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REVIEW ARTICLE

Use Of Area-Based Socioeconomic Deprivation Indices: A Scoping Review And Qualitative Analysis

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ABSTRACT There is considerable interest among researchers, clinicians, and policy makers in understanding the impact of place on health. In this scoping review and qualitative analysis, we sought to assess area-level socioeconomic deprivation indices used in public health and health outcomes research in the US. We conducted a systematic scoping review to identify area-level socioeconomic deprivation indices commonly used in the US since 2015. We then qualitatively compared the indices based on the input-variable domains, data sources, index creation characteristics, index accessibility, the geography over which the index is applied, and the nature of the output measure or measures. We identified fifteen commonly used indices of area-level socioeconomic deprivation. There were notable differences in the characteristics of each index, particularly in how they define *socioeconomic deprivation* based on input-variable domains, the geography over which they are applied, and their output measures. These characteristics can help guide future index selection and application in clinical care, research, and policy decisions.

Research focused on measuring and addressing the social determinants of health has increased substantially in recent years. In clinical care, research, and public policy settings, there is significant interest in understanding the critical influence of geography on health by evaluating the relationships among socioeconomic status, neighborhood context, and health outcomes.

A variety of tools are now available to quantify this complex interplay. (See online appendix exhibit A1 for types of tools.)[1] Socioeconomic status can be evaluated at both an individual level (for example, each person's income, education, or employment) and an area level (for example, area-level measures of poverty, education, or unemployment).

Area-level socioeconomic status can be assessed through single or multidimensional measures. Single measures can be compared directly (for example, comparing the poverty rate of one neighborhood with that of another) or indirectly, using measures of inequality such as the Gini coefficient[2] or the Index of Concentration at the Extremes.[3] One can evaluate multiple area-level factors through the use of composite indices, which combine multiple dimensions of socioeconomic deprivation into a single variable. There are many reasons to use area-level measures, either in addition to or instead of individual-level measures. First, area-level measures are able to examine the significant role that a person's neighborhood or environmental context has on their health outcomes. Second, such measures are often already collected and made publicly available in the US through the Census Bureau. These publicly accessible data provide a means to approximate individual-level data, such as a person's income, that are more difficult

to obtain, although there is a risk for ecological fallacy when using area-level measures to approximate individual-level measures. Finally, area-level measures are uniquely suited for use in population-based studies and public health interventions, and they may also have an important role in policy decisions.

Single area-level measures and composite indices each have their own strengths. Single area-level measures often have less missing data.[4] They also may be simpler to interpret. For example, it is easier to understand a difference in poverty rates between two areas compared with differences in a composite deprivation index created using multiple variables. Similarly, single area-level measures also can be useful in evaluating the impact of a specific aspect of socioeconomic deprivation, such as education or unemployment.

Composite indices also have advantages. First, they provide a more comprehensive representation of neighborhood social determinants of health, capturing multiple dimensions of socioeconomic disadvantage.[5] As a result of their comprehensive nature, composite indices have been shown to have a stronger relationship with health outcomes compared to single-variable measures.[6,7] In addition, when multiple aspects of socioeconomic deprivation are included in a composite index, statistical problems related to collinearity among individual neighborhood-level variables can be avoided in analyses.

Composite indices are gaining prominence in equity research across a variety of fields[8–11] and are being used in health policy decision making. In the United Kingdom and New Zealand, area-level socioeconomic deprivation indices have been used to adjust health care reimbursement rates, with higher payments directed toward those with increased social risk.[12] In the US, MassHealth uses a census tract neighborhood stress score to help adjust payments according to a patient's social risk.[13] More recently, the Centers for Medicare and Medicaid Services committed to addressing inequities through a new accountable care organization Realizing Equity, Access, and Community Health (ACO REACH) model, which includes adjusting reimbursement rates using the Area Deprivation Index.[14] Beyond adjusting reimbursement rates, deprivation indices can be also be used to direct public health resources to areas of need—for instance, helping inform the equitable distribution of COVID-19 vaccines.[15]

The value of such indices has led to their proliferation. However, studies to date in the US have compared only a handful of indices, and they have not been comprehensive in including all possible indices, nor have they provided rationales as to why certain indices were included and others were excluded.[16–18] Thus, there remains a gap in understanding of which indices are used in the US to capture area-level deprivation and the differences between them.

