

## Differences in Heart Disease Death Rates and Trends by County-Level Deprivation, 2010-2019

Aspen Flynn

Centers for Disease Control and Prevention<sup>1</sup>

Adam Vaughan

Centers for Disease Control and Prevention<sup>1</sup>

Michele Casper

Centers for Disease Control and Prevention<sup>1</sup>

Brian Glassman

U.S. Census Bureau<sup>1</sup>

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### **Abstract**

This study examines geographic patterns of heart disease death rates and recent changes in death rates for adults aged 35-64 years by level of deprivation as measured by the Multidimensional Deprivation Index (MDI). County-level heart disease death rates (2019) and percent change in heart disease death rates (2010-2019) were calculated using a Bayesian conditional autoregressive model for ages 35-64 years. County-level MDI values were calculated by the US Census Bureau based upon six dimensions of deprivation. MDI values were categorized relative to the national MDI. The distributions of heart disease death rates and trends were examined across MDI categories. County-level patterns of high MDI values overlapped extensively with high heart disease death rates, with 48.4% of counties with the highest rates having the highest MDI levels. Likewise, the proportion of counties with the highest MDI levels increased with greater county-level percent increases in heart disease death rates: from 10.2% in counties with strong decreases in death rates to 20.5% in counties with strong increases in death rates. The observed patterns corroborate the results from previous studies demonstrating higher mortality rates among populations with more adverse socioeconomic conditions and suggest greater increases in heart disease death rates in counties with higher deprivation.

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<sup>1</sup> This paper is released to inform interested parties of ongoing research and to encourage discussion of work in progress. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC). Any views expressed are those of the author and not necessarily of the U.S. Census Bureau. The Census Bureau reviewed this data product for unauthorized disclosure of confidential information and has approved the disclosure avoidance practices applied to this release. CDDRB-FY21-POP001-0191.

## **Introduction**

Social determinants of health (SDoH) are associated with death rates for many causes of death, including heart disease. [1-7]. The pattern of SDoH and change in heart disease death rates over time is less clear. After decades of sustained declines, widespread increases in county-level heart disease death rates have been documented, especially among adults aged 35-64 [8]. Given the established association between heart disease death rates and SDoH, investigating the relationship between SDoH and recent county-level increases may provide insight into conditions contributing to the increasing heart disease death rates.

The US Census Bureau has developed a new measure of SDoH: the Multidimensional Deprivation Index (MDI). The MDI is comprised of six dimensions of SDoH: standard of living, health, education, economic security, housing quality, and neighborhood quality [9]. The MDI is based on the idea that both income and non-income based indicators reflect deprivation, and it is designed to capture hardships that people face in multiple areas of their lives.

One main characteristic that distinguishes the MDI from other indices of deprivation is the inclusion of a neighborhood quality dimension. Other indices include dimensions only at the individual, family, or household level [10, 11]. Although the MDI includes dimensions at these levels, it also includes a measure of neighborhood quality at the census block group level (i.e., small neighborhood areas consisting of 600 to 3,000 people) [9].

This analysis examines county-level heart disease death rates and trends among working age adults, ages 35-64, by level of deprivation as measured by the MDI.

## **Methods**

### **Estimating county-level death rates and trends**

We obtained annual heart disease (HD) death counts for ages 35-64 by county of residence for 2010 through 2019 from the National Vital Statistics System of the National Center for Health Statistics (NCHS). HD deaths were defined as those with an underlying cause of death listed as ICD-10 codes I00 to I09, I11, I13, and I20 to I51.<sup>2</sup> The unit of analysis was the county. Given changes in county definitions during the study period (e.g., the creation of new counties), a single set of 3136 counties based on the most recent county definitions was used for the entire study period. We used NCHS bridged-race estimates for annual county-level populations.

