not DCI scores; however, characteristics related to discharge, mortality, and the ratings of the hospitals used by patients; odds of mortality; and receipt of home health care or inpatient rehabilitation did differ by the DCI scores for communities where patients lived.
	Schold et al: Deceased Donor Kidneys From Higher Distressed Communities Are Significantly Less Likely to Be Utilized for Transplantation[100]	Epidemiologic study	Deceased kidney donors in a database of the Scientific Registry of Transplant Recipients	US ZIP codes (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how the nonuse of kidneys procured from deceased donors for the purpose of transplantation may be associated with the DCI scores where donors lived. Although regional variations were observed, donor residential distress was found to be associated with donor kidney nonuse but did not seem to influence transplant recipient outcomes.
	Adesina et al: Pregnancy Outcomes in Women With Sickle Cell Disease in California[101]	Epidemiologic study	Pregnant Black women with and without sickle cell disease listed in California's Department of Health Care Access and Information data	US ZIP codes (in California)	Area-level composite measure was used as a covariate during the study of a health outcome in the study population	This investigation examined pregnancy outcomes in Black women from California with and without sickle cell disease, seeking to determine the role of SDH in outcomes. Following statistical adjustment using DCI scores and other measures of SDH, Black women with sickle cell disease were noted to have worse pregnancy outcomes than those without sickle cell disease. The authors suggest ways to mitigate poor outcomes through early reproductive health education, continuation of therapies for sickle cell disease during pregnancy, and increasing access to multidisciplinary perinatal care.
	Amin et al: Socioeconomic Profile Is Associated With the Type of Firearm Injuries to the Head and Neck[102]	Epidemiologic study	Patients at Grady Memorial Hospital in Atlanta, GA	US ZIP codes (a subset of US ZIP codes served by a single hospital in the Atlanta area)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how DCI scores may be associated with gun violence. Patients who sustained firearm injuries to the head and neck were more likely to live in ZIP codes with high DCI scores than in other ZIP codes, suggesting a need for more studies on the impact of current gun prevention programs and how to best serve populations living in distressed communities.
Multidimensional Deprivation Index (MDI)	Berkowitz et al: Correlation Between Ophthalmology Market Saturation and Medicare Utilization Rates[103]	Epidemiologic study	Medicare fee-for-service beneficiaries	US counties (a subset of US counties with Medicare and Medicaid provider and beneficiary data in a national-level study)	Area-level composite measure was studied as an independent variable to determine if it was associated with health service utilization	This investigation examined how market saturation of ophthalmologists, certain demographic characteristics, and DCI scores may be associated with ophthalmologic services utilization by Medicare fee-for-service beneficiaries. No association was seen between the use of services and market saturation; however, race, sex, education level, and DCI scores did correlate with use levels. The authors conclude that ophthalmologist availability alone is not the only factor in eye care service utilization.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
Neighborhood Deprivation Index (NDI)	Young-Wolff et al: Current Tobacco Smoking and Risk of SARS-CoV-2 Infection and Hospitalization: Evaluating the Role of Socio-demographic Factors and Comorbidities[104]	Epidemiologic study	Adults in the Kaiser Permanente Northern California EHR system	US census tracts (in Northern California)	Area-level composite measure was studied as an independent variable to determine if it moderated an observed health outcome in the study population	This investigation examined how sociodemographic factors (including NDI scores) and medical comorbidities may moderate the previously observed correlations in the study population between tobacco history and risk of SARS-CoV-2 infection and less severe COVID-19. Although the relationship between tobacco use and COVID-19 outcomes remained present, NDI and other factors appeared to somewhat moderate these effects.
	Roy et al: Effect of Neighborhood Deprivation Index on Breast Cancer Survival in the United States[105]	Epidemiologic study	Patients in the SEER database	US census tracts (a subset of US census tracts that had data in the SEER database, covering approximately 48% of the US population)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how NDI scores may be associated with outcomes in early-stage breast cancer. Patients living in census tracts with higher NDI scores had a greater likelihood of poor overall survival and disease-specific survival. Results suggest a need to address socioeconomic status to reduce breast cancer outcome disparities.
	Mujahid et al: Neighborhood Disinvestment and Severe Maternal Morbidity in the State of California[106]	Epidemiologic study	Individuals delivering a baby (live births) at a California hospital and represented in the California Department of Health Care Access and Information database, which links hospital discharge records and birth certificates	US census tracts (in California)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how NDI scores may be associated with severe maternal morbidity. Patients living in census tracts with worse NDI scores tended to have worse outcomes, effects that were modified in part by race and ethnicity. The results suggest a need to consider SDH when addressing severe maternal morbidity disparities and to consider including neighborhood deprivation information in EHRs and hospital discharge data.
	Li et al: Impact of Contextual-Level Social Determinants of Health on Newer Antidiabetic Drug Adoption in Patients With Type 2 Diabetes[107]	Epidemiologic study	Individuals with EHR information in the OneFlorida+ network	US census tracts (in Florida)	Area-level composite measure was studied as an independent variable to determine if it was associated with health service access and utilization	This investigation examined how contextual SDH factors, including NDI scores, may be associated with the use of novel antidiabetic drugs in the evidence-based treatment of type 2 diabetes mellitus. Patients living in census tracts with worse NDI scores had a lower likelihood of being prescribed these medications. The results suggested a need to consider the mechanisms underlying these findings.
	Floyd et al: Association Between Diabetes Severity and Risks of COVID-19 Infection and Outcomes[108]	Epidemiologic study	Patients served in an integrated health care system (Kaiser Permanente) in 3 system regions: Colorado, Washington, and Northwest (which includes Oregon and southwest Washington)	US census tracts (a subset of US census tracts with enrolled study patients from health system locations in Colorado, Washington, and Oregon)	Area-level composite measure was used as a covariate during the study of a health outcome in the study population	This investigation examined the association between a diabetes diagnosis (either type 1 or type 2 diabetes) and the risk of COVID-19 infection, as well as if a patient's level of diabetes control was related to specific COVID-19 outcomes (a need for invasive mechanical ventilation or death from COVID-19). The analysis was adjusted for factors that included demographic variables, NDI scores, body mass index, and other comorbidities. The study found that diabetes and level of glycemic control were associated with an increased risk of COVID-19 infection and poorer clinical outcome from COVID-19.
Social Deprivation Index (SDI)	Powell et al: Direct and Indirect Effects of Race and Socioeconomic Deprivation on Outcomes Following Lower Extremity Bypass[109]	Epidemiologic study	Patients in the Blue Cross Blue Shield of Michigan Cardiovascular Consortium Vascular Intervention Collaborative, a prospective, multicenter observational registry (39 participating hospitals perform most of the vascular and cardiovascular operations in the state)	US ZIP codes (a subset of US ZIP codes in Michigan with patients included in the study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SDI scores may be associated with poor outcomes (new myocardial infarction, transient ischemic attack/stroke, or death, at 30 d, as well as amputation, surgical site infection, and bypass graft patency at 30 d and 1 y after the procedure) following lower extremity bypass procedures in patients with chronic limb-threatening ischemia, a marker for delayed presentation and a proxy measure for disease severity. Patients who identified as Black or who lived in ZIP codes with worse SDI scores were found to present with more advanced disease, which in turn was associated with increased odds of poor outcomes after lower extremity bypass surgery.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/population location)	Application for area-level composite measure	Study summary
	Choi and Jung: The Moderating Role of Neighborhood Disadvantage on the Link Between Functional Limitations and Self-rated Health[110]	Epidemiologic study	Individuals surveyed in the Midlife in the United States longitudinal survey of noninstitutionalized adults in the United States (the final sample consisted of 6085 respondents)	The level of geographic disaggregation is not clearly specified in this national-level study (SDI scores are listed as being for the respondents' "neighborhood"); SDI scores are available at the following levels: US counties, US census tracts, US ZIP code tabulation areas, and primary care service areas; the study examines a subset of 1476 "disadvantaged neighborhoods" and 4609 "advantaged neighborhoods"	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SDI scores may be associated with functional limitations and self-rated health status. Individuals living in census tracts with worse SDI scores and with the highest number of functional limitations were found to have higher self-rated health than individuals from more advantaged neighborhoods. Study findings suggest that self-rated health status may best be considered along with an assessment of an individual's place of residence.
	Torabi et al: Measures of Social Deprivation and Outcomes After Percutaneous Coronary Intervention[111]	Epidemiologic study	Patients in the Indiana University Health Multicenter Cardiac Catheterization Registry Study	US census tract (a subset of US census tracts served by a statewide hospital system located in Indiana)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SDI scores may be associated with worse cardiovascular outcomes (all-cause death, congestive heart failure readmission, and myocardial infarction) after percutaneous coronary interventions. Patients in the highest quintile of SDI scores had proportionately more comorbidities and risk for having an adverse outcome. Results suggest that the SDI may be helpful in identifying patients at increased risk for adverse outcomes after percutaneous coronary interventions.
	Xi et al: Effects of Social Deprivation on Risk Factors for Suicidal Ideation and Suicide Attempts in Commercially Insured US Youth and Adults[112]	Epidemiologic study	Commercially insured individuals with health insurance claims data from the Health Care Cost Institute	US ZIP codes (a subset of US ZIP codes in a national-level study of beneficiaries covered by commercial or Medicare Advantage plans from 4 major US health insurance companies: Aetna, Humana, Kaiser Permanente, and United Healthcare)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SDI scores may be associated with risk factors for suicidal ideation and attempts (at least 1 outpatient visit for mental health, alcohol use, and/or substance use) for people aged <65 years. For young people aged <25 years, SDI scores were associated with multiple risk factors for both suicidal ideation and attempts; for adults, risk of suicidal ideation was highest where SDI scores indicated high levels of deprivation, but similar findings were not observed for suicidal attempts. Results suggest that the SDI may be helpful in planning community-based suicide prevention initiatives.
	Sanchez et al: Timely Curative Treatment and Overall Mortality Among Veterans With Stage I NSCLC[113]	Epidemiologic study	Patients diagnosed with early stage (stage I) non–small cell lung cancer in the Veterans Health Administration system	US Census tracts (a subset of US census tracts in a national study of patients served by the Veterans Health Administration system)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how SDI scores and other factors may be associated with timely treatment, treatment modality, and overall mortality in veterans with early stage (stage I) non–small cell lung cancer. Among the findings, veterans who were unmarried and who had higher SDI scores were associated with lower levels of receiving curative therapy in a timely manner; however, they were not independently associated with worse overall mortality. The study notes that the Veterans Health Administration may mitigate the types of health outcome disparities commonly observed in the general population by its efforts to promote equal and improved health care access.
COVID-19 **COVID-19 Community Vulnerability Index (CCVI)**	Johnson et al: Chicago's Citywide COVID-19 Vaccine Equity Program: Protect Chicago Plus[114]	Epidemiologic study	ZIP code–level populations in Chicago	US ZIP codes (13 US ZIP codes in Chicago, IL)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the impacts of the Protect Chicago Plus (PCP) plan, which aimed to promote citywide vaccine equity. Using Chicago COVID-19 CVI scores (a local subset of the national indicator), PCP plan implementation was found to be associated with a reduction in vaccination disparities between areas with low and high vulnerability scores over time. The authors recommend additional study of how local policies may improve vaccination uptake.
	Gerken et al: Comorbidities, Sociodemographic Factors, and Determinants of Health on COVID-19 Fatalities in the United States[115]	Epidemiologic study	US county-level populations	US counties (a subset of US counties in a national-level study of the continental United States and Hawaii, but excluding Alaska and Puerto Rico)	Area-level composite measure was used to adjust the statistical model examining linkages between SDH and other factors on a health outcome in the study population	This investigation examined how comorbidities and several measures of SDH were associated with COVID-19 fatalities. The CCVI was used to adjust the statistical model used in the study. Various studied factors were found to be associated with increasing or reducing COVID-19 fatality rates, highlighting the importance of contextual factors in assessing pandemic outcomes.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	An et al: Effectiveness of the COVID-19 Community Vulnerability Index in Explaining COVID-19 Deaths[116]	Epidemiologic study	Census tract–level populations in Cook County and Chicago, IL	US census tracts (1284 of 1319 US census tracts in Cook County and Chicago, IL, with available CCVI data)	Area-level composite measure was studied as an independent variable to determine if it (and components of it) was associated with a health outcome in the study population	This investigation examined the general themes in CCVI and its associations with COVID-19 mortality rates in the census tracts of Cook County, Illinois. The CCVI aggregates 40 indicators into 7 themes, 3 of which are rearranged from the SVI and 4 of which are specific to COVID-19. Of the findings, 2 themes in particular (high-risk environments and epidemiological factors) had the greatest associations with COVID-19 mortality levels. The authors suggest that the CCVI may need refinements to improve its value in identifying communities that are the most medically vulnerable in the pandemic.
	Her et al: Novel Mobility Index Tracks COVID-19 Transmission Following Stay-at-Home Orders[117]	Epidemiologic study	US county-level populations in Illinois, Ohio, Michigan, and Indiana	US counties (in Illinois, Ohio, Michigan, and Indiana)	Area-level composite measure was used to adjust the statistical model examining linkages between another indicator and a health outcome in the study population	This investigation sought to create a multidimensional mobility index in the context of decreasing human interactions to mitigate SARS-CoV-2 spread. Relational assessments of this index with COVID-19 cases were done with analyses that were adjusted for population density and with the CCVI. Associations were found between the index and the outcome variables, indicating that mobility data can be used to predict COVID-19 case surges.