In this study we performed two analyses. First, we conducted a scoping review to assess what area-level socioeconomic deprivation indices are used in public health and health outcomes research in the US. Then we qualitatively compared the various indices to identify similarities and differences to guide their future use in research and public policy.

Study Data And Methods

SCOPING REVIEW We pursued a scoping review to answer this question: What area-level composite indices are commonly used in public health and health outcomes research to measure and assess the impact of neighborhood socioeconomic deprivation in the US? The review protocol was developed a priori in accordance with the JBI Manual for Evidence Synthesis guidelines[19] and was published before the search.[20]

SEARCH STRATEGY The search strategy focused on three key parameters based on the guiding question for the scoping review: index, neighborhood, and deprivation. *Index* was assessed by the terms index or indices. *Neighborhood* was assessed by the terms neighborhood, community, census tract, or ZIP code. *Deprivation* was assessed by the terms deprivation, disparity, vulnerability, distress, or disadvantage. These three factors defined the initial inclusion criteria for potential studies. Exclusion criteria included limiting studies geographically to the US, limiting the search to English, limiting the search to public health and health outcomes research, and limiting the search to studies published since 2015 (as any widely used and current or relevant index should be apparent in recent literature).

TITLE AND ABSTRACT SCREENING Scopus, PubMed, and Cochrane databases were queried based on the search terms above, and the references were compiled in EndNote. No further grey literature (material published or available outside of these databases) was assessed at this stage. One reviewer then screened all of the titles to eliminate any duplicates and any study that was clearly completed outside the US or on topics not relevant to public health or health outcomes research. Two reviewers then independently screened all remaining abstracts to identify any composite indices that assessed area-level socioeconomic deprivation. If it was unclear from the abstract whether an index was used, the methods section for the article was evaluated. Any indices that potentially met

inclusion or exclusion criteria were retained at this stage.

INDEX SCREENING AND REVIEW After abstract screening, a single list of all identified indices from both reviewers was compiled. The list was then reviewed to further assess index characteristics for inclusion and exclusion. This included identifying relevant literature from before 2015 (for instance, journal articles describing the development of the index)[6] and grey literature outside of peer-reviewed journals describing the indices. Indices were excluded on the basis of geography if they did not truly assess area deprivation, they were too geographically broad (for example, they assessed a state or county), or they were too specific (that is, they only allowed assessment between or within urban areas or were only applicable to specific states or localities). Indices were excluded if they were only used once in the literature (that is, they did not reproduce a past index, nor were they cited in subsequent literature). Finally, indices were excluded if they were based on individual survey data that were not widely accessible or had inconsistent input variables.

QUALITATIVE ANALYSIS Included indices were then carefully evaluated using a standard list of defining characteristics developed based on those used in prior studies,[5,11,21,22] the authors' experience using indices in public health and health outcomes research, and the identification of notable similarities and differences during the iterative review of the indices.

The characteristics used for evaluation included input-variable domains used in index creation, input data sources, index creation characteristics, index accessibility, the geography over which the index is applied, and the nature of the output measure or measures. The input variables for each index were evaluated and assigned to one of eight domains. The choice of domains was based on a compilation of those used in prior research.[5,6,23] The data input was defined by the source of the data and available time frames. Index creation characteristics included variable selection considerations, the number of input variables, whether the individual variables were statistically transformed before index creation, the data reduction technique used, and whether the index was transformed after data reduction was applied. To examine accessibility, the first key difference assessed was whether an index was already developed and available for download (termed "precreated") or whether it must be reproduced through a published, standardized means (termed "reproducible"). The second aspect of accessibility reflected whether precreated indices were publicly available or required additional institutional affiliation to use. The geographical measures of area included ZIP code, census tract, and census block group. The output measure was the value each index assigned to the evaluated area. The outputs were defined as either rank based (most commonly percentiles or quantiles) or non–rank based (reporting values corresponding to measured deprivation). Last, we assessed whether the index output could be broken down into subcategories.