We estimated county-level HD death rates for ages 35-64 for the years 2010 to 2019 using a Bayesian conditional autoregressive model. Details of this model have been previously published [12] and it has been used extensively for heart disease mortality [13, 14]. Briefly, this model is based on the Besag-York-Mollié conditional autoregressive model for spatially-referenced count data and incorporates correlation across space and age group [15]. By iteratively estimating parameters and borrowing strength from spatial neighbors and adjacent age groups, these models generate more precise, reliable rates and trends, even in the presence of small death counts and small populations [12, 16]. We fit this model with a Markov chain Monte Carlo (MCMC) algorithm using user-developed code in the R programming language. Annual death rates were estimated as the medians of the posterior distributions defined by the MCMC iterations. Death rates were age-standardized to the 2010 US population using 10-year age groups.

We measured temporal trends by estimating total percent change in HD death rates from 2010 through 2019 using log-linear regression on time-series samples from the posterior distributions of the Bayesian model.

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<sup>2</sup> For more information on ICD-10 codes, see [ICD - ICD-10-CM - International Classification of Diseases, Tenth Revision, Clinical Modification \(cdc.gov\)](https://www.cdc.gov/nchs/icd/icd10cm-international-classification-of-diseases-tenth-revision-clinical-modification).

## Calculating the Multidimensional Deprivation Index

The MDI was constructed using the Alkire-Foster method, a widely-used flexible methodology in which individual-level indicators of deprivation in multiple dimensions are used to identify deprivation and intensity of deprivation [17]. The MDI consists of six dimensions: standard of living, health, education, economic security, housing quality, and neighborhood quality [9, 18]. In order to be considered deprived according to the MDI, a person must be deprived in at least two out of the six dimensions.<sup>3</sup>

All dimensions except for neighborhood quality are based on data collected from the American Community Survey (ACS) 1-year sample for 2019.<sup>4</sup> For neighborhood quality, the ACS data are supplemented with data at the block group level from the Area Deprivation Index (ADI) created by the University of Wisconsin-Madison [19].<sup>5</sup> The ADI is an index of seventeen socioeconomic indicators from the 2015-2019 American Community Survey 5-year dataset. The ADI score includes block group measures of education, employment, income, housing, household composition, and household resources. The ADI measure is constructed by ranking the ADI score from lowest to highest for the nation and grouping the block groups into bins corresponding to each 1 percent range of the ADI score. The ADI ranks block groups from 1, least disadvantaged, to 100, most disadvantaged in the U.S. A county-level ADI value is constructed by creating a weighted average of block group ADIs in the county.

The definitions for deprivation in each dimension are the following: *Standard of Living Dimension*: below the official poverty measure; *Health dimension*: lack health insurance coverage or 65 years of age or over and they report at least two disabilities; *Education dimension*: over 18 years of age and without a high school degree or GED or a child under age 19 for whom the householder lacked a high school degree or GED; *Economic Security Dimension*: unemployed at the time of the survey or lived in a household in which average household hours worked or average household weeks worked for adults between the ages of 18 and 64 was less than 20 hours a week or less than 26 weeks a year, respectively. Adults aged 65 and over meet this requirement if, additionally, household retirement plus Social Security plus Supplemental Security Income is less than the minimum Social Security benefit assuming 30 years of work experience; *Housing Deprivation*: live in an overcrowded housing unit (defined as more than 2 people per bedroom); *Neighborhood Quality Dimension*: live in a county with an ADI value in the top ten percent of disadvantaged counties.

Due to disclosure avoidance policies at the US Census Bureau, the Bureau only releases newly created estimates for counties with populations as large as the least populated US state (i.e., larger than Wyoming). Therefore, the county-level MDI values released by the Bureau are based on internal data for the 115 counties that have populations larger than the state of Wyoming and based on public use data using public use microdata areas that have been converted to the county level for the remaining 3,027 counties [18].

## Creating Categories of the Multidimensional Deprivation Index

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<sup>3</sup> A cut-off of two dimensions is used in much of the literature to define multidimensional deprivation. For a detailed MDI methodology, see [sehsd-wp2021-03.pdf \(census.gov\)](#).

