Heat and Health Index
Technical Documentation

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Glossary

Indicator – a variable used within the Heat and Health Index that captures a component of historical heat and health burden or influences the way a person may experience heat

Modules – functional groupings of indicators that represent distinct aspects of the impact of heat on human health

Prevalence – the number of people who have a specific characteristic or disease in a given time period. This is usually represented as the percentage, rate, or proportion of the total population in the same area

Sensitivity – biological conditions that may increase the risk of negative health outcomes when the individual is exposed to extreme heat

Sociodemographic – social or demographic characteristics that increase exposure or sensitivity to heat or lessen one's ability to cope with extreme heat

Tertile – a division of data into three equal groups

ZIP Code Tabulation Areas (ZCTA) – groupings of ZIP codes that the U.S. Census Bureau uses to allow mapping and analysis of U.S. Postal Service ZIP codes. See ZIP code Tabulation Areas | U.S. Census Bureau

Introduction

Exposure to high temperatures is related to a large number of illness and deaths each year in the United States (*1, 2*). Because climate changes are likely to lead to more frequent and intense heat events, jurisdictions need to have tools available to help prepare for extreme heat and prevent heat-related illness and death.

Communities where people are most likely to feel the effects of heat on their health may need additional assistance preparing for and responding to heat events. The Heat and Health Index (HHI) can help those communities identify which factors may contribute to their vulnerability to heat and inform which interventions might decrease this vulnerability.

What is the Heat and Health Index?

The Heat and Health Index (HHI) is the first national tool to incorporate spatially granular heat-related illness and community characteristics data to measure extreme heat vulnerability and help communities prepare for warming temperatures in a changing climate.

The HHI delivers a single ranking for each ZIP code so that public health officials, city planners, policymakers and community members can identify and map areas that may be at increased risk of experiencing negative health outcomes, such as heat-related illness, from heat across the country. In addition to including historical heat-related illness data, the HHI incorporates data on pre-existing health conditions, sociodemographic factors, and natural and built environment characteristics, to assess vulnerability to extreme heat.

Communities at increased risk of negative health impacts from heat may need more assistance preparing for and responding to heat events. The HHI can help those communities identify which factors may be contributing to their vulnerability to heat and inform which interventions might decrease this vulnerability.

What data are included in the HHI?

The Heat and Health Index comprises four (4) modules:

1. A **Historical Heat and Health Burden** module which captures measures of previous experience with heat at the local level (ZCTA or ZIP code)
2. A **Sensitivity** module made of pre-existing health conditions that may increase risk of negative health outcomes when the individual with the condition is exposed to extreme heat
3. A **Sociodemographic** module encompassing social and demographic characteristics that increase exposure or sensitivity to heat or lessen one's ability to cope with extreme heat
4. A **Natural and Built Environment** module which focuses on characteristics of the natural and built environment that increase exposure or sensitivity to heat or lessen one's ability to cope with extreme heat

Figure 1. The four modules included in the HHI.

Each indicator used within the HHI was organized into the modules described above. All indicators were selected based on review of the literature, existing indices and databases, subject matter expert guidance, data availability nationwide at the ZIP code level, satisfying inclusion criteria, and statistical analysis, including correlation analysis. Additional details on the inclusion criteria for indicators are provided in the methods section below.

How can people use the HHI?

The HHI allows public health officials, city planners, policymakers, and community members to

- Identify and prioritize areas that may require special attention during the heat season or additional action to reduce heat-related illness over time
- Educate and inform the public about heat risk in their community
- Analyze the unique, local factors driving heat-related illness to inform policy and decision-making

Important Notes on the HHI

- The HHI uses ZIP Code Tabulation Areas (ZCTAs) to aggregate data and show index ranks across the U.S. ZIP codes, created by the U.S. Postal Service, do not have physical boundaries associated with their delivery routes; therefore, the U.S. Census Bureau created ZCTAs to allow mapping and geographical analyses of ZIP codes. While ZCTAs do not precisely match ZIP code service areas, they provide a reasonable approximation of ZIP codes, making it easier to analyze and understand data for specific communities or neighborhoods. More information about the creation of ZCTAs can be found on the U.S. Census Bureau Website.
- Not all ZIP codes are represented by a ZCTA. For example, some ZIP codes that correspond to P.O. Box addresses, businesses, military bases, or organization-specific locations may not be represented within ZCTA boundaries.
- The maps may show areas where ZCTA boundaries are not included. These are normally areas that are uninhabited such as land and water areas.
- For each ZCTA-level observation in HHI, a value of missing was assigned under one of three circumstances: the original data source did not contain that ZCTA; the original data source did contain the respective ZCTA, but the indicator value was missing or left blank; or, in cases where the original data source was cross walked to ZCTA-level geography, the original geographic unit did not correspond to a ZCTA. Those cases where the original geographic unit did not correspond to a ZCTA most often occur in locations with no permanent residents.
- Index calculations for Hawaii and Alaska were not possible due to the limited availability of some of the data that were included in the index.

Questions? The Heat and Health Index (HHI) is accessible on the CDC Environmental Public Health Tracking Heat and Health Tracker.

Methods

Indicator Selection

Indicators representing Historical Heat and Health Burden, Sensitivity, Sociodemographic, and Natural and Built Environment were selected based on review of the literature, review of existing indices, and subject matter expertise. Identified indicators were evaluated for reproducibility, quality, and availability. All indicators selected for inclusion in the HHI were required to meet the following minimum criteria:

1. Data are available nationwide at the ZIP code level, ZCTA level, or can be readily created at the ZCTA level.
2. Indicator relates to or impacts vulnerability to negative health outcomes from heat.
3. Data are routinely updated to allow for future iterations of the index.

Indicators meeting the minimum criteria for inclusion were then evaluated against module-specific inclusion criteria, as described below.

Historical Heat and Health Burden Module Inclusion Criteria

Indicators representing historical heat and health burden are intended to capture measures of previous exposure to heat at the local level (ZCTA or ZIP code). All indicators included in this module must

- Represent a measure of heat or heat-related illness
- Not be represented by another historical heat and health burden module indicator

Sensitivity Module Inclusion Criteria

Indicators representing sensitivity are intended to capture biological conditions that may increase negative health outcomes when exposed to extreme heat. All indicators included in this module must

- Measure a condition of a population that impacts physiological response to heat
- Have a mechanism through which the indicator makes the body more likely to experience negative health outcomes when exposed to heat and/or the indicator itself is exacerbated by exposure to extreme heat
- Not be represented by another sensitivity module indicator

Sociodemographic Module Inclusion Criteria

Indicators representing sociodemographic factors are intended to capture social or demographic characteristics that increase exposure or sensitivity to heat or lessen one's ability to cope with extreme heat. All indicators included in this module must

- Represent a social or demographic characteristic
- Have a mechanism through which the indicator increases exposure or sensitivity to heat or lessens one's ability to cope with extreme heat

- Not be represented by another sociodemographic module indicator

Natural and Built Environment Module Inclusion Criteria

Indicators are intended to capture characteristics of the natural or built environment that increase exposure or sensitivity to heat or lessen one's ability to cope with extreme heat. All indicators included in this module must