LIMITATIONS For the scoping review, the limitations center on the search and inclusion and exclusion criteria used at each stage. It is possible, although unlikely, that an index was not captured by the initial search terms. All seven previously known indices were captured along with thirty-seven potential indices for further review. It is also possible, but unlikely, that in subsequent screening steps, an index was missed or inappropriately excluded. Two reviewers independently assessed all of the abstracts and the excluded indices. Reasons for exclusion are detailed in appendix exhibit A3.[1] Last, only indices used more than once in academic literature were included. This could have biased our review against new indices. However, given the breadth of indices used, with multiple single-use examples in the literature, this criterion was essential to allow an in-depth comparison of the commonly used indices. Limiting the search to 2015 and later also means that it is possible that an older index was missed.

Perhaps the most substantive limitation was our inability to assess and compare the external validity of the various indices. However, this was not the goal of this scoping review. Ideally, any index should be externally valid, meaning that it can be consistently used to explain differences in multiple health outcomes in different areas and during different periods. Nevertheless, the characterization of the indices we pursued here is still invaluable in understanding and appropriately selecting one. Future studies should more explicitly assess each index across a range of outcomes, areas, and times.

Study Results

SCOPING REVIEW The initial search resulted in a total of 3,080 articles (appendix exhibit A2).[1] After elimination of duplicates, research conducted outside of the US, and non–public health or health outcomes research, 1,343 abstracts remained. Initial review of the 1,343 abstracts by two reviewers yielded a total of forty-four potential indices. These indices and the related literature were then critically evaluated as described above, and twenty-nine indices were further excluded. Thus, there were fifteen indices that answered the original scoping review question. The

excluded indices and reasons for exclusion are listed in appendix exhibit A3.[1]

QUALITATIVE ASSESSMENT The fifteen indices were then qualitatively evaluated (appendix exhibits A5–A7).[1] We examined each of eight domains in this evaluation.

▶ **INPUT-VARIABLE DOMAINS:** Each input variable fell into one of eight domains (exhibit 1). The specific variables used in each index are listed in appendix exhibit A8.[1] Of the fifteen indices, all included economic variables. Most also assessed education (twelve of fifteen), housing and environment (twelve of fifteen), and household structure (eight of fifteen). Transportation (five of fifteen), race and ethnicity (four of fifteen), insurance status (three of fifteen), and language barriers (two of fifteen) are evaluated less often.

▶ **DATA SOURCES:** All fifteen indices used American Community Survey census data from 2015 or later. The Child Opportunity Index used data from additional sources, including small-area estimation of health and economic outcomes from the National Center for Health Statistics and more.[24]

▶ **INDEX CREATION CHARACTERISTICS:** The methods used to select input variables fell into three categories: use of empirical findings or theory or both, use of statistical methods that transform a larger number of variables into fewer variables while retaining the variation within the original set, and use of predictive modeling. To some extent, prior research was used to guide initial variable selection for all indices. Four of the indices, including the Social Vulnerability Index, relied solely on prior empirical and theoretical considerations. Other indices used statistical methods such as factor loading analysis or principal component analysis. At least six indices used factor loading analysis or principal component analysis and selected variables with the greatest impact on variation. The Child Opportunity Index used factor loading analysis and also selected variables for their association with health or economic outcomes. For five indices, it was unclear how the input variables were chosen.