<sup>4</sup> , “For information on confidentiality protection, sampling error, nonsampling error, and definitions in the ACS, see <https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html>”.

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Counties were grouped into four deprivation categories based upon their MDI rate and 95% confidence intervals in relation to the national MDI value (15.8%): Low, National, High, and Very High. The four categories were defined as follows:

- **Low:** Lower than the national MDI (95% confidence interval upper limit was less than the national MDI)
- **National:** Not statistically different from the national MDI
- **High:** Above the national MDI (95% confidence interval limits ranged from just above the national MDI to 2x the national MDI)
- **Very High:** Much above the national MDI (95% confidence interval lower limit was more than 2x the national MDI).

#### Summarizing HD death rates and trends by MDI category

Modelled estimates of the HD death rates and trends were summarized by MDI category. The percent of counties with increasing rates were calculated by MDI category. These percentages were calculated using the posterior distributions of percent change and therefore incorporate uncertainty in the underlying rate estimates. Statistical differences in the rates and trends by MDI category was assessed by calculating the probabilities based on the posteriors of the model output.

#### Data inclusion

For a counties to be included in this analysis, we required that the estimated heart disease death rates were reliable (i.e. the credible interval width was less than the point estimate) and the population was greater than 100 for all years (2010-2019). These requirements ensured that we only reported reliable HD death rates in sufficiently large populations and that the same set of counties was used for all years of the study period and resulted in a final set of 3117 counties.

## Results

Table 1: Distributions of county-level Multidimensional Deprivation Index (MDI) values (2019), county-level heart disease death rates (2019) and percent change in heart disease death rates (2010-2019) for adults ages 35-64 years, and United States.

	MDI (%), 2019	Heart Disease Death Rate per 100,000, 2019	Percent Change in Heart Disease Death Rates (%), 2010-2019
Median (IQR*)	13.0 (9.6, 19.4)	108.3 (83.0, 144.9)	6.5 (-2.5, 15.7)
Range (minimum and maximum)	2.7, 72.3	27.2, 355.8	-34.7, 140.9

\* Interquartile range (IQR): 25<sup>th</sup> and 75<sup>th</sup> percentiles

National MDI Value = 15.8%

Source: National Vital Statistics System and the 2019 American Community Survey 1-year data.

Table 2: Distributions of Multidimensional Deprivation Index (MDI) values, county-level heart disease death rates (2019), percent change in heart disease death rates (2010-2019), and percent of counties with rate increases, by MDI category, for adults ages 35-64 years, United States.

MDI Category	Total counties	MDI Median (IQR)	Median Heart Disease Death Rate per 100,000, 2019 (IQR)	Median Percent Change in Heart Disease Death Rate, 2010-2019 (%) (IQR)	% Counties with Increases in Heart Disease Death Rates, 2010-2019 (95% Credible Interval)
Low MDI	1473	9.6 (7.9, 11)	88.1 (71.8, 107.8)	5.3 (-2.9, 14.2)	61.0 (58.3, 63.6)
National MDI	884	15.7 (14, 17.1)	120.9 (94.0, 149.7)	7.5 (-3.4, 16.6)	63.3 (60.8, 66.3)
High MDI	208	24.0 (21.3, 27.2)	127.2 (98.1, 160.3)	6.3 (-3.3, 14.3)	63.5 (58.2, 68.8)
Very High MDI	552	45.0 (41.5, 49.6)	168.4 (135.5, 198.5)	8.2 (0.2, 18.6)	68.5 (63.6, 72.8)

Source: National Vital Statistics System and the 2019 American Community Survey 1-year data.

### County-level MDI values

The median county-level MDI value was 13.0% (Table 1). The MDI distribution was bimodal (Figure 1). Counties with Very High MDI values were concentrated primarily in the South. Counties with Low MDI scores were concentrated in portions of the Midwest and the Northeast.

