Heat-Related Illnesses

Identification

1. Indicator Description

Extreme heat events (i.e., heat waves) have become more frequent in the United States in recent decades (see the High and Low Temperatures indicator), and studies project that the frequency, duration, and intensity of extreme heat events will continue to increase as a consequence of climate change (Melillo et al., 2014). When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses such as heat exhaustion and heat stroke. Thus, as extreme heat events increase, hospitalizations for heat-related illnesses are also expected to increase (Melillo et al., 2014). Tracking the rate of reported heat-related hospitalizations over time provides a measure of how climate change may affect human well-being.

Components of this indicator include:

- A graph showing the rate of heat-related hospitalizations each year, aggregated across 20 states that participate in a U.S. Centers for Disease Control and Prevention (CDC) program to track hospitalizations (Figure 1).
- A map showing the average heat-related hospitalization rate over time for 23 participating states (Figure 2).
- A graph showing the total number of heat-related hospitalizations by sex and by age group during the study period (Figure 3).

2. Revision History

August 2016: Indicator published.

Data Sources

3. Data Sources

This indicator is based on surveillance data for heat stress illness, also referred to as heat-related illness, collected by CDC's National Environmental Public Health Tracking (EPHT) Network. The tracking network is the central component of the EPHT Program, which compiles heat stress illness surveillance data using hospital discharge data from 25 states. A total of 23 of these states have a mandate to collect surveillance data; the other two voluntarily collect data (Choudhary and Vaidyanathan, 2014).

Figures 1 and 3 present a CDC analysis (Choudhary and Vaidyanathan, 2014) that covers 20 states that CDC selected to provide a representative national average. Figure 2 presents data for all 23 states that

mandate the collection of heat stress illness surveillance data. For background information on the EPHT Network, see: www.cdc.gov/nceh/tracking/background.htm.

4. Data Availability

The 20-state aggregate rates shown in Figure 1 and the 20-state demographic breakouts shown in Figure 3 were calculated by CDC and obtained from a summary article published by Choudhary and Vaidyanathan (2014). For Figure 2, EPA obtained annual age-adjusted heat stress illness hospitalization rates by state by querying the EPHT Network's online data system at: http://ephtracking.cdc.gov/showIndicatorPages.action.

Methodology

5. Data Collection

This indicator is based on hospitalizations due to heat stress illness as recorded on hospital discharge records. Every hospitalization is recorded on a record that includes the admission date and the causes of hospitalization. Causes of hospitalization are certified by a physician or other medical professional, and they are classified according to a standard set of codes called the International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9-CM). For more information about these codes, see: www.cdc.gov/nchs/icd/icd9cm.htm.

For this indicator, CDC defined a heat stress hospitalization as any illness requiring hospital admission (an inpatient hospital stay for 23 or more hours) and for which a primary or other diagnosis was categorized using specific heat-related ICD-9-CM codes (see Section 6). Although causes of hospitalization rely to some degree on the judgment of medical professionals, the "measurements" for this indicator are expected to be generally reliable based on the medical knowledge required of the "measurer" and the use of a standard classification scheme based on widely accepted medical definitions.

The EPHT Network has agreements with 23 states that mandate the collection of hospital discharge data:

- California
- Connecticut
- Florida
- Iowa
- Kansas
- Louisiana
- Maine
- Massachusetts
- Minnesota
- Missouri
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- Oregon
- Pennsylvania
- South Carolina
- Tennessee
- Utah
- Vermont
- Washington
- Wisconsin

Figures 1 and 3 exclude three of these states—New Hampshire, North Carolina, and Tennessee—because data were unstable or unavailable at the time the analysis was conducted.

States provide the EPHT Network with heat stress illness hospitalization data on an annual basis. These data are submitted to CDC as county-level, de-identified, monthly totals. The original data are collected at inpatient hospitals, which submit their discharge data to state data stewards, typically on a quarterly basis. A data steward is a delegated authority (e.g., a hospital association) or a public entity (e.g., a segment of the state government). These state stewards are responsible for validating and finalizing the discharge data, then submitting their de-identified data to the network on an annual basis. After receiving data from the states, the EPHT Network processes the data and makes the results accessible through its publicly available web-based query system at: http://ephtracking.cdc.gov/showIndicatorPages.action (CDC, 2008).

