MAINTAIN AND EXPAND

THE HEALTHCARE COST AND UTILIZATION PROJECT (HCUP)

Contract No. HHSA-290-2018-00001-C

Assessing and Predicting Medical Needs in a Disaster

Final Report

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OVERVIEW AND OBJECTIVES

The Department of Health and Human Services (HHS) leads the public health and medical response to disasters and emergencies. HHS must prepare for all disaster types in all geographic regions, but then respond to a specific event in a specific region. The Healthcare Cost and Utilization Project (HCUP) databases produced by the Agency for Healthcare Research and Quality (AHRQ) include a wealth of information about inpatient and emergency department utilization in the United States. These data can be used by HHS agencies in emergency response planning. Since 2017, AHRQ has utilized HCUP data to conduct several analyses to guide the response work of the Office of the Assistant Secretary for Preparedness and Response (ASPR) after several recent U.S. hurricanes, including Hurricane Harvey (August 2017), Hurricane Irma (September 2017), and Hurricane Florence (September 2018).

The current project, begun in 2018, "Assessing and Predicting Medical Needs in a Natural Disaster," funded through the Patient-Centered Outcomes Research Trust Fund, involves a partnership among AHRQ, ASPR, and the Office of the Assistant Secretary for Planning and Evaluation (ASPE). The purpose of this project was to develop a data resource that can identify the medical needs of specific populations in specific locations following a natural disaster. To respond to an imminent natural disaster, analyses of the data can determine appropriate deployment of medical expertise and supplies to affected geographic areas, tailored to expected patient needs. Furthermore, to facilitate longer term planning, research conducted using the data resource can evaluate interventions, health consequences, and response strategies.

The three key objectives of this project were to:

1. Design an improved data reporting system for the collection and dissemination of disaster-related medical encounters
2. Create a disaster-relevant analytic platform with two key audiences (access levels): Federal researchers (secure access) and the public
3. Perform analyses on disaster-related outcomes using HCUP data from the analytic data platform

The four primary deliverables for this project were:

1. Disaster-relevant analytic file accessible through a secure local area network for Federal health services researchers
2. Disaster-relevant statistics accessible through a public-facing statistical query system
3. User guidance, related technical support materials, and other documentation on the disaster-relevant restricted-access researcher analytic file and the public statistical query system
4. Public report or manuscript of publishable quality that uses HCUP data to examine health utilization and/or outcomes relevant to a disaster

BACKGROUND – PROBLEMS ADDRESSED

The Healthcare Cost and Utilization Project (HCUP) databases produced by the Agency for Healthcare Research and Quality (AHRQ) represent the largest collection of longitudinal hospital care data in the United States. In recent years, AHRQ has used the HCUP data to conduct analyses to guide emergency response work of the Office of the Assistant Secretary for Preparedness and Response (ASPR) after several U.S. hurricanes:

- In the aftermath of Hurricane Harvey (August 2017), the HCUP team estimated overall changes in inpatient stays post-Harvey in Texas based on patterns of hospital use in Texas and Louisiana after Hurricane Ike (2008). These estimates were shared with the Department of Health and Human Services (HHS) and the Texas Department of State Health Services to inform decisions about deploying medical resources to the area.

- In September 2017, the HCUP team produced county-level estimates for Hurricane Irma in Florida based on historical data from Hurricanes Frances (2004) and Wilma (2005), both of which impacted Florida. These estimates were shared with HHS and the Florida Agency for Health Care Administration.

- In 2018, the HCUP team refined its estimation methodology by augmenting the HCUP data at the time of nine historical hurricanes with several publicly available external data sources, allowing posthurricane estimates to account for proximity of affected counties to the hurricane path:
  - National Oceanic and Atmospheric Administration (NOAA) for information on hurricane trajectories
  - Federal Emergency Management Agency (FEMA) for county-specific disaster classifications
  - Centers for Disease Control and Prevention (CDC) for county-specific information on vulnerability to natural disasters

- In September 2018, prior to Hurricane Florence's landfall in the Carolinas, the HCUP team used the refined approach to estimate posthurricane hospital utilization.   This analysis presented posthurricane projections for the 4 weeks following Hurricane Florence by specific condition, age group, and hurricane proximity. Because the information was provided to ASPR before the hurricane made landfall, ASPR had sufficient time to share the results with Federal staff and interagency liaisons in the Secretary's Operations Center for the public health and medical response. ASPR reported that the information was greatly appreciated by senior leadership and regional authorities to help guide decision making for overall awareness and support for the public health and medical response.