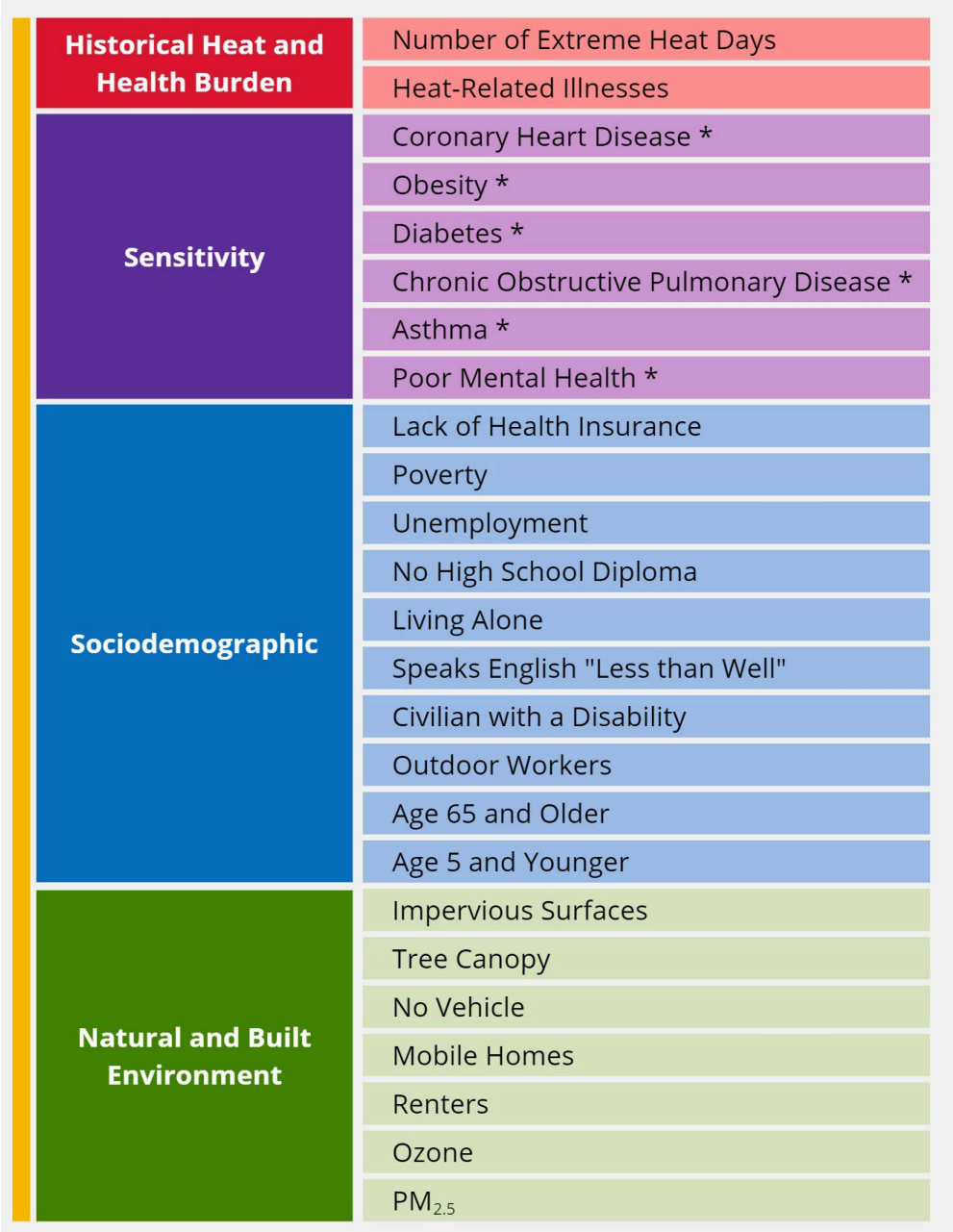
- Represent a characteristic of the natural or built environment
- Have a mechanism through which the indicator increases exposure or sensitivity to heat or lessens one's ability to cope with extreme heat
- Not be represented by another natural and built environment module indicator

In addition to passing the inclusion criteria described above, all indicators underwent statistical analysis, including correlation analysis, to identify the final set of indictors. Some indicators initially identified as candidates for inclusion using the above criteria (percent of ZCTA that is high intensity development, housing cost burden, crowding, prevalence of high blood pressure, and prevalence of stroke) were ultimately excluded from the HHI due to significant correlation with other indicators or lack of contribution to the index. For example, the percent of ZCTA that is high intensity development was highly correlated with the percent of ZCTA covered by impervious surfaces. Because both indicators capture similar aspects of the built environment, only percent of ZCTA covered by impervious surfaces was retained. Several sensitivity indicators that were significantly correlated, such as chronic obstructive pulmonary disease and diabetes, were retained because they capture distinct disease mechanisms for which there is scientific support that comorbidity could increase negative health outcomes from or increase sensitivity to extreme heat. Prevalence of chronic kidney disease was excluded due to discontinuation of the measure in the data source it was obtained from (CDC PLACES data; described below).

Indicators Included in the HHI

Figure 2 below shows the final indicators included within the HHI, grouped by module.

Figure 2. The final indicators included in the HHI, grouped by module.



* Sensitivity module indicators are marked with asterisks because they are calculated differently than other indicators in the index. While most indicators can have a range of values, the Sensitivity module indicators represent only whether a given ZCTA has a high estimated prevalence of the disease or not.

Text-Only Version of Figure 2- Final indicators included in the HHI, grouped by module.

Historical Heat and Health Burden

- Number of Extreme Heat Days
- Heat-related Illness

Sensitivity

- Coronary Heart Disease *

- Obesity *
- Diabetes *
- Chronic Obstructive Pulmonary Disease *
- Asthma *
- Poor Mental Health *

Sociodemographic

- Lack of Health Insurance
- Poverty
- Unemployment
- No High School Diploma
- Living Alone
- Speaks English “Less than Well”
- Civilian with a Disability
- Outdoor Workers
- Age 85 and Older
- Age 5 and Younger

Natural and Built Environment

- Impervious Surfaces
- Tree Canopy
- No Vehicle
- Mobile Homes
- Renters
- Ozone
- $PM_{2.5}$

Data Sources and Indicator Rationale and Processing

Multiple data sources contributed to the final indicators. Table 1 provides a link to each of the data sources, years of data included, and limitations of the data. A brief description of the indicator processing and rationale are included below.

Table 1. Data sources used for the indicators in the Heat and Health Index including links to the data, years of data acquired, and limitations.

Data Source	Indicators Derived from Data Source	Indicator Descriptions	Years of Data	Limitations of Data
Centers for Disease Control and Prevention, National Environmental Public Health Tracking Network (Tracking Network) **National Environmental Public Health Tracking Network Data Explorer (cdc.gov)**	1. Number of Extreme Heat Days	1. Annual Mean Number of Extreme Heat Days (95th percentile)	2018-2022	The Tracking Network derives the census tract measure of number of extreme heat days from the National Land Data Assimilation System (NLDAS-2), which is modeled meteorological data that may not accurately reflect the true maximum air temperature in all locations. Temperatures are derived from modeled meteorological data and may differ from the temperature measurements of weather stations. Extreme heat days are defined as days where the temperature in a ZCTA exceeded the 95th percentile of all values for that ZCTA from 1991-2020. Individuals may have varying degrees of acclimatization to climate conditions. Therefore, these data may not reflect what is perceived as extreme across all geographic regions. Due to the crosswalk employed to transform data to ZCTA geographies, measurement may not be wholly representative of entire ZCTA population.
National Emergency Medical Services Information System (NEMSIS) **National Emergency Medical Services Information System**	1. Heat-Related Illness	1. Percentile Rank of the rate of Heat-Related EMS Activations reported to NEMSIS	2020-2022	Due to data use agreements, raw NEMSIS data cannot be shared. NEMSIS percentile ranked raw data prior to sharing with CDC/ATSDR. Incomplete data may bias distribution and ranking of rates. Additionally, due to the nature of reported data, certain localities may not have reported data to NEMSIS during the time period 2020-2022 and are thus not captured in the data.