This indicator excludes Veterans Health Administration hospitals, Indian Health Service hospitals, and institutionalized (e.g., prison) populations, as these entities do not submit hospital inpatient discharge data to the EPHT Network.

6. Indicator Derivation

Figures 1 and 2 of this indicator report age-adjusted rates of heat-related hospitalizations per 100,000 population from 2001 to 2010. Figure 3 reports the total number of hospitalizations during this 10-year period. These rates and totals reflect hospitalizations for which the primary or other cause had one of the following ICD-9-CM diagnosis or cause-of-injury classification codes:

Other and Unspecified Effects of External Causes

992: Effects of heat and light

- 992.0: Heat stroke and sunstroke
- 992.1: Heat syncope
- 992.2: Heat cramps
- 992.3: Heat exhaustion, anhidrotic
- 992.4: Heat exhaustion due to salt depletion
- 992.5: Heat exhaustion, unspecified
- 992.6: Heat fatigue, transient
- 992.8: Other specified heat effects
- 992.9: Unspecified effects of heat and light

Accidents Due to Natural and Environmental Factors

E900: Excessive heat

- E900.0: Excessive heat due to weather conditions
- E900.9: Excessive heat of unspecified origin

To reduce the chance of including hospitalizations that were incorrectly classified, this analysis does not count the following events:

- Hospitalizations occurring during colder months (October through April). Thus, the analysis is limited to hospitalizations that occurred from May 1 to September 30.

- Any hospitalizations for which the ICD-9-CM code E900.1, "exposure to a man-made source of heat" appears in any cause field. This step removes certain occupational-related hospitalizations (e.g., working inside a hot factory).

- Emergency room visits that do not require hospital admission. (Some states also track emergency room visits as part of a related surveillance program.)

The graph in Figure 1 shows the age-adjusted rate of heat-related hospitalizations per year, aggregated across 20 states that were the focus of CDC's 2014 publication (Choudhary and Vaidyanathan, 2014). To obtain the rates shown in Figure 1, CDC determined the total number of May–September heat-related hospitalizations across all 20 states for each year, then divided this total by the total midyear resident population of those 20 states.

The map in Figure 2 shows the average heat-related hospitalization rate over time for each of the 23 states that mandate reporting. CDC calculated an annual (May–September) age-adjusted rate for each state. EPA averaged these annual rates together for each state to determine a long-term (2001–2010) average.

The graph in Figure 3 shows the total number of heat-related hospitalizations, aggregated over 20 states (the same 20 states covered by Figure 1) and aggregated over the entire period of study (2001–2010). Totals are displayed by sex and by standard CDC age groups.

A few states have data for 1999 and 2000, and several also have data for 2011 and later. Due to data gaps, however, this indicator only covers the period from 2001 to 2010. As more states report their lagging totals from 2011 onward, this indicator can be updated to make it more current. The indicator will eventually incorporate cases classified using the new ICD-10 codes that took effect in October 2015.

For a more detailed description of the EPHT Network's analytical methods, see the indicator documentation at: http://ephtracking.cdc.gov/showIndicatorPages.action. CDC age-adjusted all rates using the 2000 U.S. Standard Population. For more information on this approach, see the statistical notes at: www.cdc.gov/nchs/data/statnt/statnt20.pdf.

7. Quality Assurance and Quality Control

The EPHT Network has established standard guidelines on how to prepare and submit data, and it requires all states to follow them. After receiving data from the states, the EPHT Network processes the data to ensure that the resulting analysis is nationally consistent (CDC, 2008; Choudhary and Vaidyanathan, 2014).

Analysis

8. Comparability Over Time and Space

All methods have been applied consistently over time and space. ICD-9-CM codes allow physicians and other medical professionals across the country to use a standard scheme for classifying illnesses and causes of injuries. This indicator is intentionally restricted to states in which all hospitals (with a few exceptions noted in Section 5) participate in a mandatory surveillance program. Age-adjusting ensures

that differences in incidence from one year to another, or between one geographic area and another, are not due to differences in the age distribution of the populations being compared.

9. Data Limitations

Factors that may impact the confidence, application, or conclusions drawn from this indicator are as follows:

1. This indicator is based solely on data compiled by CDC's EPHT Network. It may not capture the full range of heat-related illness occurrence if exposure to excess heat is not explicitly documented in hospital discharge records.