In 2019, AHRQ partnered with ASPR and the Office of the Assistant Secretary for Planning and Evaluation to conduct the current project, "Assessing and Predicting Medical Needs in a Natural Disaster," funded through the Patient-Centered Outcomes Research Trust Fund (PCORTF). The purpose of this project was to expand on the preliminary hurricane-related work conducted by AHRQ and ASPR by building a data resource with HCUP data that can be used to estimate

the impact of hurricanes on hospital utilization. This new hurricane data resource was to be used to develop a public-facing statistical query system and a public research report that provide hurricane-related hospital use statistics, and the data resource was to be made available to HHS researchers for additional research work.

This project supports the primary PCORTF functionality to build data capacity within HHS to support patient-centered outcomes research. By creating a new analytic data resource, titled "HCUP Hurricane Data Resource," this project brings together HCUP data on hospital inpatient and emergency department utilization with data from a variety of other public sources, including hurricane and weather-related data from NOAA, disaster declaration data from FEMA, community vulnerability data from CDC, and community characteristics from the U.S. Census Bureau American Community Survey. Through this project, the enhanced data resource served as the basis for a public research report on the impact of hurricanes on injury-related hospitalizations and an online public query tool on the impact of hurricanes on hospital use. The data resource was also made accessible to HHS researchers to continue research on medical needs following a hurricane.

The HCUP Hurricane Data Resource and resultant public products will allow Federal researchers, local and Federal emergency management agencies, and hospital and health systems, among others, to better answer a variety of questions related to healthcare needs following a hurricane:

- Who will require hospital-level resources following a hurricane (e.g., children, adults, elderly)?
- What type of resources will be needed (e.g., inpatient beds, emergency department personnel, injury/trauma resources, specialists in infectious disease)?
- Where will hospital resources be needed (e.g., in areas directly impacted by the hurricane, in neighboring communities affected by hurricane-related high winds and flooding)?
- When will these resources be needed (e.g., within the first days/week following the hurricane, within the first month of the hurricane, within 6 months of the hurricane)?
- How many resources will be needed (e.g., double the typical need)?

METHODOLOGY

This section provides details on the approach taken to fulfill this project's requirements, covering five key areas:

1) expanding the Healthcare Cost and Utilization Project (HCUP) databases,
2) developing a new HCUP Hurricane Data Resource for Department of Health and Human Services (HHS) researchers,
3) creating a State Hurricane Impact on Hospital Use topic within the HCUP Fast Stats online public query tool,
4) publishing hurricane-related hospital use statistics through an HCUP Statistical Brief,
5) developing a methodology to respond to quick-turnaround requests for predicting hospital use for impending hurricanes.

The methodology employed in the development of work for this project was informed by four primary factors. First, the Agency for Healthcare Research and Quality (AHRQ) worked in conjunction with the Office of the Assistant Secretary for Preparedness and Response (ASPR) and its technical experts to provide guidance on key project decisions, such as the hurricane characteristics data to include in the HCUP Hurricane Data Resource. Second, prior hurricane-related analyses conducted by AHRQ in 2017 and 2018, in conjunction with ASPR, as well as a 2018 AHRQ-funded study on the effects of U.S. hurricanes on emergency department utilization, were used as a basis for the current project work. Third, analytic flexibility for users was a driving factor in the approach to developing the HCUP Hurricane Data Resource and accompanying hurricane impact estimate program. Finally, inherent limitations in key data sources (e.g., the National Oceanic and Atmospheric Administration (NOAA) Best Track dataset and the Federal Emergency Management Agency (FEMA) Disaster Declaration Data) influenced the definition of critical variables such as hurricane proximity.

HCUP Databases

A fundamental requirement of this project concerns expanding the HCUP databases by recruiting, acquiring, processing, and creating new State quarterly inpatient and outpatient databases to develop the hurricane data resource and support hurricane-related analyses. This activity involved several key steps.

First, new quarterly inpatient and outpatient data files[1] were recruited and acquired. The HCUP databases are based on the data collection efforts of data organizations in participating States that maintain statewide data systems and that have partnered with the Agency for Healthcare Research and Quality (AHRQ; i.e., HCUP Partners). The status of all HCUP Partners was reviewed in terms of the availability of inpatient and outpatient quarterly data and whether these data could be provided to HCUP in a timely manner. A group of HCUP Partners already was submitting inpatient quarterly data to HCUP, and a subset of this group also was submitting outpatient quarterly data, although the latter was not being processed. Based on discussion with the Office of the Assistant Secretary for Preparedness and Response, eight States were identified to prioritize the acquisition and processing of inpatient and outpatient quarterly data: California, Florida, Georgia, Maryland, Mississippi, New Jersey, South Carolina, and Texas. These eight States were selected based on their likelihood of experiencing hurricanes and other natural disasters (e.g., earthquakes, wildfires) as well as the HCUP Partner's ability to submit quarterly data files for HCUP in a timely manner. Several other States were identified to pursue for quarterly data, if possible.