	Brown et al: COVID-19 Vaccination Rates Vary by Community Vulnerability: A County-Level Analysis[118]	Epidemiologic study	US county-level populations	US counties (a subset of US counties in a national-level study, limited to the 2415 counties with CDC vaccination data for at least 80% of residences)	Area-level composite measure was studied as an independent variable to determine if it (and components of it) was associated with a health outcome in the study population	This investigation examined the CCVI and the 7 general themes within it to assess the association between these data and COVID-19 vaccination rates. One CCVI theme in particular (housing type, transportation, household composition, and disability) was found to have the greatest association with vaccination disparities, meaning the largest gap in vaccination coverage between the least and most vulnerable counties. The authors emphasize that these findings support the need to consider community vulnerability in the public health response to the pandemic.
COVID-19 Pandemic Vulnerability Index (PVI)	Wolkin et al: Comparison of National Vulnerability Indices Used by the Centers for Disease Control and Prevention for the COVID-19 Response[119]	Descriptive analysis, methods/ correlation study of 3 area-level composite measures	US county-level and census tract–level populations	US census tracts and US counties (national study)	Three area-level composite measures were studied to determine how they correlate with each other	This investigation examined the similarities and differences among 3 area-level composite measures used to measure the level of vulnerability to morbidity in a community during the COVID-19 response: the CDC SVI, the CCVI, and the PVI. The study authors note that these indicators share many component metrics and that both the CCVI and PVI are modifications of the CDC-SVI. High levels of correlation were found among the 3 indicators for all US counties. The authors note that, collectively, area-level composite measures are helpful for informing the efforts of public health officials in relation to resource allocation and interventions.
	Park et al: COVID-19 Deaths in the United States: Shifts in Hot Spots Over the Three Phases of the Pandemic and the Spatiotemporally Varying Impact of Pandemic Vulnerability[120]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined spatiotemporal trends in United States COVID-19 death rates and how certain time-dependent factors and aspects of social vulnerability (including the individual data components within the PVI) affected these rates. The authors demonstrate the shifting dynamics of COVID-19 death rates relative to the various factors examined, noting the value of data and analytics in informing the development and implementation of public health plans.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Carroll and Prentice: Community Vulnerability and Mobility: What Matters Most in Spatio-temporal Modeling of the COVID-19 Pandemic?[121]	Epidemiologic study, descriptive analysis, methods/ correlation study of 4 area-level composite indicators and 2 community mobility measures	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined which of several composite measures studied best explained community patterns of COVID-19 spread and mortality using 3 outcome measures: number of confirmed cases, number of new cases, and number of deaths. The composite measures examined included 2 community mobility measures (Google measures for work- and residential-related mobility), 3 composite measures of community vulnerability (the ADI, SVI, and CCVI), and 1 composite measure that combines vulnerability and human behavior (the PVI). Overall, the mobility measures served better than community vulnerability in their ability to model the COVID-19 pandemic. Of the composite community vulnerability measures, the authors note that only the PVI is the most comprehensive measure and is dynamic and changes over time, whereas the other 3 indicators are spatial and remain constant over time. As such, the PVI achieved the best fit for modeling of pandemic outcomes examined among the vulnerability measures. Although the authors note that COVID-19 disproportionately affects populations with high vulnerability scores, they suggest that community mobility must be considered along with vulnerability measures when modeling COVID-19 spread.
	Marvel et al: The COVID-19 Pandemic Vulnerability Index (PVI) Dashboard: Monitoring County-Level Vulnerability Using Visualization, Statistical Modeling, and Machine Learning[48]	Descriptive presentation of a public health data dashboard that presents county-level information using area-level composite measures for population health planning	US county-level populations	US counties (national study)	Area-level composite measure used for population health planning	This investigation describes a dashboard developed to aid state and local officials in dynamic, community-level decision-making, allocating resources, caring for populations deemed vulnerable, and implementing local- and state-level interventions. The dashboard presents county-level pandemic data and key vulnerabilities at the community level using the PVI and allows officials to monitor the trajectories of the pandemic, to forecast key outcomes with these data and to identify and address racial disparities. The information is presented in a manner aiming to serve diverse audiences and is flexible/modular in a way to adapt to pandemic dynamics (eg, vaccine distribution).
	Schweig et al: Allocating Resources for COVID-19 Recovery: A Comparison of Three Indicators of School Need[122]	Epidemiologic study	Sample of nearly 1.7 million US public school students in grades 3-8 (representing about 7% of the national level)	US counties (a subset of US counties in a national study with data on US public school students in grades 3-8)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population; area-level composite measure compared with other indicators	This investigation examined how 3 area-level composite measures (pre–COVID-19 student performance and progress, school and community poverty, and pandemic vulnerability) correlated with outcome metrics of cross-pandemic student performance to best determine the appropriate indicator(s) for school needs. The authors noted that, across the measures examined, school poverty measures— specifically the percentage of students who are eligible for free and reduced-price lunch— served as the best predictors of the outcome measures. Nonetheless, wide variation was seen in all the indicators examined, and the authors caution that local education agencies should rely on multiple sources of data and local context in their strategic decision-making during the pandemic.
COVID-19 Vaccine Coverage Index (VCI)	Cuadros et al: Impact of Healthcare Capacity Disparities on the COVID-19 Vaccination Coverage in the United States: A Cross Sectional Study[123]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between county-level COVID-19 VCI scores and local disparities in health care capacity. An association between low vaccine coverage and health care capacity constraints was observed. The authors suggest that strengthening health care system funding and infrastructure should be intensified to best assist medically vulnerable communities.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Mirpuri and Rovin: COVID-19 and Historic Influenza Vaccinations in the United States: A Comparative Analysis[124]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between rates of COVID-19 vaccination, as assessed by county-level COVID-19 VCI scores, with historical influenza vaccination rates for adults aged 65 years or older. It also examined the county-level demographic, socioeconomic, and political factors that appear to have effects/a relationship with COVID-19 vaccination rates. In most (83.4%) counties, COVID-19 vaccination rates exceeded influenza vaccination rates; the opposite finding was largely observed in the South, in politically more conservative states with a high proportion of non-Hispanic Black residents. The authors suggest that vaccine uptake campaigns probably should account for the factors present and the needs of medically vulnerable counties.
	Reimer et al: Moral Values Predict County-Level COVID-19 Vaccination Rates in the United States[125]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between county-level COVID-19 VCI scores and other vaccination data with the following county-level "moral values": care, fairness, loyalty, authority, and purity (using crowd-sourced and other data). After adjusting for structural barriers to vaccination, lower vaccination rates were associated with moral concerns about bodily and spiritual purity, and higher rates were associated with fairness and loyalty. The authors note implications for their findings in health communication and intervention strategies.
	Schnake-Mahl et al: Higher COVID-19 Vaccination and Narrower Disparities In US Cities With Paid Sick Leave Compared to Those Without[126]	Epidemiologic study	US county-level populations in 44 of the largest US cities	US counties (a subset of US counties that were located in 44 of the largest US cities)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between vaccine coverage rates in cities and the presence of policies for paid sick leave in those cities. The analysis was adjusted for potential compositional and contextual confounders using measures of neighborhood social vulnerability from sources including the CDC SVI and the COVID-19 VCI. Results showed that cities with a paid sick leave policy had on average a 17% higher rate of vaccination coverage than those without a policy, suggesting that access to such policies may help to increase vaccination rates.
	Wu: Racial Concentration and Dynamics of COVID-19 Vaccination in the United States[127]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the interplay between county-level COVID-19 vaccination rates, the racial composition of populations, measures of political ideology, and measures of community vulnerability (with the latter leveraging sources including the COVID-19 VCI). Study findings note that both social vulnerability and political influences may serve as underlying factors for the time-varying patterns of vaccination uptake observed across and within race groups and suggesting that vaccine hesitancy may not be the sole root cause for these observations. The author recommends that addressing the barriers faced by various racial groups may be crucial for achieving an effective and equitable pandemic response.
Rurality **Index of Relative Rurality (IRR)**	Montgomery et al: County-Level Jail Incarceration, Community Economic Distress, Rurality, and Preterm Birth Among Women in the US South[128]	Epidemiologic study	Black, Hispanic, or White women having live singleton births before 37 completed weeks of gestation	US counties (a subset of 766 US counties located in 13 southern/rural states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Missouri, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and West Virginia)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population; area-level composite measure compared with other indicators	This investigation examined how rurality (using the IRR), socioeconomic stressors (using the DCI), and incarceration (using data from the Vera Institute) were related to rates of preterm birth in 766 counties across 13 southern/rural states. Associations were found with economic distress in Black and White mothers and with rurality in White mothers, but none of the study variables were associated with premature births among Hispanic mothers, and no association was found with jail admission rates. Further investigation into the linkages between structural inequities and preterm births was recommended.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Franks et al: Defining Rurality: An Evaluation of Rural Definitions and the Impact on Survival Estimates[129]	Epidemiologic study	US county-level populations	US counties (a subset of 605 US counties were included that had data in the SEER database)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population; area-level composite measure compared with other indicators	This investigation examined how various definitions of rurality (including by using the IRR) were related to inferior cancer outcomes, specifically the hazard ratios for cancer mortality at 5 y (for multiple types of cancer). Of the 605 counties analyzed in this study, 57.7% were considered rural according to the US Department of Agriculture's Rural–Urban Continuum Codes (RUCCs) and the National Center for Health Statistics (NCHS) Urban–Rural Classification Scheme for Counties (URCSC), and 57.8% according to the IRR. When using the rural/urban binary definitions of the RUCC, URCSC, and IRR, or when using the ternary definitions of rurality (metropolitan, micropolitan, or noncore/rural) and comparing metropolitan counties with rural counties, largely comparable adjusted hazard ratios of cancer death were observed. However, when using IRR as a continuous measure, different hazard ratios were observed. The results suggest that, in general, rural definitions and categorization must be chosen carefully, depending on the purpose of a given study.
	Cohen et al: Black/ White Disparities in Obesity Widen With Increasing Rurality: Evidence From a National Survey[130]	Epidemiologic study	A sample of US county-level populations from the nationally representative sample of the 2012 Behavioral Risk Factor Surveillance System (BRFSS) survey	US counties (a subset of US counties in a national study of a sample of BRFSS respondents)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population; area-level composite measure compared with other indicators	This investigation examined how rurality (using the IRR) may serve to moderate observed racial health disparities in obesity (and obesity-related) behaviors and conditions. Among other findings, multivariable associations were found between an interaction term (for Black race and IRR quintile) and obesity and diabetes. Results suggest a need to consider the geographic context for racial disparities in obesity and related conditions.
	Svynarenko and Lindley: Defining Rurality in Hospice Research: Evaluation of Common Measures[131]	Epidemiologic study	US county-level and ZIP code–level populations from the nationally representative sample of hospices in the 2014 Medicare Provider Utilization and Payment Dataset (public use file)	US counties (a subset of US counties in a national study of Medicare beneficiaries for 6 of the rural measures studied) and US ZIP codes (a subset of US ZIP codes in a national study of Medicare beneficiaries for 2 of the rural measures studied)	Area-level composite measure was studied as an independent variable to determine if it was associated with certain health system characteristics; area-level composite measure compared with other indicators	This investigation examined how various definitions of rurality (using the IRR) differed from the Office of Management and Budget (OMB) definition in hospice research that focuses on hospice characteristics (age in years, type of ownership), hospice services (home health aide, skilled nurse, and social worker), and community characteristics (proportion of population that was female, proportion of population that was non-Hispanic White, mean age, median annual household income, US regional location). Among the study findings, the IRR and the Health Resources and Services Administration's Federal Office of Rural Health Policy classified the largest number of hospices as rural and had good agreement with the OMB method, and, as such, the authors suggest that these measures can be used interchangeably.
	Pro et al: US Trends in Mask Wearing During the COVID-19 Pandemic Depend on Rurality[132]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with health behaviors in the study population	This investigation examined how rurality (using the IRR) may be associated with face mask wearing during the COVID-19 public health emergency. When daily case rates and certain other county characteristics were held constant, the predicted probability of face mask wearing decreased significantly with increasing levels of rurality. The study findings suggest a need to better understand how COVID-19 risk is perceived in rural areas.
Food insecurity Map the Meal Gap (MMG)	Wen et al: Association Between Non-profit Hospital Community Benefit Spending and Health Outcomes[133]	Epidemiologic study	US county-level populations served by select hospitals—1 large hospital with >300 beds, 1 medium-sized hospital with 100-300 beds, and 1 small hospital with <100 beds—chosen at random from each of 4 regions (Northeast, Midwest, South, and West)	US counties (a subset of 1093 US counties, on average, per study year [2015-2019] served by nonprofit hospitals examined in a national-level study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how expenditures for community benefits and provision of charity care by nonprofit hospitals might be associated with better health outcomes locally, by studying 4 county-level outcome measures in particular: the food insecurity rate (using data from MMG), the number of health professionals per 1000 people, and the medication adherence rates for both diabetes and hypertension medications. Generally, higher community benefit expenditures were not found to be associated with meaningful improvements in the studied health outcomes. The authors suggest that this information could be used to reassess hospitals' community benefit strategies, and government funders may want to redefine the measures of community benefit that they use to grant tax exemptions.