To calculate index values, eight of fifteen indices used factor loading analysis or principal component analysis; five used summation;

EXHIBIT 1

Input domains of 15 commonly used social deprivation indices used in the US since 2015

	Domains assessed							
Indices	**Economic**	**Education**	**Housing and environment**	**Household structure**	**Transportation**	**Race and ethnicity**	**Insurance**	**Language barrier**
Area Deprivation Index	•	•	•	•	•			
Social Vulnerability Index	•	•	•	•	•	•		•
Social Deprivation Index	•	•	•	•	•			
Material Community Deprivation Index	•	•	•				•	
Community Need Index	•	•	•	•		•	•	•
Distressed Communities Index	•	•	•					
Child Opportunity Index	•	•	•	•			•	
NCI Census Tract–Level Socioeconomic Status Variable	•	•	•					
Neighborhood Socioeconomic Status Index	•	•		•				
Neighborhood Socioeconomic Disadvantage Index[a]	•			•		•[b]		
AHRQ Socioeconomic Status Index	•	•	•					
Neighborhood Concentrated Disadvantage Index	•			•		•		
Townsend Deprivation Index	•		•		•			
Modified Darden-Kamel Composite Socioeconomic Index	•	•	•		•			
Neighborhood Socioeconomic Status Score	•	•	•					

SOURCE Reference material for each index is listed in appendix exhibit A4 (see note 1 in text). **NOTES** NCI is National Cancer Institute. AHRQ is Agency for Healthcare Research and Quality. [a]Also called the National Neighborhood Data Archive Neighborhood Socioeconomic Disadvantage Index. [b]This index has two versions, one with and one without inclusion of race and ethnicity.

one, the Distressed Communities Index, averaged values; and the calculation methodology was unclear for the Community Need Index (appendix exhibit A6).[1]

The number of input variables ranged from four to twenty-nine. The Social Vulnerability Index and Child Opportunity Index were the only two indices that could be broken into subcategories. These subcategories are meant to represent different domains of deprivation and can be used independent of the composite index. For several of the indices, input data were transformed, through either normalization or ranking. After data reduction, all indices either normalized or standardized the data, and many ranked the data into quantiles.

▶ **ACCESSIBILITY:** Ten of the indices were precreated (available without the need to statistically compute them), whereas five needed to be reproduced. Of the precreated indices, all were publicly available except the National Cancer Institute Census Tract–Level Socioeconomic Status Variable and the National Neighborhood Data Archive Neighborhood Socioeconomic Disadvantage Index, which required further institutional affiliations.

▶ **GEOGRAPHY:** Most indices used data at the census tract level. However, the Area Deprivation Index was available at the census block group level, and the Community Need Index and Distressed Communities Index were only available at the ZIP code level.

▶ **OUTPUT MEASURES:** Six of the ten precreated indices and two of the five reproducible indices were rank based. Appendix exhibit A4 details additional factors assessed, including who developed and maintains the index, the initial purpose behind the index, and how to access the index.[1]

Discussion

This comprehensive scoping review identified fifteen indices of area-level deprivation used in recent public health and health outcomes research in the US, highlighting the variety of tools available. Developing an understanding of the key characteristics of each index, and the variability between indices, is an important step for public health practitioners and health outcome researchers to take before index selection and application. The three characteristics we consider most important in comparing the indices are the input variable domains, the geographical definition of *neighborhood*, and the nature of the output measure or measures.

INPUT VARIABLES AND DOMAINS The input variables used for each index are critical, as they constitute how the index defines *deprivation*. In examining the different input variable domains, we highlight three points worth considering.

▶ **ASSESS RELEVANCE:** First, there is a need to critically evaluate how each input domain and each included variable relate to socioeconomic deprivation. The inclusion of certain variables, or domains, is rather straightforward—for example, every index includes a measure of poverty. Other input variables, such as race, disability, or household composition, are not always as clearly linked to socioeconomic deprivation. Their inclusion may involve underlying assumptions that should be named.