### County-level heart disease death rates and trends

The median county-level heart disease death rate was 108.3 per 100,000 (Table 1). The highest rates were concentrated in the South and extended west to parts of Oklahoma and Texas (Figure 1). Median county-level percent change in heart disease death rates from 2010-2019 was 6.5%, with 69.0% of counties experiencing an increase. Counties with the largest increases in heart disease death rates (>10%) were located throughout the country and not concentrated in any single geographic region (Figure 1).

### Patterns of MDI with Heart Disease Death Rates and Trends

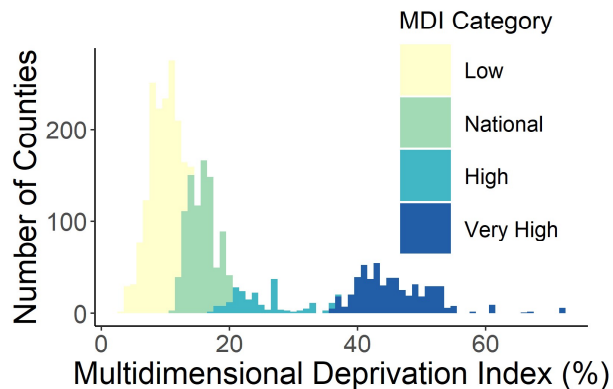
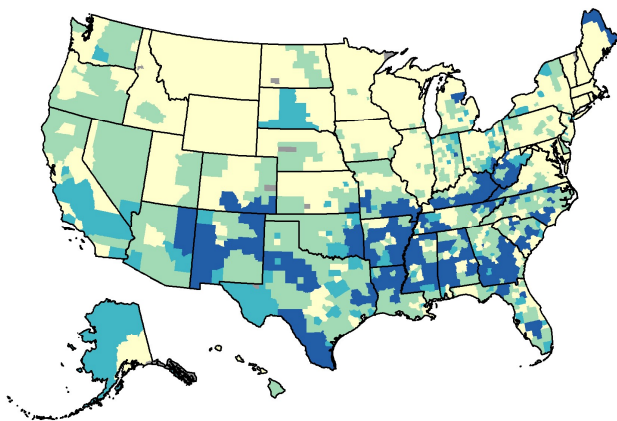
Median county-level heart disease death rates increased as the category of MDI increased. (Table 2). The distributions of HD death rates in the lowest and the highest MDI categories were distinct such that the IQRs did not overlap (IQRs: Low MDI (71.8, 107.8), Very High MDI (135.5, 198.5)).

The Median percent change in heart disease death rates is lower with counties with a Low MDI compared to counties with a Very High MDI (Table 2). The percent of counties with increasing death rates is greater in the very High MDI category compared to the in the Low MDI category (Low MDI: 61.0%, Very High MDI: 68.5%) (Table 2).

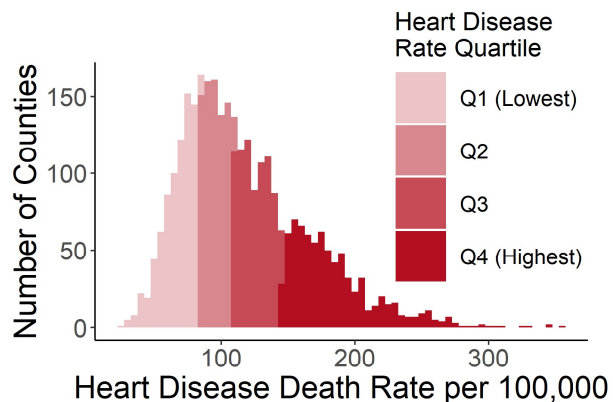
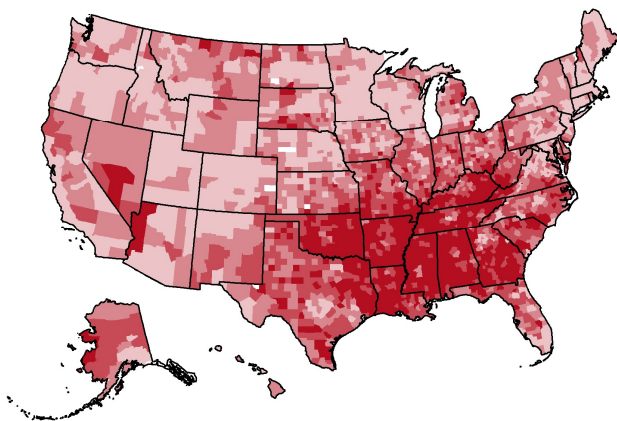
The percent of counties with Very High MDI values increased with each quartile of heart disease death rates. (Figure 2). Among counties in the lowest quartile, 79.1% of counties had a Low MDI and 0.9% of counties had a Very High MDI. Conversely, of counties in the highest rate quartile, 10.1% of counties had a Low MDI and 48.4% of counties had a Very High MDI. The proportion of counties with Very High MDI increased with each sequential percent change quartile, from 10.2% in counties with strong decreases to 20.5% in counties with strong increases.