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Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Kim et al: Community Food Insecurity Predicts Child Maltreatment Report Rates Across Illinois ZIP codes, 2011-2018[134]	Epidemiologic study	Illinois children for whom there were child maltreatment reports from the Illinois Department of Children and Family Services in the study years (2011-2018)	US ZIP codes (a subset of US ZIP codes in Illinois for which there were data from child maltreatment reports)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health and child welfare outcome in the study population	This investigation examined how food insecurity rates (using data from MMG) were associated with rates of child maltreatment reports in large urban, small urban, and rural areas of Illinois, when controlling for certain community and maltreatment characteristics. The authors suggest a need to consider community-level factors in statewide policies and a need to assist communities with high levels of food insecurity.
	Kim et al: Community Food Insecurity and Child Maltreatment Reports: County-Level Analysis of U.S. National Data From 2009 to 2018[135]	Epidemiologic study	US county-level populations present in several linked national databases, including child maltreatment report data for dependent variables, food insecurity data for independent variables, and US Census data for control variables	US counties (a subset of US counties with data from the primary study sources in a national-level study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health and child welfare outcome in the study population	This investigation examined how food insecurity rates (using data from MMG) were associated with rates of child maltreatment reports in urban and rural areas of the nation, when controlling for certain community and maltreatment characteristics. The authors suggest a need to further examine how food insecurity affects child maltreatment, and that interdisciplinary policies and efforts may be needed to promote the health and well-being of families and their children.
	Ali et al: The Association Between Food Insecurity and Gun Violence in a Major Metropolitan City[136]	Epidemiologic study	Patients meeting study inclusion criteria at the Norman E. McSwain Jr. MD, Spirit of Charity Trauma Center at University Medical Center (UMC), located in New Orleans, LA	US parishes (US parishes served by a hospital trauma center in the New Orleans area)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how food insecurity rates (using data from MMG) may be associated with rates of overall gun trauma and the odds of gun-related violence. Among other findings, food insecurity rates were found to be significantly and incrementally associated with firearm injury rates. The authors suggest a need to further examine how initiatives to curb food insecurity may help to reduce gun violence and screening/ intervening for household food insecurity at hospitals may help to reduce gun violence offenses.
	Leonard et al: Overlapping Geographic Clusters of Food Security and Health: Where Do Social Determinants and Health Outcomes Converge in the U.S.?[137]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how clusters of low and high food security (using data from MMG) may overlap with clusters of measures for good or poor health. In general, the Mississippi Delta, Black Belt, Appalachia, and Alaska regions were found to have "unfavorable" clusters where there were overlaps for poor health measures and high levels of food insecurity. Similar characteristics were observed in counties with higher proportions of Black residents and higher poverty levels. The Corn Belt and New England were found to have favorable clusters where there were overlaps for good health measures and low levels of food insecurity. The authors note that these patterns suggest that shared causal mechanisms may underlie food insecurity and health and that this insight may help to guide policies and public health interventions.
Emergency response and community resilience						
CDC Social Vulnerability Index (SVI)	Korvink et al: A Novel Approach to Developing Disease and Outcome Specific Social Risk Indices[138]	Descriptive methods study of data variable weighting for an area-level composite measure	Clinical cohorts of individuals with acute inpatient hospitalizations in 2021 represented in the Premier Healthcare Database (a private all-payer administrative database) with the following conditions: acute myocardial infarction, heart failure, perinatal and related conditions, pneumonia, stroke, total hip and knee arthroplasty, and COVID-19	US counties (a subset of US counties with data in the Premier Healthcare Database in a national-level study)	Weighting of data variables for an area-level composite measure were examined	This investigation proposed an approach for assigning weights (based on outcome and disease groups) to social risk variables to form disease- and outcome-specific social risk indices. The authors undertook this investigation due to widespread use of area-level composite measures but concerns about how such indices may (redundantly) comprise correlated variables. The authors' proposed weighting approach served to reduce root mean-squared error in explaining county-level mortality (using the SVI as a benchmark). The authors suggest that their methods provide a means to help overcome the limitations of social risk indices.

Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Elenwa et al: A Census Tract–Level Examination of HIV Care Outcomes and Social Vulnerability Among Black/African American, Hispanic/ Latino, and White Adults in the Southern United States, 2018[139]	Epidemiologic study	US census tract populations living with HIV in 2018	US census tracts (a subset of US census tracts in 9 Deep South states, including Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas, and 6 other southern states: Washington, DC, Delaware, Maryland, Oklahoma, Virginia, West Virginia)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined how social vulnerability (using SVI data) may be associated with rates of HIV diagnoses, linkage to HIV medical care, and viral suppression among adults living in the South. An association was observed among social vulnerability, HIV diagnoses, and some poor outcomes for Black/African American, Hispanic/Latino, and White adults. The authors note that improved access and tailored interventions will likely be necessary to reduce HIV transmission and improve health outcomes for Southern adults that reside in areas with high levels of social vulnerability.
	Flores et al: The 2021 Texas Power Crisis: Distribution, Duration, and Disparities[140]	Epidemiologic study	County-level populations in Texas	US counties (in Texas)	Area-level composite measure was studied as an independent variable to determine if it was associated with public resources with health implications in the study population	This investigation examined how social vulnerability (using SVI data) may be associated with the distribution and duration of power outages during the February 2021 Texas Power Crisis. Among the study findings, more severe power outages tended to occur in counties where there were more Hispanic residents; however, socioeconomic and medical disparities were not observed. The authors note that medically and socioeconomically vulnerable groups may be disproportionately affected by or have lower levels of preparedness for power outages and that equity should be considered in climate and energy policies.
	Basile Ibrahim et al: Inequities in Availability of Evidence-Based Birth Supports to Improve Perinatal Health for Socially Vulnerable Rural Residents[141]	Epidemiologic study	County-level populations where the 93 surveyed rural hospitals were located	US counties (in a subset of US counties containing the 93 surveyed rural hospitals)	Area-level composite measure was studied as an independent variable to determine if it was associated with health care service access in the study population	This investigation examined the availability of evidence-based supports and services promoting maternal and infant health in rural communities with a survey of 93 (responding) rural hospitals and for each responding hospital examined the county-level SVI score. Results (adjusted for geography and hospital size) found that residents living in the most socially vulnerable rural counties had lower access to evidence-based supports for maternal and infant health (certified lactation support, midwifery care, doula support, postpartum support groups, and childbirth education classes). Because these communities include many Black, Indigenous, and People of Color individuals who are at increased risk for poor birth outcomes, the findings may have policy implications that help to guide policies focusing on increasing access to needed maternal and infant health supports.
	Sedani et al: Inequalities in Tobacco Retailer Compliance Violations Across the State of Oklahoma, 2015-2019[142]	Epidemiologic study	Census tract–level young populations in Oklahoma noted in tobacco violations in the publicly available US Food and Drug Administration's Compliance Check Inspections of Tobacco Product Retailers database in the study period of October 2015 to September 2019	US census tracts (a subset of US census tracts in Oklahoma with data in the source database used in this study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health risk factor in the study population	This investigation examined the relationship between neighborhood social vulnerability in Oklahoma (using SVI data) and violations for selling tobacco products to young people by retailers (as found through compliance checks). After controlling for socioeconomic vulnerability, a strong association was observed between having a violation (and proportion of a tobacco retailer's violations) and retailer store type. The authors suggest a need for more targeted enforcements and retailer education to increase compliance with sales bans for young people.
Baseline Resilience Indicators for Communities (BRIC)	Derakhshan et al: Degree and Direction of Overlap Between Social Vulnerability and Community Resilience Measurements[143]	Descriptive analysis, methods/ correlation study between 2 area-level composite measures	US county-level populations	US counties (national study)	Two area-level composite measures were studied to determine how they correlate with each other and serve as predictors for public need	This investigation used spatial–temporal correlations to examine the measurement similarities and differences between social vulnerability (using SVI data) and community resilience (using BRIC data) as the concepts of vulnerability and resilience are often empirically treated similarly in public health investigations. Only a minority of examined counties contained hot spot clustering of correlations of vulnerability and resilience scores, and there were notable regional differences in how measures overlapped and diverged. In other words, a vulnerable community may or may not be highly resilient, and vice versa. As such, the authors urged continued use of both social vulnerability and resilience metrics during planning for natural hazards risk.

Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Johnson et al: A Factor Analysis Approach Toward Reconciling Community Vulnerability and Resilience Indices for Natural Hazards[144]	Descriptive analysis, methods/ correlation study between several area-level composite measures	US county-level populations	US counties (national study; note that SVI data available at the US census tract level was deemed pertinent to and used at the county level by the study investigators)	Several area-level composite measures were studied to determine how they correlate with each other and serve as predictors for public need	This investigation examined why natural disasters of similar type and magnitude may have different effects on different communities by exploring the concepts of and data variables comprising social vulnerability (including with SVI data) and community resilience (including with BRIC data). Five factors (wealth, poverty, agencies per capita, elderly populations, and non–English-speaking populations) tend to account for the most county-level variation across the numerous variables comprising the composite measures examined. The authors suggest a need to further evaluate the ability of these data to predict and explain disaster outcomes, noting that they may not be the best predictors of community vulnerability and resilience and might not be well-equipped to quantify community vulnerability or guide policy makers in reducing the risk of unfavorable disaster outcomes in communities.
Community Resilience Estimates (CRE)	Asher: The Relationship Between Historical Redlining and Census Bureau Community Resilience Estimates in Columbus, Ohio[145]	Epidemiologic study	US census tract–level populations in Columbus, OH	US census tracts (a subset of US census tracts in Columbus, OH, with data in the source databases used in this study)	Area-level composite measure was studied as an independent variable to determine if it was associated with an exposure in the study population	This investigation examined the relationship between census tract–level CRE scores in Columbus and the practice of redlining (ie, denying mortgage loans to racially discriminate against Black people and other people of color through officially sanctioned means and resulting in racial segregation in housing). Neighborhoods with a history of being redlined were found to have lower levels of resources to withstand disasters. The authors recommend that the effects of racism in housing policies have direct effects on public health and that this could be counteracted through guided policies and funding to historically oppressed areas.
	Shour et al: Your Neighborhood Matters: An Ecological Social Determinant Study of the Relationship Between Residential Racial Segregation and the Risk of Firearm Fatalities[146]	Epidemiologic study	US county-level populations in Wisconsin	US counties (in Wisconsin)	Area-level composite measure was studied as an independent variable to determine if it was associated with an exposure in the study population	This investigation examined the relationship between racial segregation in Wisconsin and rates of firearm fatalities. Several data sources were used in this study, including census tract–level CRE scores. The study found that both high levels of income inequality and low levels of community resilience were associated with a greater likelihood of firearm fatalities and that residential areas with high levels of racial segregation tended to also have a high rate of firearm fatalities. The authors suggest that addressing disparities in firearm fatalities will require a multipartner approach that includes addressing SDH.
Federal Emergency Management Agency (FEMA) National Risk Index (NRI)	Van Berkel et al: Planning for Climate Migration in Great Lake Legacy Cities[147]	Public policy development	US census tract–level populations in the Great Lakes region, which includes Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin (Ontario, Canada, was excluded from this study but also is in this region)	US census tracts (a subset of US census tracts in the 8 states in the Great Lakes region: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin)	Area-level composite measure was used to assess risk and guide public policy decision-making	This investigation examined how the Great Lakes region might be viewed as a more desirable residential area and for drawing population influx as a result of climate change. The authors use NRI data and other information to better understand how migratory shifts might affect residents already living in Great Lakes region communities, hoping to inform sustainability policies and to avoid exacerbating existing inequalities and climate vulnerabilities.
	Phelos et al: Social Determinants of Health and Patient-Level Mortality Prediction After Trauma[148]	Epidemiologic study	US ZIP code–level populations in Pennsylvania aged 16 years and older included in the Pennsylvania Trauma Outcomes Study from 2000 to 2020	US ZIP codes (a subset of US ZIP codes in Pennsylvania with data in the source databases used in this study)	Area-level composite measures were used to adjust the statistical models used to predict a health outcome in the study population	This investigation examined whether adjusting predictive models for trauma outcomes with 2 area-level composite measures, the DCI and the NRI, or other data sources improved their performance. The study found that all data examined did improve model fit and that the SDH themselves were also associated with a risk of mortality after injury. As such, the authors recommend that it may be wise to account for SDH when setting trauma center performance benchmarking.