(NEMSIS) Website				
Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Population Level Analysis and Community Estimates (PLACES) Data **PLACES: Local Data for Better Health | CDC**	1. Coronary Heart Disease 2. Obesity 3. Diabetes 4. Chronic Obstructive Pulmonary Disease 5. Asthma 6. Poor Mental Health	1. Crude Prevalence of Coronary Heart Disease (CHD) among Adults Aged >= 18 Years of Age (Model-based; ZCTA) 2. Crude Prevalence of Obesity among Adults Aged >= 18 Years of Age (Model-based; ZCTA) 3. Crude Prevalence of Diagnosed Diabetes among Adults Aged >= 18 Years of Age (Model-based; ZCTA) 4. Crude Prevalence of Chronic Obstructive Pulmonary Disease (COPD) among Adults Aged >= 18 Years of Age (Model-based; ZCTA) 5. Crude Prevalence of Current Asthma among Adults Aged >= 18 Years of Age (Model-based; ZCTA) 6. Crude Prevalence of Mental Health Not Good for >=14 Days among Adults Aged >= 18 Years of Age (Model-based; ZCTA)	PLACES 2023 release	PLACES data are based on self-reported survey data from BRFSS, which may be subject to error and bias. PLACES data are produced by small area estimation methods. Limitations of the PLACES data are outlined in the measure definitions page of the PLACES website under "Limitations of Indicator" portion of the documentation: PLACES: Measure Definitions | CDC
U.S. Census Bureau, American Community Survey (ACS) 5-year estimates **American Community Survey (ACS) Data**	1. Lack of Health Insurance 2. Poverty 3. Unemployment 4. No High School Diploma 5. Living Alone 6. Speaks English "Less Than Well" 7. Civilian with a Disability 8. Outdoor Workers	1. Percentage Uninsured in the Total Civilian Noninstitutionalized Population Estimate 2. Percentage of Persons Below 150% Poverty Level Estimate 3. Unemployment Rate Estimate 4. Percentage of Persons with No High School Diploma (Age 25+) Estimate	2015 - 2019	ACS data are estimates based on data collected from a sample of the population in the U.S. rather than from the whole population. The U.S. Census provides guidance here Guidance for Data Users (census.gov)

	9. Aged 65 and Older 10. Aged 5 and Younger 11. No Vehicle 12. Mobile Homes 13. Renters	5. Percentage of Persons (Age 18+) Living Alone Estimate 6. Percentage of Persons (age 5+) who Speak English "Less Than Well" Estimate 7. Percentage of Civilian Noninstitutionalized Population with a Disability Estimate 8. Percent Civilian Employed Population (Age 16+) Employed in Natural Resources, Construction, and Maintenance Occupations Estimate 9. Percentage of Persons Aged 65 and Older Estimate 10. Percentage of Persons Under 5 Years Estimate 11. Percentage of Households with No Vehicle Available Estimate 12. Percentage of Mobile Homes Estimate 13. Percent of Renter Occupied Housing Units Estimate		
Multi-Resolution Land Characteristics Consortium (MRLC) **NLCD Data**	1. Impervious Surface 2. Tree Canopy	1. Percent of ZCTA Covered in Impervious Surfaces 2. Percent of ZCTA Covered with Tree Canopy Cover	2021 NLCD	National Land Cover Database (NLCD) data are released periodically with a lag, meaning that data might not represent current conditions. Given the extent of the pixels, granular features and changes should be verified with a higher resolution data source and might not be captured in the current measures.
Environmental Protection Agency (EPA) Downscaler Modeled Data	1. Ozone 2. $PM_{2.5}$	3. Annual Mean Days Above Ozone Regulatory Standard – 3 Year Average 4. Annual Mean Days Above $PM_{2.5}$	2018-2020	EPA Downscaler data are modeled data; therefore, ozone and $PM_{2.5}$ indicators may over or under-estimate true pollutant concentrations.

EPA Downscaler Data Download		Regulatory Standard – 3 Year Average		Due to the crosswalk employed to transform data to ZCTA geographies, measurement may not be wholly representative of entire ZCTA population.

CDC National Environmental Public Health Tracking

Module(s): Historical Heat and Health Burden Module
Indicator(s): Number of Extreme Heat Days

The CDC's National Environmental Public Health Tracking Network (Tracking Network) provided data on relative heat burden with the number of extreme heat days. This indicator is meant to quantify the 5-year average number of extreme heat days from 2018-2022 for each ZCTA in the HHI to evaluate the relative burden of extreme heat nationally. The heat days are described as "relative" because the extreme heat values are relative to what people in the ZCTA typically experience. For example, temperatures in the northwest are typically cooler on average than those in the southwest, so an extreme heat day in a northwestern ZCTA may be ten degrees lower than an extreme heat day in a southwestern ZCTA.

Rationale for inclusion:
High ambient temperatures can lead to negative health outcomes, such as heat cramps, heat exhaustion, heat syncope, and heat stroke *(3)*. Understanding a community's experience with extreme heat and potential for subsequent adverse health effects requires temperature and relative-humidity data at highly resolved spatiotemporal scales. Though reliable temperature and relative-humidity data are available from the National Weather Service Office weather stations, these stations are designed to provide climatological observations, and many are far from population centers. The National Land Data Assimilation System (NLDAS-2) provided by the Tracking Network provides modeled, quality controlled, spatially and temporally continuous meteorological data covering the entirety of the United States, except Alaska and Hawaii.

Data Processing:
The number of extreme heat days measure is derived from the census tract number of extreme heat days, using a relative threshold of the 95th percentile of temperatures, produced by the Tracking Network for years 2018-2022. The census tract measure is cross walked to overlapping 2010 ZCTAs. ZCTAs are assigned the value of the census tract that it overlaps. When a ZCTA overlaps multiple census tracts, the average value of the census tracts is assigned to the ZCTA. If more than one ZCTA overlaps with a single census tract, all overlapping ZCTAs receive the value of the census tract. The crosswalk and alignment of values was repeated for each year of data 2018-2022. The 5-year average number of extreme heat days per ZCTA was then calculated. Percentile ranked number of extreme heat days is calculated by taking the percentile rank of the 5-year average number of extreme heat days per ZCTA.

National Emergency Medical Services Information System (NEMSIS)

Module(s): Historical Heat and Health Burden Module
Indicator(s): Heat-Related Illness

The National Emergency Medical Service Information System (NEMSIS) collects Emergency Medical Service (EMS) data across the U.S. For the HHI, NEMSIS provided percentile rankings of the rates of heat-related emergency medical services calls by ZCTA across the U.S. for the period 2020–2022. This indicator was intended to quantify the burden of historical heat-related illness for each ZCTA in the HHI to evaluate the relative burden of heat-related illness nationally.

Rationale for inclusion:
The Intergovernmental Panel on Climate Change (IPCC) reported that heat waves increased in magnitude and frequency towards the end of the twentieth century and are projected to further increase in frequency, intensity, and duration worldwide (*4*), which could result in increases in heat-related illness, morbidity, and mortality. During heat waves, hospital admissions (*5*) and calls to emergency medical services (*6*) also increase.

Any individual, regardless of age, sex, or health status can develop heat-related illness if engaged in intense physical activity and/or is exposed to environmental heat and humidity. Heat-related illnesses range from mild heat edema and rash, heat syncope (temporary loss of consciousness as a result of prolonged heat exposure), and heat cramps (brief, intermittent, and often severe muscular cramps typically occurring in muscles that are fatigued by heavy work) to heat exhaustion (symptoms include mild disorientation, generalized malaise, weakness, nausea, vomiting, headache, tachycardia (rapid beating of the heart) and hypotension) (*7*). As untreated heat exhaustion can progress to heat stroke (a medical emergency, that if left untreated, can result in death or permanent neurological impairment (*8*), treatment should begin at the first sign of heat exhaustion (*9*).

Data processing:
Data were received from NEMSIS at the ZCTA level as percentile ranks of the 3-year average heat-related EMS activation rates for 2020–2022. This was done by summing the rates, which are the number of EMS calls per 100,000 population, and dividing by the number of years, 2020–2022, and then calculating the percentile rank for each ZCTA. The rank value was then used to place ZCTAs into quartile groups based on overall distribution with the lowest rank values being placed in quartile 1 and the highest being assigned to quartile 4. ZCTAs with 10 or fewer EMS calls are denoted in the data to draw attention to potentially unstable rates. This is included in the column called “LOW_EMS.” ZCTAs with 10 or fewer EMS calls are given the value of “1” and those with greater than 10 EMS calls given the value “0.”

CDC Population Level Analysis and Community Estimates (PLACES) Data

Module(s): Sensitivity Module
Indicator(s): Coronary Heart Disease, Obesity, Diabetes, Chronic Obstructive Pulmonary Disease, Asthma, Poor Mental Health

The CDC Population Level Analysis and Community Estimates (PLACES) data provides model-based, population-level analysis and community estimates of health measures for all ZCTAs across the United States. For the HHI, six health conditions were included in the sensitivity module because they are conditions that can increase a person’s sensitivity to heat or can be exacerbated by exposure to heat: coronary heart disease, obesity, diabetes, chronic obstructive pulmonary disease, asthma, and mental health.