Figure 1: Multidimensional Deprivation Index (MDI), heart disease death rates per 100,000 (2019) in adults ages 35-64, and percent change in heart disease death rates (2010-2019) in adults ages 35-64, by county, United States

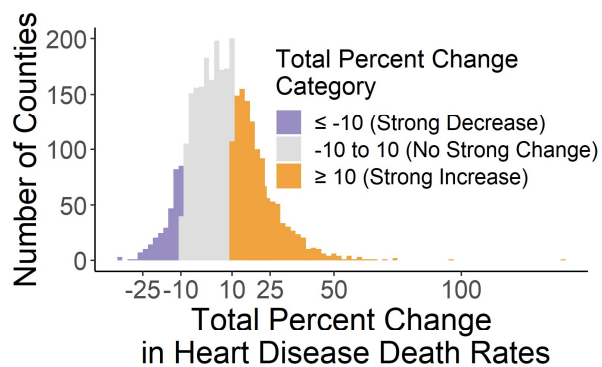
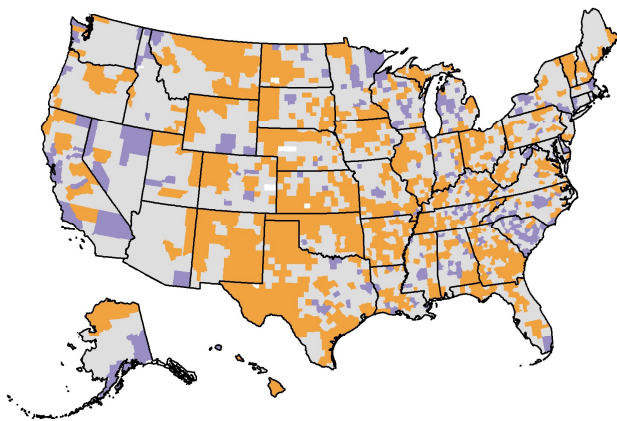
### MDI, 2019