(Continued)

Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Harrati et al: Spatial Distributions in Disaster Risk Vulnerability for People With Disabilities in the U.S.[149]	Epidemiologic study	US county-level populations	US counties (a subset of US counties in a national study, excluding those located in Hawaii, Alaska, and US territories)	Area-level composite measure was studied as an independent variable to determine if it was associated with a risk factor in the study population	This investigation examined the association between disability and risk from natural disasters by looking at a subcomponent of the NRI (the Expected Annual Loss index) to determine how it might correlate with the proportion of the county-level population reporting a disability. The study found an inverse relationship between these 2 factors at a national level, suggesting that people with disabilities may more often live in areas with lower risks for natural hazards. However, this might not be the case when examining individual counties, which is an important consideration for emergency planning.
	Grubesic and Durbin: Breastfeeding, Community Vulnerability, Resilience, and Disasters: A Snapshot of the United States Gulf Coast[150]	Epidemiologic study	US county-level populations in the Gulf Coast states of Alabama, Louisiana, and Mississippi	US counties (a subset of 213 US counties in the study area: 67 in Alabama, 82 in Mississippi, and 64 in Louisiana; parishes, a county equivalent, were used in Louisiana)	Area-level composite measures were used to adjust the statistical models used to predict a health behavior in the study population	This investigation examined the association between rates of infant breast-feeding and the risk of natural disasters to assess 1 aspect of community resilience, because in a disaster, breast-feeding may be the only option available for nourishing infants. The study findings suggest that there are broad geographic discrepancies between rates of vulnerability, resilience, and breast-feeding initiation, an important consideration for disaster planning.
Minority Health Social Vulnerability Index (MH-SVI)	Saelee et al: Minority Health Social Vulnerability Index and COVID-19 Vaccination Coverage—the United States, December 14, 2020–January 31, 2022[151]	Epidemiologic study	US county-level populations aged >18 years who had a valid county of residence in 1 of the 50 states or the District of Columbia, and who had received their first dose of a COVID-19 vaccine between December 14, 2020, and January 31, 2022 (Pfizer-BioNTech, Moderna, or Janssen/Johnson & Johnson)	US counties (a subset of US counties that had data in the source databases used in this national-level study; 9 of the nation's 3142 counties were excluded: 1 in Alaska and 8 in California)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health risk factor and health outcome in the study population	This investigation examined the relationship between county MH-SVI scores in terciles of vulnerability (low, moderate, high) and COVID-19 vaccine administration coverage (≥1 dose, primary series completion, receipt of a booster dose). Although vaccination uptake was associated with several data variables, no clear patterns in COVID-19 vaccination coverage were observed by terciles for the composite measure. As such, the use of this composite measure might mask disparities in COVID-19 vaccination uptake that would have otherwise been observed using individual data variables.
	Tipirneni et al: Associations of 4 Geographic Social Vulnerability Indices With US COVID-19 Incidence and Mortality[152]	Epidemiologic study	US county-level populations	US counties (a subset of 3125 US counties or county equivalents with aggregated COVID-19 county-level data, in a study at the national level)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined whether the relationship between county scores for several area-level composite measures (including the SVI, CCVI, ADI, and MH-SVI) was associated with COVID-19 incidence and mortality. All the examined indices had similar (positive) associations with COVID-19 incidence and all were also associated with COVID-19 mortality; however, the ADI had the strongest association with mortality. The study suggests utility for all the studied indicators in guided vaccination policies and efforts.
The National Health Security Preparedness Index (NHSPI)	Keim and Lovallo: Validity of the National Health Security Preparedness Index as a Predictor of Excess COVID-19 Mortality[153]	Epidemiologic study	US state-level populations	US states and Puerto Rico (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between state NHSPI scores and COVID-19 mortality, finding that the NHSPI did not appear to predict excess COVID-19 mortality rates during the first 6 mo of the pandemic. The authors note the challenges in establishing a valid scale for disaster preparedness and that the NHSPI is unlikely to be practical for policy and planning applications if it is not found to directly relate to health outcome indicators.
Social Vulnerability to Environmental Hazards Index (SoVI or SVEHI)	Phelos et al: Can Social Vulnerability Indices Predict County Trauma Fatality Rates?[154]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between the scores for 3 social vulnerability indices (the Hazards & Vulnerability Research Institute's SoVI, CDC's SVI, and the Economic Innovation Group's DCI) and county-level trauma fatality rates (overall, firearm, and motor vehicle collision deaths per 100 000 population). Although all 3 indices were associated with increasing fatality rates, the DCI best predicted overall injury fatality. Significant geographic variations were observed for SoVI scores, DCI scores, and injury fatality rates. The authors note that these indices may be useful in assessments of injury-related fatality rates, but further study is needed to determine if they perform better than other SDH measures.