Rationale:
The Intergovernmental Panel on Climate Change (IPCC) reported that heat waves increased in magnitude and frequency towards the end of the 20th Century and are projected to further increase in frequency, intensity, and duration worldwide, which could result in increases in heat-related morbidity and mortality (*4*). Heat-related deaths are preventable(*5, 10*) and exposure to extreme heat can overwhelm a person's ability to keep the body temperature at a normal level, thereby causing the person to suffer heat-related illness, which can sometimes lead to death (*10*).

Certain groups of people are more at risk for heat-related illness and death from extreme heat (*11*). Certain health conditions, such as diabetes, mental health conditions, and obesity can increase a person's risk of adverse outcomes (*12, 13*). Studies of heat waves and mortality in the United States demonstrate that increased temperatures or periods of extended high temperatures have increased heat-related mortality, cardiovascular-cause mortality, respiratory mortality, heart attacks, and all-cause mortality (*5, 14-18*). During heat waves, calls to emergency medical services and hospital admissions have also increased (*5, 6*).

Because not all populations are equally at risk from heat, knowing where those with increased sensitivity to heat are located can help cities allocate resources, such as cooling centers, more effectively and ensure those most at risk stay safe during a heat event.

Data Processing:
Data are already modeled and produced by the CDC PLACES team. Each of the following indicators was created by taking the percentile rank of the following PLACES measures:

- Coronary Heart Disease: Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they had angina or coronary heart disease
- Obesity: Respondents aged ≥18 years who have a body mass index (BMI) ≥30.0 kg/m² calculated from self-reported weight and height. Exclude the following
    - Height: data from respondents measuring <3 ft or ≥8 ft
    - Weight: data from respondents weighing <50 lbs or ≥650 lbs
    - BMI: data from respondents with BMI <12 kg/m^2 ≥100 kg/m^2
    - Pregnant women
- Diabetes: Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they have diabetes other than diabetes during pregnancy
- Chronic obstructive pulmonary disease: Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they had chronic obstructive pulmonary disease (COPD), emphysema, or chronic bronchitis
- Asthma: Weighted number of respondents who answer "yes" to both of the following questions: "Have you ever been told by a doctor, nurse, or other health professional that you have asthma?" and the question "Do you still have asthma?"
- Mental health not good for ≥14 Days: Respondents aged ≥18 years who report 14 or more days during the past 30 days during which their mental health was not good

All sensitivity indicators were flagged based on whether they were in the top tertile (33.33%) of all ZCTAs. A ZCTA receives a score of 1 for a given indicator if the estimate for that ZCTA (e.g., diabetes prevalence) is flagged

as being in the top tertile of all ZCTAs; otherwise, the ZCTA receives a score of 0. All indicator flags for a ZCTA are averaged, creating a flag score between 0-1 (1 meaning all 6 indicators were flagged). Finally, the flag score is percentile ranked to create a final Sensitivity ranking between 0-1.

U.S. Census Bureau American Community Survey (ACS)

Module(s): Sociodemographic and Natural and Built Environment Modules

Indicator(s): Lack of Health Insurance, Poverty, Unemployment, No High School Diploma, Living Alone, Speaks English "Less than Well", Civilian with a Disability, Outdoor Workers, Age 65 and Older, Age 5 and Younger, No Vehicle, Mobile Homes, Renters

All the Sociodemographic indicators and three of the Natural and Built Environment indicators were generated using the U.S. Census Bureau American Community Survey (ACS) 5-year estimates 2015–2019 data. These population characteristics were selected to identity communities that may experience disproportional adverse outcomes during extreme heat.

The following indicators were included from the ACS data

1. Percentage Uninsured in the Total Civilian Noninstitutionalized Population Estimate *(Sociodemographic Module)*
2. Percentage of Persons Below 150% Poverty Estimate *(Sociodemographic Module)*
3. Unemployment Rate Estimate *(Sociodemographic Module)*
4. Percentage of Persons with No High School Diploma (Age 25+) Estimate *(Sociodemographic Module)*
5. Percentage of Persons (Age 18+) Living Alone Estimate *(Sociodemographic Module)*
6. Percentage of Persons (age 5+) who Speak English "Less Than Well" Estimate *(Sociodemographic Module)*
7. Percentage of Civilian Noninstitutionalized Population with a Disability Estimate *(Sociodemographic Module)*
8. Percent Civilian Employed Population (Age 16+) Employed in Natural Resources, Construction, and Maintenance Occupations Estimate *(Sociodemographic Module)*
9. Percentage of Persons Aged 65 and Older Estimate *(Sociodemographic Module)*
10. Percentage of Percent Persons Under 5 Years Estimate *(Sociodemographic Module)*
11. Percentage of Households with No Vehicle Available Estimate (*Natural and Built Environment Module)*
12. Percentage of Mobile Homes Estimate *(Natural and Built Environment Module)*
13. Percent of Renter Occupied Housing Units Estimate *(Natural and Built Environment Module)*

Rationale for inclusion:

Certain groups of people are more at risk for heat-related illness and death from extreme heat (*19, 20*). Demographic and socioeconomic factors, such as people 65+ years old or living alone, can increase a person's risk for heat-related illness (*20, 21*). Older adults are physiologically and socially more vulnerable to hot weather and heat waves (*20*). Additional factors, including a lack of health insurance, poverty, unemployment, no high school diploma, limited English proficiency, living alone, and/or living with a disability may also increase vulnerability by making individuals less resilient during a heat wave and by preventing or making individuals less likely to seek out emergency services when needed (*22-24*).

Studies have also shown that extreme heat is associated with workplace injuries and can lead to occupational heat-related illness and death (*25-30*). Occupational heat exposures can affect workers in indoor, outdoor, and hybrid (indoor/outdoor, vehicular) work environments (*30*). Occupational heat exposures have been recognized as problems since at least the 1970s. Climate change is raising average temperatures and increasing the number, duration, and intensity of hazardous heat events, which will increase risk for workers over time (*31*).

Housing characteristics and vehicle access can be important factors affecting resilience to extreme heat. Renters may face barriers from property management or even total restrictions on modifications to rental properties that hinder heat mitigation efforts like insulation or installation and upgrading of air conditioning units (*32-34*). For structures such as mobile homes, poor construction and energy inefficiency can render residents more susceptible to extreme heat (*35*). Ownership of a vehicle is also often included in measures of resilience or vulnerability to heat (*36, 37*). Those without a vehicle and without access to public transportation may be more likely to be exposed to extreme heat in the course of daily activities. Understanding the distribution of populations whose household characteristics may make them less resilient to extreme heat can help to better characterize heat risk for a community.

Because not all populations are equally at risk from heat, knowing where populations more vulnerable to heat are located can help cities target their resources more effectively and can help facilitate the coordination of emergency plans at state and regional levels. A national map of ZCTA-level heat vulnerability allows us to situate vulnerability to heat in geographic space and identify areas most in need of intervention. Understanding heat vulnerability at the individual level is important, as understanding how factors beyond individuals, including "place", contribute to differing levels of risk may help find preventative solutions (*38-40*).

Data Processing:
Percentages were calculated using the count and total estimates from ACS for any measure for which ACS does not provide a percent of population value. This applied to Poverty, Isolation, English Language Proficiency, Outdoor Workers, and Renter indicators. Each measure was then percentile ranked to be included in the index.

National Land Cover Database

Module(s): Natural and Built Environment
Indicator(s): Impervious Surfaces, Tree Canopy

The National Land Cover Database is produced by the Multi-Resolution Land Characteristics Consortium. The database contains a map that characterizes every 30m x 30m spatial resolution into 16 categories of land cover such as developed, cultivated crops, and pastures. The database also contains areas with impervious surfaces and tree canopy cover, which are the two indicators derived from this data source.

Rationale for inclusion:
Land cover plays a key role in helping identify at greater risk and with existing vulnerabilities intrinsic to a given area. Land cover characteristics can influence how resilient a community may be to extreme heat and can help to better characterize heat risk for a community (*12, 41*).

Tree canopy can increase community resilience to extreme heat by providing shade and by mitigating urban heat island effects though local changes in surface temperature, air temperature, and heat retention (42, 43).

The percent impervious surface area has been recognized as an important data source to quantitatively determine the extent of developed land cover at both regional and national scales and has been widely used to evaluate urban land cover extent and associated effects on hydrological and ecological systems (*44, 45*). Impervious surface is an important factor in contributing to urban heat island effects, absorbing and retaining heat for extended periods (*46, 47*).