Consider the inclusion of race: Several of the indices include the percentage of Black people within an area. A neighborhood's racial composition is linked to socioeconomic deprivation via racist structures and systems. However, a neighborhood's racial composition is not, in and of itself, a marker of socioeconomic deprivation. Indeed, race is a social construct, and its use in public health and health outcomes research requires careful acknowledgment of underlying assumptions and interpretations.[25,26] When racial or ethnic composition is included, the sociopolitical context that the measure represents should be clearly delineated. For example, racial composition could be thought to be a marker of policies such as redlining, which have led to disproportionate socioeconomic disadvantage in communities populated by those identifying as Black or African American. Thus, including the percentage of Black people in a community, or, similarly, the number of disabled people or the percentage who are single female heads of household, in an index of deprivation does not mean that these are inherently depriving but may instead be a reflection of the historical links between these characteristics and socioeconomic status.

It is especially important to understand and acknowledge these relationships when an index is used to inform public policy. For example, during the COVID-19 pandemic, Michigan used the Social Vulnerability Index to help inform the distribution of COVID-19 vaccines,[27] resulting in political backlash because of the inclusion of race in the index. In this instance, the use of the Social Vulnerability Index may have been appropriate, as there were clear inequities in COVID-19 cases and fatalities based on race. Researchers and policy makers should understand what domains and variables are used to develop an index and intentionally choose one that appropriately defines *deprivation* based on the context in which the index is used. In addition, researchers and policy makers should understand and explicitly acknowledge the assumptions they

Understanding the key characteristics of each index is an important step to take before index selection and application.

are making when they define *deprivation*; this means critically evaluating the variables and domains that make up the selected index. In recognition of this complexity, the National Neighborhood Data Archive Neighborhood Socioeconomic Disadvantage Index has two options: one with race and one without.

Variable selection and data reduction methodology together affect how the input variables influence the final deprivation index. Some indices, such as the Social Vulnerability Index, rely on expert consensus for selecting variables and then do not weight variables differently in data reduction. Indices developed through factor loading analysis or principal component analysis weight variables differently based on their association with the variation in the larger variable set. This approach can help maintain the variation and reduce collinearity, as only a handful of factors may actually account for the majority of the variation in deprivation.

▶ **ASSESS THE LOCAL CONTEXT:** A second key consideration is how the input domains relate to the local context. For example, many indices include vehicle ownership as an input variable. Although this may reflect socioeconomic deprivation in much of the US, it might not in larger urban areas such as New York City. Yet studies conducted within that city have used indices that include vehicle ownership as part of their assessment of deprivation.[28] Not only should the variables relate to deprivation in the local context, but they should also vary sufficiently within the geographical area being studied to detect meaningful differences.

▶ **ASSESS INTERACTION OF INPUT DOMAINS:** A third point to consider is how the input domains interact with the rest of the study analysis. A research study, public health intervention, or public policy may use measures of socioeconomic deprivation at both the individual and area levels. When race or other variables such as insurance status are included as an input variable in a composite index, their interactions with other parts of the analysis may be overlooked. For example, if a researcher is evaluating the intersection of socioeconomic status, race, and health, they should be cautious in choosing an index that also includes race as an input factor. If they do, they should acknowledge the complexity of controlling for area-level racial composition when evaluating individual-level associations with race. When applying an index, one should carefully consider potential interactions between the variables and domains used in an index and the rest of the analysis.

GEOGRAPHY Beyond examining the input variables, the geographic unit over which the index is applied is important to consider, as the geographic unit is how the index defines *neighborhood*. In general, there is a trade-off between the accuracy of an index and data completeness. The smaller the geographic areas assessed, the more accurately an index reflects the neighborhood context because of reduced heterogeneity. Assessments of larger areas are more likely to mask local variability in socioeconomic deprivation, but data are usually more complete.