(Continued)

Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
Health						
California Healthy Places Index (CHPI)	Bakhsh et al: Association of Area-Based Socioeconomic Measures With Tuberculosis Incidence in California[155]	Epidemiologic study	County-level populations in California in the state's tuberculosis registry, as reported to the California Department of Public Health from 2012-2016	US counties (a subset of US counties in California that had data in the source databases used in this state-level study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship between county-level incidence of tuberculosis in California and birth country as well as socioeconomic status (using measures including the California Healthy Places Index). Socioeconomic status level was found to have an inverse relationship with tuberculosis incidence across all the measures used, including CHPI, and birth health countries. The authors note that measures of socioeconomic status could be used to inform tuberculosis prevention efforts, including for resource allocation to priority communities.
	Martinez et al: Equitable COVID-19 Vaccination for Hispanics in the United States: A Success Story From California Border Communities[156]	Epidemiologic study	County-level populations in California with vaccination rates data in the California Healthy Places Index database	US counties (a subset of US counties in California that had data in the source databases used in this state-level study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health risk factor and health outcome in the study population	This investigation examined the relationship between county-level COVID-19 vaccination rates for the California Hispanic community and both (1) residence in a border location and (2) community scores for the California Healthy Places Index. Hispanic people had substantially lower vaccination rates when residing in border counties and in counties with poorer CHPI scores (indicating lesser health). Counties with health education and promotion tailored to language and culture saw more equitable and unbiased vaccination, offering promising practices for future efforts.
County Health Rankings and Roadmaps (CHRR)	Jasani et al: Association Between Primary Care Availability and Emergency Medical Services Utilization[157]	Epidemiologic study	US county-level populations using EMS and represented in the National Emergency Medical Services Information System	US counties (a subset of roughly 83% of all US counties that had data in the National Emergency Medical Services Information System)	Area-level composite measure was used as a covariate in a study to determine if health care access levels were associated with other health service utilization in the study population	This investigation examined the relationship at the county level between access to primary care (number of county primary care physicians per 10 000 population) and EMS utilization (number of EMS trips per 10 000 population), finding that higher primary care availability was associated only with less EMS utilization when communities had higher levels of health insurance coverage (>90%). The analytic model included demographic characteristics, number of primary care resources, health insurance, and SDH (using CHRR data). The authors note that health insurance coverage plays an important role in decreasing EMS utilization.
	Klein et al: Generating Data to Facilitate More Equitable Distribution of Health Resources: An Illustration of How Local Health Surveys Can Identify Probable Need in Mixed Socioeconomic Regions[158]	Descriptive methods study comparing area-level composite measures and survey data	County-level populations in 5 counties in Southeastern Pennsylvania with responses in the Public Health Management Corporation Southeastern Pennsylvania Household Health Survey	US counties (a subset of 5 US counties located in Southeastern Pennsylvania, determined using ZIP codes, that had data in the source databases used in this state-level study)	An area-level composite measure was examined relative to survey data to determine which may be a better indicator of socioeconomic status at small geographic levels	This investigation examined whether health planners who want to allocate governmental and grant funding to best serve people and communities in need are better served by using county-level data to assess socioeconomic status (CHRR data) or health survey data (data from the 2018-2019 Southeastern Pennsylvania Household Health Survey, combined with US Census data). The authors report their findings suggest that local health survey analysis can sometimes lead to a more precise identification of health needs, helping to identify and allocate limited resources to low socioeconomic status communities within counties, than can be achieved using survey data that describes broader areas (counties).
	Keeney et al: County-Level Analysis on Occupation and Ecological Determinants of Child Abuse and Neglect Rates Employing Elastic Net Regression[159]	Epidemiologic study	US county-level populations in the study areas, in states (California, Colorado, Minnesota, Oregon, New Mexico) with comparable publicly available county-level data on substantiated child abuse and neglect rates during a 5-y period (2015-2020)	US counties (a subset of 278 US counties in California, Colorado, Minnesota, Oregon, and New Mexico and with confirmed data on child victims of abuse or neglect rate in the Annie E. Casey Kids Count Data Center)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health and child welfare outcome in the study population	This investigation examined the relationship at the county level between occupation in certain job sectors (agriculture/forestry/ fishing, manufacturing, wholesale, retail, finance, education) and (1) child maltreatment rates and (2) assessments of community health and well-being (using CHRR data). Among the study's findings was the suggestion that counties with a larger presence of certain job sectors that tend to have higher injury and fatality rates than other occupations (specifically agriculture/forestry/fishing and retail) had higher rates of child maltreatment. The authors suggest that occupational hazards and stressors may relate to child well-being outcomes, and as such, occupational factors may need to be considered in child maltreatment prevention efforts.

(Continued)

Table 3. (continued)

Area-level composite measure	Selected US public health investigations in which area-level composite measures were applied	Study type	Study population	Study geographic disaggregation level (study/ population location)	Application for area-level composite measure	Study summary
	Olson-Williams et al: Ecological Study of Urbanicity and Self-reported Poor Mental Health Days Across US Counties[160]	Epidemiologic study	US county-level populations	US counties (national study)	Area-level composite measure was studied as an independent variable to determine if it was associated with a health outcome in the study population	This investigation examined the relationship at the county level between urbanicity and self-reported poor mental health days in US counties, using data from the BRFSS and the US Census Bureau, aggregated by the CHRR. The study's primary finding was that improved mental health was observed in large central metropolitan counties, even after adjusting for factors such as age, income, education, race, and ethnicity. This finding was mediated in part by factors in the built environment, such as access to exercise and food environment, resulting in the authors suggesting that implementing policies to build urban green spaces or expanding food access may have positive mental health effects.
	Ramezani et al: The Relationship Between Community Public Health, Behavioral Health Service Accessibility, and Mass Incarceration[161]	Epidemiologic study	US county-level populations	US counties (national study)	Data variable components of the area-level composite measure were studied as independent variables to determine if they were associated with incarceration outcomes in the study population	This investigation examined the relationship at the county level between health care service accessibility in the community and incarceration (using the Vera Institute's incarceration trends database). Public health data used in the models included data from the CHRR. Higher per-capita jail populations were associated with several studied factors, including fewer per-capita psychiatrists, lower percentage of drug treatments paid by Medicaid, higher per-capita health care costs, higher number of physically unhealthy days in a month, lower high school graduation rate, smaller county size, and more police officers per capita. After controlling for covariates, violent crime rate was not a predictor of incarceration rate. As such, the authors suggest that increasing access to mental health and substance use services and improving the affordability of health care services and medications may result in reduced rates of incarceration.
Healthiest Communities Ranking (HCR)	Weisner et al: Health Symptoms and Proximity to Active Multi-Well Unconventional Oil and Gas Development Sites in the City and County of Broomfield, Colorado[162]	Epidemiologic study	County-level populations in a Colorado city/ county: Broomfield, CO	US counties (1 US city/county: Broomfield)	Area-level composite measure was used to contextualize need	This investigation examined the relationship between living within 1 mile of a multiwell unconventional oil and gas development (UOGD) site and frequency of health symptoms. Adjusted findings suggested a higher rate of health symptoms (upper respiratory, lower respiratory, gastrointestinal, and acute in nature) for those living within 1 mile of a UOGD site than among those who lived >2 miles from UOGD sites, suggesting a need to further study the relationship between proximity to UOGD and health symptoms. The findings are contextualized with Healthiest Communities Ranking results, which indicate that the county examined (Broomfield) was rated as being the fifth healthiest county in the United States.