Data Processing:
The NLCD data provides 30m x 30m grids estimates of the impervious surfaces and tree canopy across the U.S. ZCTAs were spatially aligned with the NLCD data to estimate the percent of a ZCTA that was covered by impervious surfaces and the percent of a ZCTA covered by tree canopy. Once the percent values were estimated, the values were percentile ranked for all ZCTAs across the U.S. The percent of a ZCTA covered by tree canopy was percentile ranked so that areas with the lowest percent of a ZCTA covered by tree canopy received the highest percentile rank, indicating greater vulnerability to heat.

U.S. Environmental Protection Agency (EPA)

Module(s): Natural and Built Environment
Indicator(s): Ozone, $PM_{2.5}$

The EPA produces modeled estimates of several pollutants across the U.S., including fine Particulate Matter ($PM_{2.5}$) and Ozone (O_3). These data were used to produce the average number of days annually that O_3 and $PM_{2.5}$ were above the regulatory standards for those pollutants.

Rationale for Inclusion:
Air pollution is associated with increased rates of hospitalization for respiratory and cardiovascular conditions, adverse birth outcomes, and lung cancer (*48-50*). Research also suggests that air pollution is associated with 100,000 to 200,000 excess deaths annually in the United States and Canada, and human-caused emissions have been linked with 100,000 excess deaths in the United States alone (*51, 52*).

Air pollution can exacerbate the effects of extreme heat on human health and wellbeing. Air pollution and extreme heat affect humans through similar biological pathways including inflammation and oxidative stress and may have synergistic effects on health that are more severe even than the sum of individual effects (53). Both fine particulate matter ($PM_{2.5}$) and ground level ozone may contribute to more severe health impacts from extreme heat events, particularly in areas of lower socioeconomic status (*53, 54*).

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for widespread pollutants from sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of people who are at higher risk such as persons with asthma, children, and older adults. Secondary standards set limits to protect public welfare, including visibility impairment and damage to animals, crops, vegetation, and buildings. The measures in this indicator utilize primary standards and reflect acceptable pollution levels before harm will occur based on current epidemiological and medical research (*55*).

Data Processing:

The EPA modeled data were processed to identify the annual number of days when $PM_{2.5}$ and O_3 were above defined respective thresholds per census tract. The regulatory standards used as thresholds were the 24-hr National Ambient Air Quality Standard (NAAQS) of 35.0 micrograms per cubic meter (mg/m3) for $PM_{2.5}$ and the 8-hr NAAQS of 0.070 parts per million (ppm) for O_3. The annual number of days above defined regulatory standards by census tract were cross walked to ZCTA to produce the annual number of days above regulatory standards by ZCTA. Observations with duplicate dates and values per ZCTA were removed. The total number of days over each threshold were summed by ZCTA and averaged for the 3-years of data (2018-2020).

Other Indicators Considered for the HHI

Several other potential indicators were considered, evaluated, and ultimately not selected for inclusion in the HHI. Indicators could be excluded for a number of reasons, including data availability, inconsistent coverage of data, correlation with another variable included in the model, or lack of recent data. Table 2 below describes these additional indicators and the reason for exclusion. Future iterations may reevaluate these indicators as additional data become available.

Table 2. Additional indicators considered for inclusion in the HHI with reasons for exclusion.

Indicator Considered	**Reason for Exclusion**
Historic Heat and Health Burden	
Extreme heat events	Captured by another indicator included in the HHI.
Daytime summer surface temperature	Captured by another indicator included in the HHI.
Nighttime temperature	Captured by another indicator included in the HHI.
Heat-related mortality	Not available nationally at the ZCTA level.
Heat-related hospitalizations	Not available nationally at the ZCTA level.
Heat-related emergency department visits	Not available nationally at the ZCTA level.
Sensitivity	
High blood pressure prevalence	Excluded after statistical analysis.
Stroke prevalence	Excluded after statistical analysis.
Chronic kidney disease prevalence	Excluded due discontinuation of the measure.
Sociodemographic	
Percent of workers who commute to work by transit, walking or cycling	Did not meet inclusion criteria.
Sex	Did not meet inclusion criteria.
Young adults ages 15-34	Did not meet inclusion criteria.
Foreign born	Did not meet inclusion criteria.
Substance abuse	Not available nationally at the ZCTA level.
Elderly living alone	Captured by another indicator included in the HHI.
Median income	Captured by another indicator included in the HHI.
Percent of households with no one aged >= 14 years speaking English	Captured by another indicator included in the HHI.
Percent of households living in a RV, van, or boat	Captured by another indicator included in the HHI.

HHS emPOWER electricity-dependent durable medical and assistive equipment and devices	Did not meet inclusion criteria.
Air conditioning availability	Not available nationally at the ZCTA level.
Energy burden	Not available nationally at the ZCTA level.
Natural and Built Environment	
Highly developed areas	Excluded after statistical analysis.
Housing Cost Burden	Excluded after statistical analysis.
Crowding	Excluded after statistical analysis.
Health care access	Did not meet inclusion criteria.
Median year structure built	Did not meet inclusion criteria.
Houses built before certain year	Did not meet inclusion criteria.
Subsidized housing or public housing	Did not meet inclusion criteria.
Rural versus urban	Did not meet inclusion criteria.
Percent of ZCTA covered in vegetation	Captured by another indicator included in the HHI.
Average summertime enhanced vegetation (EVI) score	Captured by another indicator included in the HHI.
Plant health	Captured by another indicator included in the HHI.
Underdeveloped areas	Captured by another indicator included in the HHI.
Non-green space	Captured by another indicator included in the HHI.
Built-up index	Captured by another indicator included in the HHI.
Housing density	Captured by another indicator included in the HHI.
Reflectivity	Captured by another indicator included in the HHI.
Nursing homes	Captured by another indicator included in the HHI.
Libraries	Did not meet inclusion criteria.
Neighborhood energy centers, drop-in centers, senior centers, or cooling centers	Not available nationally at the ZCTA level.
Pools and spraygrounds	Not available nationally at the ZCTA level.

Note: Captured by another indicator included in the HHI means that the concept was represented or overlapped significantly with another indicator included in the HHI. Statistical analysis could have excluded variables due to significant correlation with other indicators or due to lack of contribution to the index after principal component analysis.

Calculating the HHI

Module Rankings

ZIP Code Tabulation Areas (ZCTA) within the 48 contiguous states (Alaska and Hawaii were not included due to gaps in data) and the District of Columbia were assigned ranks to enable mapping and analysis of where people are most likely to feel the effects of extreme heat on their health. For a given ZCTA, ranks for three HHI modules (Historical Heat and Health Burden, Sociodemographic, and Natural and Built Environment) were calculated as described below:

- Indicator rankings for each ZCTA were calculated by ordering indicator values for all ZCTA in the dataset and assigning each ZCTA percentile rank of between 0-1, with 0 representing the lowest value among all ZCTA in the dataset and 1 representing the highest, except for Tree Canopy, for which this was reversed.

- To calculate module rankings, the individual indicator rankings were averaged by module to produce the module scores. The module scores were then percentile ranked to determine the module rankings between 0-1.

NEMSIS Heat-Related Illness Flags

ZCTA-level flags were calculated for the NEMSIS heat-related illness indicator due to data considerations. Each ZCTA-level observation was assigned a quartile value of 1 to 4, based on rank position value that was initially calculated by NEMSIS. This transformation was done to offset the skewed distribution present within rank position values and as a method of suppression for areas with low number of EMS occurrence.

Sensitivity Module Flags

ZCTA-level rankings for the Sensitivity Module were calculated differently than the other modules due to data considerations. The PLACES estimates used in the Sensitivity Module are based on survey data collected as part of the CDC's Behavioral Risk Factor Surveillance System (BRFSS) and calculated using a method known as small area estimation (SAE) that incorporates demographic data, including data on age, race/ethnicity, education, and poverty. Because these data are used to produce each estimate, directly combining these estimates could lead to overweighting of underlying demographic variables. To avoid this, health indicators are incorporated into the HHI by using the estimates to flag ZCTA with disease prevalence estimates in the top tertile (33.33%) of all ZCTA included in the HHI. The process for calculating Sensitivity Module ranking based on this method is described below:

- A ZCTA receives a score of 1 for a given indicator if the estimate for that ZCTA (e.g., diabetes prevalence) is flagged as being in the top tertile of all ZCTAs; otherwise, the ZCTA receives a score of 0.
- All indicator flags for a ZCTA are averaged, creating a flag score between 0–1 (1 meaning all 6 indicators were flagged).
- Finally, the flag score is percentile ranked to create a final Sensitivity ranking between 0–1.