2. While the EPHT Network is the best available data source for tracking heat-related hospitalizations nationwide, it only covers a subset of U.S. states.

3. The EPHT Network excludes heat stress illness hospitalization data from some hospital populations (Veterans Health Administration, Indian Health Service, and institutional [e.g., prison]).

4. This indicator could double-count cases that involved a transfer between hospitals or readmission for the same heat stress event.

5. Reports are based on the patient's state of residence. Without reciprocal reporting agreements with abutting states, statewide totals and rates may undercount heat stress hospitalizations to the extent that people living near the border use health care services across state lines—for example, if a resident of southeastern Massachusetts receives treatment at a hospital in Rhode Island.

6. By focusing exclusively on the warmer months from May 1 to September 30, this indicator could potentially miss changes in heat-related illnesses that occur in other parts of the year.

7. While hospital assessments use a standard set of ICD-9-CM codes to classify diagnoses and causes of injury, they rely on the judgment of the individual physician or medical provider who assesses each patient.

8. The fact that a hospitalization is classified as "heat-related" does not mean that high temperatures were the only factor that caused the hospital admission. Pre-existing medical conditions can greatly increase an individual's vulnerability to heat.

9. Heat waves are not the only factor that can affect trends in "heat-related" hospitalizations. Other factors include the vulnerability of the population, the extent to which people have adapted to higher temperatures, the local climate and topography, and the steps people have taken to manage heat emergencies effectively. In particular, heat-response measures can make a big difference in hospitalization rates. Response measures can include early warning and surveillance systems, air conditioning, increased access to cooling centers, health care, public education, infrastructure standards, and air quality management.

Other studies may shed some light on the extent of undercounting inherent in this data set. As described in USGCRP (2016), a direct attribution approach "produced an average estimate of 65,299

emergency visits [though not necessarily hospitalizations] for acute heat illness during the summer months (May through September)—an average of 21.5 visits for every 100,000 people each year. This result was based only on recorded diagnosis codes for hyperthermia. […] A wider range of health outcomes is potentially affected by extreme heat. […] In a national study of Medicare patients from 2004 to 2005, an annual average of 5,004 hyperthermia cases and 4,381 hypothermia cases were reported for inpatient and outpatient visits. None of these studies link health episodes to observed temperature data, thus limiting the opportunity to attribute these adverse outcomes to specific heat events or conditions."

10. Sources of Uncertainty

Uncertainty estimates are not available for this indicator. Some uncertainty could be introduced as a result of the professional judgment required of the medical professionals filling out hospital records, which could potentially result in misclassification or underreporting in some number of cases.

11. Sources of Variability

There is substantial year-to-year variability within the data, due in part to the influence of a few large events. Some of the spikes apparent in Figure 1 can likely be attributed to specific severe heat waves occurring in large urban areas.

12. Statistical/Trend Analysis

This indicator does not report on the slope of the apparent trends in heat-related hospitalizations, nor does it calculate the statistical significance of these trends.

Separately, Choudhary and Vaidyanathan (2014) analyzed trends in state-level rates from 2001 to 2010. Using Poisson regression, they found statistically significant ($p < 0.05$) changes in the rate of heat stress illness hospitalizations in 13 states, including eight increases ranging from 2 to 6 percent (California, Connecticut, Florida, Louisiana, Missouri, New Mexico, South Carolina, and Washington) and five decreases ranging from 5 to 12 percent (Iowa, Maine, Massachusetts, New York, and Wisconsin).

References

CDC (U.S. Centers for Disease Control and Prevention). 2008. National Environmental Public Health Tracking Network. Data re-release plan. Version 2.5. http://ephtracking.cdc.gov/docs/Tracking_Re-Release_Plan_v2.5.pdf.

Choudhary, E. and A. Vaidyanathan. 2014. Heat stress illness hospitalizations — Environmental public health tracking program, 20 states, 2001-2010. Surveillance Summaries 63(SS13):1–10. www.cdc.gov/mmwr/preview/mmwrhtml/ss6313a1.htm.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate change impacts in the United States: The third National Climate Assessment. U.S. Global Change Research Program. http://nca2014.globalchange.gov.

USGCRP (U.S. Global Change Research Program). 2016. The impacts of climate change on human health in the United States: A scientific assessment. https://health2016.globalchange.gov.