For example, area-level socioeconomic measures usually underestimate the true socioeconomic status and mortality associations compared with individual-level measures, but they are more accurate in smaller geographic areas such as the census block, block group, or tract than in larger geographic areas such as the ZIP code.[29,30] Expected associations between deprivation and health outcomes identified at the census tract level can disappear when examined at higher levels such as the ZIP code.[20] Thus, assessing smaller geographic areas helps limit ecological bias and provide a more accurate analysis of the impact of one's neighborhood context. As such, most indices use census block groups or tracts that are both more consistent in size and smaller in size, generally containing 300–3,000 residents or 2,500–8,000 residents, respectively. Furthermore, census tract boundaries usually follow visible features and landmarks and are designed to be as homogenous as possible in terms of population characteristics, economic status, and living conditions.[31]

However, drawbacks of using smaller geographic areas include missing data and the potential for sampling bias. For example, using the Agency for Healthcare Research and Quality Socioeconomic Status Index, Seth Berkowitz and colleagues found that 99 percent of patients in a primary care network could be assigned a value for their home address at the ZIP code level, but only 89 percent and 91 percent could be assigned a value for their home address at the block group or census tract level, respectively.[4] In addition,

with more missing data in smaller areas, there is the potential for greater sampling bias and less precision in the estimation of deprivation than for larger areas such as the ZIP code.

In general, census tract– or block group–level data more accurately reflect neighborhood status and associations with health outcomes, but it is important to be aware of the drawbacks of using small areas, including the potential for missing data.

OUTPUT MEASURES Finally, the output measure or measures must be considered when choosing an index. All of the outputs can be categorized either as rank based or non–rank based. Rank-based assessments can be useful in studies with a limited population size by allowing for meaningful comparison groups such as quintiles or quartiles of deprivation. However, one important disadvantage is that ranking can diminish the variability in true deprivation. Most of the variability occurs at the extremes, and grouping the neighborhoods at either end into similar ranks can mask this variation. For example, using the Material Community Deprivation Index to evaluate all census tracts across the US, there is more variability in the top quintile (0.469–1.000) then in the rest of the quintiles combined, and there is more variability in the bottom quintile (0.000–0.239) than in the middle three quintiles (0.307–0.469) combined.[32] Using non-rank-based outputs, when possible, can help avoid masking significant variability.

OTHER CONSIDERATIONS In addition to the three key index attributes we have identified, some authors consider the data source used for index creation as a key attribute.[20] Ideally, the data source used should be up to date, available, and consistently defined across a wide range of geographic areas and times, with minimal missing data.[20,26] In the US, the American Community Survey data satisfy these requirements well, which explains their use in the creation of all indices.

Only the Child Opportunity Index includes data from other sources. Importantly, the Child Opportunity Index is also the only index to weight factors during index development based on their ability to predict health and economic outcomes.[24] This may be advantageous in certain situations—for example, if trying to identify children most at risk for adverse health outcomes. However, when analyzing the relationships between an area-level index and health outcomes, it may be desirable to use an index that was created without consideration of health outcomes, to prevent an inadvertent feedback loop between exposures and modeled or predicted outcomes.

Some authors may also value the number of variables included in an index or the ability to subdivide an index into domains. However, often many of the variables are highly correlated with one another. That is, many of the input variables are collinear, and the index variability may result from a small number of variables.[5,6] Thus, it is unclear whether including twenty-nine variables (as in the Child Opportunity Index) provides a more accurate or complete picture of deprivation than an index that includes just five variables (as in the National Neighborhood Data Archive Neighborhood Socioeconomic Disadvantage Index). Similarly, although some may value the ability to subdivide an index,[15] the primary goal of using an index is to maintain a complete, multidimensional assessment of deprivation. If a researcher or public health practitioner does not want a multidimensional assessment, they should consider using single-variable area-level measures instead.

Conclusion

This scoping review identified fifteen indices commonly used to evaluate area-level socioeconomic deprivation in the US in public health and health outcomes research. To guide application, the indices can be qualitatively compared on the basis of their input variables and domains, the geography over which they are applied, and the nature of their output measures. ■

Cole Brokamp was responsible for the creation of the Material Community Deprivation Index, which was included and evaluated in the scoping review. The authors acknowledge the Cincinnati Children's Hospital Edward L. Pratt Library's research librarians for their assistance in developing the scoping review protocol.

NOTES

1 To access the appendix, click on the Details tab of the article online.
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