The four module rankings variables, detailed in the data dictionary below, are

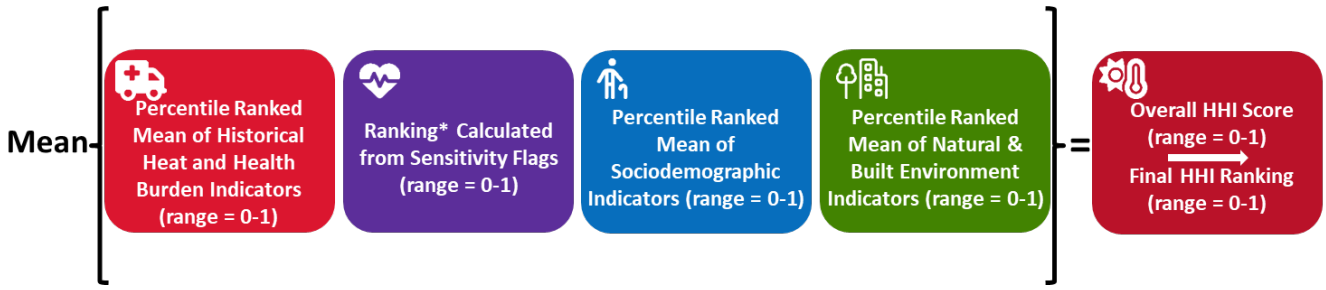
- Historical Heat and Health Burden – HHB_RANK
- Sensitivity – SEN_RANK
- Sociodemographic – SOCIODEM_RANK
- Natural & Built Environment – NBE_RANK

Overall HHI Ranking

All modules were weighted equally in calculating the Overall HHI rank. To calculate an overall HHI ranking, the module rankings were averaged to create an overall HHI score between 0-1. The HHI score was then percentile ranked to produce the final HHI ranking between 0–1.

The overall ranking variable is OVERALL_RANK.

Figure 3. Calculation of the overall HHI ranking.



* The Sensitivity Module is calculated differently than other modules in the index. While most indicators can have a range of values, the Sensitivity Module Indicators represent only whether a given ZCTA has a high estimated prevalence of the disease or not.

Text-Only Version of Figure 3- Overall HHI Score calculated by averaging rank of modules.

Mean (Historical Heat and Health Burden Module (Percentile Ranked Average of Historic Heat and Health Burden Indicators (range = 0 to 1)), Sensitivity Module (Ranked Average of Calculated Sensitivity Flags (range = 0 to 1)), Sociodemographic Module (Percentile Ranked Average of Sociodemographic Indicators (range = 0 to 1)), Natural & Built Environment Module (Percentile Ranked Average of Natural & Built Environment Indicators (range = 0 to 1))) = Overall HHI Score (range = 0 to 1), Percentile Ranked (Overall HHI Score (range 0 to 1)) = Overall HHI Ranking (range = 0 to 1)

Limitations and Considerations of the HHI

The HHI is intended as a high-level mapping tool to help identify and prioritize areas across the country where people are most likely to feel the effects of extreme heat on their health. However, like any tool, the HHI is subject to several limitations that should govern proper use of the tool.

- The indicator for Heat-Related Illness is based on data for heat-related emergency medical services (EMS) activations collected by the National Emergency Medical Services Information System (NEMSIS). These data are subject to several limitations, including restrictions on accessing raw counts or rates due to data use agreements. Additionally, EMS activations are not a comprehensive representation of all heat-related emergency health events or all heat-related non-emergent health events. For example, these data does not include emergency department visits or urgent care visits for heat-related illness, nor does it include heat-related illnesses where treatment was not sought.
- ZCTAs with an estimated population of less than 50 residents were excluded from the index. Population size exclusion criteria was used due to the likelihood of low population areas having higher margins of error for variable estimations and as a measure of suppression to prevent attempts at identifying individual residents. The cut-off of excluding ZCTAs with populations of less than 50 residents was selected to align with the cut-off that CDC PLACES uses for their ZCTA estimates. Visit PLACES: Local Data for Better Health | CDC to learn more about CDC PLACES methods.
- ZCTAs that fall within Los Angeles County CA, Schleicher County TX, or Culberson County TX do not have Heat-Related Illness data because these counties currently do not report EMS activation data to NEMSIS.
- The HHI relies on historical data generated by various institutions on varying time scales, meaning that the HHI is not entirely reflective of current or future conditions and that the data for some indicators may be less up to date than others. Information on the years that data for each indicator were collected is included in this documentation for reference.

- Indicators used to construct the HHI rely on estimates that involve some level of uncertainty. Measurements of uncertainty are available for many datasets, as with Census-calculated margins of error (MOEs), but this uncertainty is not factored into HHI calculations.
- As a population-level tool, the HHI cannot determine the likelihood of an individual to experience heat-related illness. A person residing in an area with a high HHI rank is not necessarily at a higher risk for heat related illness than anyone else. Instead, it is the population of that area that is more likely to feel the negative effects of heat on their health.
- It is important to note that all communities have the potential to be affected by extreme heat. While areas with HHI ranks may be more severely impacted by extreme heat, communities and individuals in an area with a low HHI rank should still take precautions to protect their health. See Extreme Heat | CDC for helpful tips, information, and resources to help stay safe in the extreme heat this summer.
- Health indicators represented within Sensitivity Module of the HHI are derived from PLACES estimates produced by the Division of Population Health within the CDC's National Center for Chronic Disease Prevention and Health Promotion. Because of certain methodological considerations outlined in the Methods section of this document, these estimates were incorporated into the HHI as "flags" representing tracts identified by our methodology as experiencing a high burden of chronic disease prevalence. Users who wish to view more detailed and nuanced estimates of chronic disease prevalence or learn more about the small area estimation techniques used to produce PLACES estimates should visit PLACES: Local Data for Better Health | CDC.
- Finally, a lack of data for some indicators led to the exclusion of Alaska, Hawaii, the Commonwealth of Puerto Rico, and all other Island Territories (the U.S. Virgin Islands, American Samoa, Commonwealth of the Northern Mariana Islands, Guam) from the current HHI calculations. The HHI currently includes only the continental United States (48 states plus the District of Columbia). Future iterations of the HHI may include Alaska, Hawaii, and Puerto Rico. However, there are currently no plans to produce indices for other U.S. Island Territories due to a lack of data collected for these entities.

Next Steps for the HHI

Going forward, the HHI will be updated periodically using the most recent data available from included data sources. Future iterations of the HHI will be updated to reflect input from subject matter experts, public health partners, and communities where relevant. Additionally, as new data sources become available, they will be evaluated for inclusion in future iterations of the HHI.

2024 Data Dictionary

Modules
1. Historical Heat and Health Burden
2. Sensitivity
3. Sociodemographic
4. Natural and Built Environment

The overall ranking variable is OVERALL_RANK.

Variables beginning with "P_" are percent estimates, and those beginning with "PR_" are percentile ranks. Values of -999 represent "null" or "no data."