### HD Death Rate, 2019

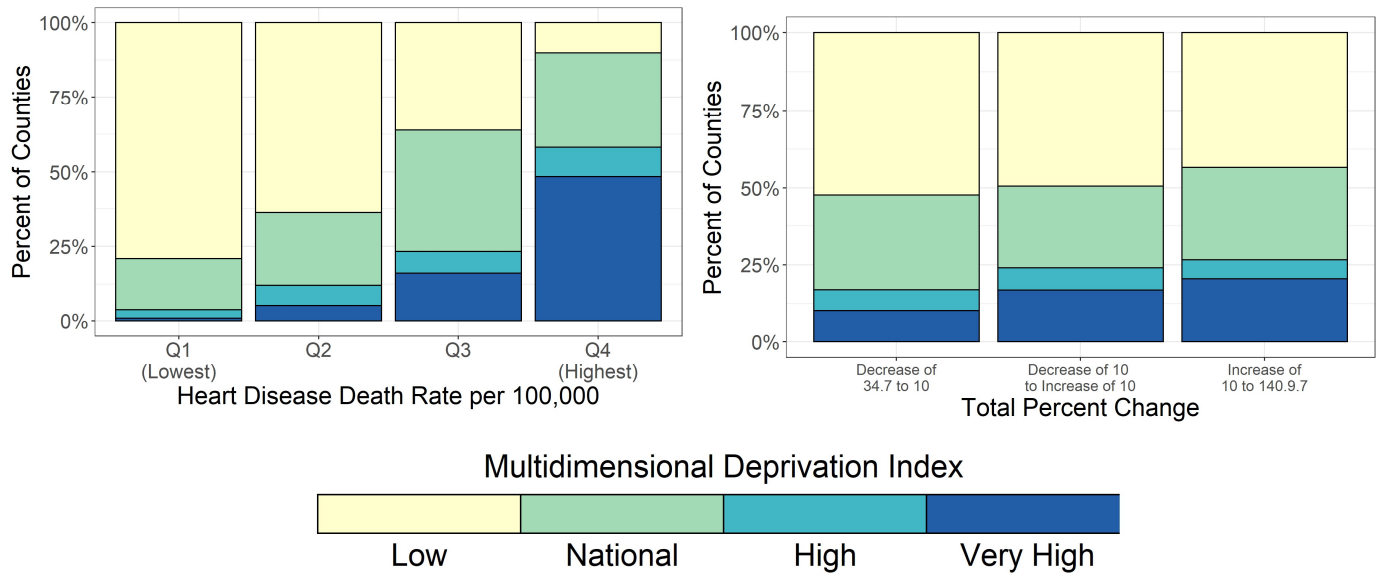


### Percent Change in HD Death Rates, 2010-2019



Source: National Vital Statistics System and the 2019 American Community Survey 1-year data.

Figure 2: Multidimensional Deprivation Index (MDI) category by heart disease death rate quartile (2019) for adults ages 35-64 and total percent change (2010-2019) for adults ages 35-64, United States



Source: National Vital Statistics System and the 2019 American Community Survey 1-year data.



## **Discussion**

This study examined county-level heart disease death rates in 2019 and percent change in death rates from 2010 to 2019 in adults ages 35 to 64 in relation to county-level deprivation as defined using the Multidimensional Deprivation Index (MDI) developed by the US Census Bureau. We found similar geographic patterns in heart disease death rates and MDI values, with the highest values for both concentrated in the South. We also found that increases in heart disease death rates were slightly more concentrated in counties with the highest MDI values.

This is the first study to our knowledge that examines the relationship between the MDI and a health outcome. The results reported here demonstrate that the MDI is strongly associated with heart disease death rates. The findings corroborate results from other studies that examined the associations of single measures of community-level social determinants of health (SDoH) (e.g. including poverty, education, and unemployment) with heart disease [6, 20, 21]. There are very few published studies of the association between SDoH and trends in heart disease mortality. A recent study in Sweden found that neighborhoods with higher deprivation levels, defined using a national deprivation index, had slower declines in heart disease death rates [22]. These study results are similar to ours; however, they only observed decreases in heart disease mortality, while we observed increases in many counties.

A major strength of this study is the ability to account for uncertainty in both the exposure and the outcome. The categorization of the MDI based on confidence intervals accounts for uncertainty in the MDI estimates, and the use of Bayesian analysis incorporates uncertainty in both heart disease death rates and trend estimates. A strength of the MDI is the inclusion of the neighborhood quality dimension, thereby incorporating important factors outside of the individual/household level. The ability of the MDI to capture multiple, compounding disadvantages in the same location is also a strength, as these factors can overlap in communities [10, 23]. A limitation of this study is the potential misclassification of cause of death on the death certificates. However, use of the broad category All Diseases of the Heart substantially reduces this potential bias.

## **Conclusion**

The relationships between the MDI and heart disease death rates and trends among working age adults observed in this study corroborate the results from previous studies demonstrating higher mortality rates among populations with more adverse socioeconomic conditions and suggest greater increases in heart disease death rates in counties with higher deprivation.

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