[a] For some area-level composite measures, the representative literature was limited to the 5 most recent publications in which measure data were directly applied in a US-based, peer-reviewed public health initiative and/or investigation. Publications that were perspective pieces were excluded.

suggests that certain composite measures may be more strongly associated with health outcomes than single measures.[167]

How to best scale up health system–level policy interventions to address SDH by leveraging area-level composite measures remains somewhat uncertain.[8,168-170] Nonetheless, an opportunity exists to meaningfully drive population health improvements through thoughtfully designed, well-implemented, and rigorously evaluated initiatives (Figure 2).[170-172] For example, public health funders, including federal agencies, could ask grant applicants to elaborate upon the hardships faced by their communities using neighborhood-level data, to better align investments with levels of community need. Applicants could propose performance metrics, based on their community's data, to track progress toward expected outcomes they might achieve were they to receive funding. Recipients of US Department of Housing and Urban Development block grants for community development and affordable housing currently use such an approach. Funded communities must develop a comprehensive planning document (Consolidated Plan) that uses data and mapping to identify their community's highest priority needs and to develop a strategy to address them.[173] Similarly, public health agencies could consider using composite measures during process evaluations of their grant programs to determine the extent to

Population	Context	Application
Shared identities and experiences • Living in a common geographic area or sharing geographic characteristics • Belonging to a specific demographic or other categorical subgroup • Having a specific exposure, health status, risk factor, or health condition in common **Health system linkages** • Association with a specific health care delivery setting or system • Receiving a specific health service • Delivering a health care or other service • Having a specific health insurance status or payor **Logistical linkages** • Supported through a program or funding line • Association with a research study	**Health care** • Health, wellness, and health outcomes • Health care delivery to people, populations, and communities • Other service delivery to people, populations, and communities • Health education and promotion • Health care facilities and systems • Payers, public insurance programs, value-based payment **Policies and planning** • Development, implementation, and oversight of policies and regulations • Infrastructure development and support • Resource allocation and management • Risk mitigation **Community-focused efforts** • Emergency planning and response, community readiness, and resilience • Community planning, urban planning, green space planning • Community-based initiatives and collaboratives • Environmental factors with public health implications **Family wellness and opportunity** • Supporting families, mothers, and children • Reducing child maltreatment • Schools and education **Research studies** • Clinical trials, epidemiology studies, descriptive analyses, correlational studies	**Measurement of needs and demand** • Understanding needs/demand, addressing low resources, reducing economic distress, maximizing community benefits • Matching investments to need • Reducing disparities and structural inequities **Evidence to drive health care/system decisions** • Guiding/assessing clinical interventions and approaches to patient care • Understanding, assessing prevalence of, and mitigating disease, disease risk factors, and risk behaviors • Driving quality, timeliness, affordability, equity, and appropriateness of service delivery **Evidence to drive policy and program decisions** • Developing and implementing screening and predictive tools • Understanding the impacts of policies, laws, and politics • Communication of information to the public and policy makers • Evaluating processes • Risk adjustment of public health insurance payments in value-based payment programs • Reducing expenditures, strengthening accountability, linking of health care and social services **Other aspects of data and statistical analysis** • Serving as a predictor or covariate of a need/outcome • Adjusting statistical models for social risks • Quantifying characteristics of populations and communities • Data collection, analytics, and validity • Validation of indicator use; assessing correlations, redundancy, and performance

Figure 2. Applications for area-level composite social determinants of health measures.

which their grant-funding distributions align with areas and/or populations that are facing comparatively greater adversity. Using many of the composite measures found in this study, the Health Resources and Services Administration has built an initial prototype for a tool (https://data.hrsa.gov/maps/health-equity) that could facilitate such efforts and plans to expand upon this tool in the future.[174]

Composite measures might be useful in Medicare value-based payment programs aiming to drive better health outcomes, reduce expenditures, and strengthen accountability by linking reimbursement processes to the quality and cost of the care delivered.[175] Such payment models can inadvertently create financial penalties for health care providers disproportionately serving communities where poor health outcomes are largely driven by SDH outside of care delivery and what health care providers and hospitals can reasonably control, potentially serving as a disincentive for health care providers to take on such patients.[176,177] Composite measures could be used to improve models and minimize potential disincentives, establish reasonable performance outcome metrics, and more fairly support all health care providers.[177] Composite area deprivation indicators are currently used in

this manner by public payers in other countries.[15] Composite measures could also be used to assess care network adequacy, to estimate the sufficiency of available social services.[178] This information could be particularly useful for accountable care organizations, in which health care provider–hospital partnerships share risks and incentives in the delivery of coordinated services to the Medicare patients in their communities.[92,175]

Limitations

Scoping reviews can be an effective approach for investigations seeking to examine a large and heterogenous body of literature.[179] However, they are subject to several potential limitations. First, the search parameters necessary to ensure comprehensiveness in a scoping review may not be feasible given time and resources, potentially leading to incomplete results.[20] The use of additional databases beyond the 3 used in this study could have led to additional publications (and indices) being identified. Second, scoping review findings are prone to potential bias and/or inconsistency in an individual screener's inclusion and exclusion decisions.[20,179] Other

composite measures might also have been found in these databases by using additional search criteria. The potential for inadvertently excluding composite measures is particularly high for broad topics such as SDH, in which a large number of references were screened, multiple structured searches were used, and findings known by 1 or more study authors prior to the review were included.[20] Scoping reviews typically prioritize finding all incidences of a given topic in the literature over assessing the quality of those incident findings.[179] Additional efforts to validate the composite measures found in this study will be necessary. Finally, we did not assess the integrity or validity of the composite measures described in this review. It is important for readers to review measure documentation and methodology before use in research.

Composite measures, in order to reliably serve their intended purpose, and to avoid drawing overly simplistic conclusions from them, should be constructed in a transparent manner, be based on sound statistical principles, incorporate a holistic cadre of data variables, and have appropriate weighting applied to each of the included variables when calculating the composite measure's aggregate values.[16] Incorrect weighting assumptions can result in the perpetuation of social disadvantages, a potential concern for the Area Deprivation Index.[180,181] Source data should also be timely and dependably characterize a high proportion of individuals in the measured population.[166] Although indices and rankings estimate health disparities, they often do not define the exact cause of that disparity.[166] When applying composite measures to health reforms, policy makers should be mindful of the potential shortcomings of payment models that sometimes make overly broad assumptions about populations, medicalize social ills by charging health care organizations with tackling risks that would be better addressed by social service organizations, and fail to address the intersectional root causes driving inequities and poor population health.[2,182,183] Erroneous assumptions may be why many health reforms, including value-based payment programs, have had mixed or disappointing results to date.[25,169,170,184,185] Nonetheless, government policies that improve equitable access to healthy food, safe and stable housing, educational and employment opportunities, and high-quality health care have great potential to drive desired population health outcomes.[186]

Conclusions

A broad range of area-level composite indices and rankings exist that describe SDH, including many in which index and ranking data are made available for public use. As policy makers aim to become more effective in assessing community needs and leveraging data to invest in population health, an opportunity likely exists to use composite measures that describe social risk to guide investments to the right places and populations. Composite measures may help them achieve more meaningful health outcomes for populations that are facing disproportionate levels of adversity. To ensure that these indices and rankings reliably serve their intended purpose in such initiatives, it will be critical that they are objectively validated, timely, deemed broadly accurate in how they characterize locations and populations, and interpreted correctly.

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ORCID iD

Thomas C. Hassett, PhD ID https://orcid.org/0000-0001-8407-0556

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