The four module ranking variables, detailed in the Data Dictionary below, are:

- **Historical Heat and Health Burden – HHB_RANK**
- **Sensitivity – SEN_RANK**
- **Sociodemographic – SOCIODEM_RANK**
- **Natural and Built Environment – NBE_RANK**

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
STATEFP10	State-level FIPS code	NO VALUE	NO VALUE	NO VALUE	NO VALUE	NO VALUE
STATE	State name	NO VALUE	NO VALUE	NO VALUE	NO VALUE	NO VALUE
STATE_ABV	State abbreviation	NO VALUE	NO VALUE	NO VALUE	NO VALUE	NO VALUE
ZCTA	ZIP Code Tabulation Area code	NO VALUE	NO VALUE	NO VALUE	NO VALUE	NO VALUE
GEOID10	Unique ID combination of State FIPS and ZCTA code	NO VALUE	NO VALUE	NO VALUE	NO VALUE	NO VALUE
MULTI_STATE	Indicator of whether a ZCTA spans multiple states	NO VALUE	NO VALUE	NO VALUE	NO VALUE	A value of "0" in this field indicates that a ZCTA does not span multiple states. A value of "1" in this field indicates that a ZCTA does span multiple states.
POP	Population estimate, 2015-2019 ACS	NO VALUE	U.S. Census Bureau 5-year ACS	S0601_C01_001E	NO VALUE	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
			2015-2019			
PR_HRI	Percentile rank of heat-related EMS activation reported to NEMSIS	Historical Heat and Health Burden	NEMSIS	NO VALUE	NO VALUE	NEMSIS does not share raw data. Therefore, only the percentile rank indicator is available.
F_HRI	Percentile rank assigned a quartile value of 1 to 4	Historical Heat and Health Burden	HHI	NO VALUE	NO VALUE	NO VALUE
LOW_EMS	ZCTA with 10 or fewer EMS activations for 2+ years of data are denoted with a value of 1 those with greater than 10 EMS activations in 2+ year of data are denoted with a value of 0	Historical Heat and Health Burden	NEMSIS	NO VALUE	NO VALUE	NO VALUE
P_NEHD	Number of extreme heat days	Historical Heat and Health Burden	NLDAS-2 from the Tracking Network	NO VALUE	Number of days above the 95% of temperatures per ZCTA	NO VALUE
PR_NEHD	Percentile rank of number of extreme heat days	Historical Heat and Health Burden	HHI	In R: using the dplyr percent_rank() function on P_NEHD	NO VALUE	NO VALUE
HHB_SCORE	Average of percentile ranked historical heat and health burden indicators	Historical Heat and Health Burden	HHI	(PR_NEHD + PR_HRI)/n	Where n is the number of non-missing indicators in the module per ZCTA	NO VALUE
HHB_RANK	Percentile rank of averaged historical heat and health burden indicators (HHB_SCORE)	Historical Heat and Health Burden	HHI	In R: using the dplyr percent_rank() function on HHB_SCORE	NO VALUE	NO VALUE
P_CHD	Crude prevalence of persons (age 18+) with Coronary Heart Disease (CHD)	Sensitivity	CDC PLACES 2023 and	Crude prevalence of coronary heart disease among adults aged >= 18 years	NO VALUE	Florida did not have data from the PLACES 2023 release.

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
			2022 release			Therefore, data from the 2022 release were used where 2023 data were unavailable.
PR_CHD	Percentile rank of crude prevalence of persons (age 18+) with Coronary Heart Disease (CHD)	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_CHD	NO VALUE	NO VALUE
F_CHD	Flag indicating ZCTA with >= 0.6666 percentile rank for CHD 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_CHD>= 0.6666,1,0)	NO VALUE	NO VALUE
P_OBS	Crude prevalence of persons (age 18+) with Obesity	Sensitivity	CDC PLACES 2023 and 2022 release	Crude prevalence of obesity among adults aged ≥18 years	NO VALUE	Florida did not have data from the PLACES 2023 release. Therefore, data from the 2022 release were used where 2023 data were unavailable.
PR_OBS	Percentile rank of crude prevalence of persons (age 18+) with Obesity	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_OBS	NO VALUE	NO VALUE
F_OBS	Flag indicating ZCTA with >= 0.6666 percentile rank for Obesity 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_OBS>= 0.6666,1,0)	NO VALUE	NO VALUE
P_DIABETES	Crude prevalence of persons (age 18+) with Diabetes	Sensitivity	CDC PLACES 2023 and 2022 release	Crude prevalence of diagnosed diabetes among adults aged ≥18 years	NO VALUE	Florida did not have data from the PLACES 2023 release. Therefore, data from the 2022 release were used where 2023 data were unavailable.

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
PR_DIABETES	Percentile rank of crude prevalence of persons (age 18+) with Diabetes	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_DIABETES	NO VALUE	NO VALUE
F_DIABETES	Flag indicating ZCTA with >= 0.6666 percentile rank for Diabetes 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_DIABETES>= 0.6666,1,0)	NO VALUE	NO VALUE
P_COPD	Crude prevalence of persons (age 18+) with Chronic Obstructive Pulmonary Disease (COPD)	Sensitivity	CDC PLACES 2023 and 2022 release	Crude prevalence of chronic obstructive pulmonary disease among adults aged ≥18 years	NO VALUE	Florida did not have data from the PLACES 2023 release. Therefore, data from the 2022 release were used where 2023 data were unavailable.
PR_COPD	Percentile rank of crude prevalence of persons (age 18+) with Chronic Obstructive Pulmonary Disease (COPD)	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_COPD	NO VALUE	NO VALUE
F_COPD	Flag indicating ZCTA with >= 0.6666 percentile rank for COPD 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_COPD>= 0.6666,1,0)	NO VALUE	NO VALUE
P_ASTHMA	Crude prevalence of persons (age 18+) with current asthma	Sensitivity	CDC PLACES 2023 and 2022 release	Crude prevalence of current asthma prevalence among adults aged ≥18 years	NO VALUE	Florida did not have data from the PLACES 2023 release. Therefore, data from the 2022 release were used where 2023 data were unavailable.
PR_ASTHMA	Percentile rank of crude prevalence of	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_ASTHMA	NO VALUE	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
	persons (age 18+) with current asthma					
F_ASTHMA	Flag indicating ZCTA with >= 0.6666 percentile rank for Asthma 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_ASTHMA>= 0.6666,1,0)	NO VALUE	NO VALUE
P_MNTLH	Crude prevalence of persons (age 18+) reporting “not good” mental health for >= 14 days	Sensitivity	CDC PLACES 2023 and 2022 release	Crude prevalence of mental health not good for ≥14 days among adults aged ≥18 years	NO VALUE	Florida did not have data from the PLACES 2023 release. Therefore, data from the 2022 release were used where 2023 data were unavailable.
PR_MNTLH	Percentile rank of crude prevalence of persons (age 18+) reporting “not good” mental health for >= 14 days	Sensitivity	HHI	In R: using the dplyr percent_rank() function on P_MNTLH	NO VALUE	NO VALUE
F_MNTLH	Flag indicating ZCTA with >= 0.6666 percentile rank for mental health 1 or 0 if not	Sensitivity	HHI	In R: ifelse(HHI$PR_MNTLH>= 0.6666,1,0)	NO VALUE	NO VALUE
F_SEN_COUNT	Sum of flagged indicators for sensitivity module	Sensitivity	HHI	F_CHD + F_OBS + F_DIABETES + F_COPD + F_ASTHMA + F_MNTLH	NO VALUE	NO VALUE
SEN_SCORE	Average of flagged sensitivity indicators	Sensitivity	HHI	F_SEN_COUNT * 1/6	The sum of flagged indicators is multiplied by a constant of 1/6 in order to calculate an average flagged score	NO VALUE
SEN_RANK	Percentile rank of averaged sensitivity indicators (SEN_SCORE)	Sensitivity	HHI	In R: using the dplyr percent_rank() function on SEN_SCORE	NO VALUE	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
P_UNINSUR	Percentage uninsured in the total civilian noninstitutionalized population estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	S2701_C05_001E	NO VALUE	NO VALUE
PR_UNINSUR	Percentile rank of percent uninsured estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_UNINSUR	NO VALUE	NO VALUE
P_POV	Percentage of persons below 150% poverty estimate	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	(POV / S1701_C01_001E) * 100	(Persons below 150% poverty level estimate / Population for whom poverty status is determined estimate) * 100	NO VALUE
PR_POV	Percentile rank of percent of persons below 150% poverty estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_POV	NO VALUE	NO VALUE
P_UNEMP	Unemployment Rate estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	DP03_0009PE	NO VALUE	The ACS calculated Unemployment Rate = E_UNEMP/civilian population age 16+ in the labor force.
PR_UNEMP	Percentile rank of percent of civilian (age 16+) unemployed estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_UNEMP	NO VALUE	NO VALUE
P_NOHSDP	Percentage of persons with no high school diploma (age 25+) estimate	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	S0601_C01_033E	NO VALUE	NO VALUE
PR_NOHSDP	Percentile rank of percent of persons with no high school	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_NOHSDP	NO VALUE	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
	diploma (age 25+) estimate					
P_ISO	Percentage of persons (age 18+) living alone estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	(ISO / B09021_001E) * 100	(Persons (age 18+) living alone estimate / Persons (age 18+) for whom living arrangement status is determined estimate) * 100	NO VALUE
PR_ISO	Percentile rank of percent of persons (age 18+) living alone estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_ISO	NO VALUE	NO VALUE
P_ELP	Percentage of persons (age 5+) who speak English "less than well" estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	((B16005_007E + B16005_008E + B16005_012E + B16005_013E + B16005_017E + B16005_018E + B16005_022E + B16005_023E + B16005_029E + B16005_030E + B16005_034E + B16005_035E + B16005_039E + B16005_040E + B16005_044E + B16005_045E) / B16005_001E) * 100	(Estimate; Native: - Speak Spanish: - Speak English "not well" + Estimate; Native: - Speak Spanish: - Speak English "not at all" + Estimate; Native: - Speak other Indo-European languages: - Speak English "not well" + Estimate; Native: - Speak other Indo-European languages: - Speak English "not at all" + Estimate; Native: - Speak Asian and Pacific Island languages: - Speak English "not well" + Estimate; Native: - Speak Asian and Pacific Island languages: - Speak English "not at all" + Estimate; Native: - Speak other languages: - Speak English "not well" + Estimate; Native: - Speak other languages: - Speak English "not at all" + Estimate; Foreign born: - Speak Spanish: - Speak English "not well" + Estimate; Foreign born: - Speak Spanish: - Speak English "not at all" + Estimate; Foreign born: - Speak other Indo-European languages: - Speak English "not well" + Estimate; Foreign born: - Speak other Indo-	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
					European languages: - Speak English "not at all" + Estimate; Foreign born: - Speak Asian and Pacific Island languages: - Speak English "not well" + Estimate; Foreign born: - Speak Asian and Pacific Island languages: - Speak English "not at all" + Estimate; Foreign born: - Speak other languages: - Speak English "not well" + Estimate; Foreign born: - Speak other languages: - Speak English "not at all" / Population age 5 and over estimate) * 100	
PR_ELP	Percentile rank of percent of persons (age 5+) who speak English "less than well" estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_ELP	NO VALUE	NO VALUE
P_DISABL	Percentage of civilian noninstitutionalized population with a disability estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	DP02_0072PE	NO VALUE	NO VALUE
PR_DISABL	Percentile rank of percent of civilian noninstitutionalized population with a disability estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_DISABL	NO VALUE	NO VALUE
P_ODW	Percent civilian employed population (age 16+) employed in natural resources, construction, and maintenance occupations estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	(ODW / S2401_C01_001E) * 100	(Persons (age 16+) with a natural resources, construction, or maintenance occupations estimate / Civilian employed population 16 years and over estimate) * 100	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
PR_ODW	Percentile rank of percent of civilian employed population (age 16+) employed in natural resources, construction, and maintenance occupations estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_ODW	NO VALUE	NO VALUE
P_AGE65	Percentage of persons aged 65 and older estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	S0101_C02_030E	NO VALUE	NO VALUE
PR_AGE65	Percentile rank of percent of persons aged 65 and older estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_AGE65	NO VALUE	NO VALUE
P_AGE5	Percent persons under 5 years estimate, 2015-2019 ACS	Sociodemographic	U.S. Census Bureau 5-year ACS 2015-2019	S0101_C02_002E	NO VALUE	NO VALUE
PR_AGE5	Percentile rank of percent of persons under 5 years estimate	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on P_AGE5	NO VALUE	NO VALUE
SOCIODEM_SCORE	Average of percentile ranked sociodemographic indicators	Sociodemographic	HHI	(PR_UNINSUR + PR_POV + PR_UNEMP + PR_NOHSDP + PR_HBURD + PR_CROWD + PR_ISO + PR_ELP + PR_DISABL + PR_ODW + RP_AGE65 + PR_AGE5)/n	Where n is the number of non-missing indicators in the module per ZCTA.	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
SOCIODEM_RANK	Percentile rank of averaged sociodemographic indicators (SOCIODEM_SCORE)	Sociodemographic	HHI	In R: using the dplyr percent_rank() function on SOCIODEM_SCORE	NO VALUE	NO VALUE
P_IMPERV	Percent of ZCTA covered with an impervious surface	Natural and Built Environment	Calculated from National Land Cover Database	NO VALUE	NO VALUE	NO VALUE
PR_IMPERV	Percentile rank of percent of ZCTA covered with an impervious surface	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_IMPERV	NO VALUE	NO VALUE
P_TREEC	Percent of ZCTA with tree canopy cover	Natural and Built Environment	Calculated from U.S. Forest Service Tree Canopy Cover Dataset	NO VALUE	NO VALUE	NO VALUE
PR_TREEC	Percentile rank of percent of ZCTA with tree canopy cover	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_TREEC	NO VALUE	NO VALUE
P_NOVEH	Percentage of households with no vehicle available estimate, 2015-2019 ACS	Natural and Built Environment	U.S. Census Bureau 5-year ACS 2015-2019	DP04_0058PE	NO VALUE	NO VALUE
PR_NOVEH	Percentile rank of percent of households with no vehicle available estimate	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_NOVEH	NO VALUE	NO VALUE
P_MOBILE	Percentage of mobile homes estimate, 2015-2019 ACS	Natural and Built Environment	U.S. Census Bureau 5-year ACS	DP04_0014PE	NO VALUE	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
			2015-2019			
PR_MOBILE	Percentile rank of percent of mobile homes estimate	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_MOBILE	NO VALUE	NO VALUE
P_RENT	Percent of renter occupied housing units estimate, 2015-2019 ACS	Natural and Built Environment	U.S. Census Bureau 5-year ACS 2015-2019	(RENT/ S2502_C01_001E) * 100	(Renter occupied housing units estimate / Occupied housing units) * 100	NO VALUE
PR_RENT	Percentile rank of percent of renter occupied housing units estimate	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_RENT	NO VALUE	NO VALUE
P_OZONE	Annual mean days above O3 regulatory standard - 3-year average	Natural and Built Environment	U.S. EPA Air Quality System (AQS) 2018-2020	NO VALUE	NO VALUE	NO VALUE
PR_OZONE	Percentile rank of annual mean days above O3 regulatory standard - 3-year average	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_OZONE	NO VALUE	NO VALUE
P_PM25	Annual mean days above $PM_{2.5}$ regulatory standard - 3-year average	Natural and Built Environment	U.S. EPA Air Quality System (AQS) 2018-2020	NO VALUE	NO VALUE	NO VALUE
PR_PM25	Percentile rank of annual mean days above $PM_{2.5}$ regulatory standard - 3-year average	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on P_PM25	NO VALUE	NO VALUE
NBE_SCORE	Average of percentile ranked natural and built	Natural and Built Environment	HHI	(PR_IMPERV + PR_TREEC + PR_LNDCOV + PR_NOVEH +	Where n is the number of non-missing indicators in the module per ZCTA.	NO VALUE

2024 VARIABLE NAME	2024 DESCRIPTION	MODULE	DATA SOURCE	2024 TABLE FIELD CALCULATION	CALCULATION DESCRIPTION	NOTES
	environment indicators			PR_MOBILE + PR_RENT + PR_OZONE + PR_PM25)/n		
NBE_RANK	Percentile rank of averaged natural and built environment indicators (NBE_SCORE)	Natural and Built Environment	HHI	In R: using the dplyr percent_rank() function on NBE_SCORE	NO VALUE	NO VALUE
OVERALL_SCORE	Sum of percentile ranked modules	NO VALUE	HHI	(HHB_RANK + SEN_RANK + SOCIODEM_RANK + NBE_RANK)/n	Where n is the number of non-missing module ranks per ZCTA.	NO VALUE
OVERALL_RANK	Overall percentile ranking	NO VALUE	HHI	In R: using the dplyr percent_rank() function on OVERALL_SCORE	NO VALUE	NO VALUE

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