Second, an infrastructure was developed to create standardized, uniformly formatted outpatient quarterly data files for analytic and research purposes. HCUP has had an infrastructure in place for several years to create inpatient quarterly data files. For this project, the existing inpatient quarterly processing infrastructure was adapted to include outpatient quarterly data. Specifically, a set of SAS® processing programs was developed to load State outpatient

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[1] Quarterly files include 3 months of data and start being received 3 months after the end of a calendar quarter. The advantage of acquiring quarterly data is the receipt of information periodically through the year instead of the alternative of waiting for a complete annual file.

quarterly data, conduct limited data quality checks, and create new outpatient quarterly data files in standard HCUP format.

Third, inpatient and outpatient quarterly data files for the eight priority States and select other States were processed into HCUP uniformly formatted files. These standardized HCUP quarterly data files were then used, where applicable, in developing the HCUP Hurricane Data Resource to ensure that the most timely data were available for analyses.

HCUP Hurricane Data Resource

The HCUP Hurricane Data Resource includes county-level information on daily hospital utilization for the year before and after 11 hurricanes that made landfall in the United States between 2005 and 2017. This resource was designed for use by HHS researchers in order to facilitate research that will inform the varied health needs of a specific population in a specific geographic location as impacted by a specific hurricane. Development of this data resource involved multiple steps.

1. Create a data structure, including the number and type of files to be included in the data resource, and define the relationship among files (how the files should be linked).
2. Determine the content (variables) to include in each file. For the HCUP data files, this involved selecting the geographic level (e.g., patient county, State), hospital settings (e.g., inpatient, emergency department [ED]), clinical conditions (e.g., all conditions, injuries), patient characteristics (e.g., age, sex), and level of data aggregation (e.g., daily, weekly) for the included data.
3. Review HCUP Partner Data Use Agreements (DUAs) to ensure the planned use for the data resource is in compliance with Partner requirements. For one Partner, this required negotiating a special DUA to permit reporting data for this project at a level smaller than a quarterly time period.
4. Identify and obtain hurricane-relevant external data. This project required non-HCUP data about county-level storm and community characteristics, in particular, the Best Track storm data from the National Oceanic and Atmospheric Administration to identify county-level proximity categories for two new hurricanes (Harvey and Irma) not previously included in AHRQ's hurricane-related HCUP work.
5. Create and conduct quality assurance testing on the data resource files to ensure accuracy.
6. Develop detailed user documentation.
7. Conduct user testing of the data resource to ensure clarity and usability. A junior/midlevel SAS programmer was given access to the data resource files and user documentation, along with four questions to answer that required using all types of files in the data resource.
8. Deploy the final data resource on a secure Federal system with access restricted for HHS researchers. This involved developing a new page on AHRQ's HCUP User Support (HCUP-US) website with a special permission level to restrict log-in access to designated HHS researchers.

The HCUP Hurricane Data Resource was developed in two phases. The first phase consisted of constructing and testing an initial set of data files and creating the user documentation, based on the steps described above. The files constructed were based on patient county—the county of residence of patients in States impacted by a hurricane—and included two types of clinical conditions: all conditions and injuries. In the second phase, the data resource was expanded to provide an additional set of data files based on hospital county—the county of hospitals in States impacted by a hurricane—and covered three additional types of conditions: circulatory conditions, infections, and respiratory conditions.

HCUP Fast Stats Hurricane Impact on Hospital Use Topic

The HCUP Fast Stats topic, Hurricane Impact on Hospital Use, reports the percent change in population rates of treat-and-release ED visits and hospital inpatient stays following a hurricane.[2] This public access to hurricane-related statistics was developed utilizing an existing AHRQ HCUP tool, HCUP Fast Stats,[3] an online query tool that provides summary statistics in simple figures or tables designed to convey information on hospital utilization and costs at a glance on a variety of topics (e.g., trends in inpatient stays, opioid-related hospital use). The HCUP Fast Stats hurricane topic was designed following the standard HCUP Fast Stats tool format, which allows the user several selection options and then produces a graph and table of summary statistics. The Fast Stats hurricane statistics were based on the data in the HCUP Hurricane Data Resource. Development of this HCUP Fast Stats topic involved multiple steps.

1. Determine the specific user options to provide in the tool. HCUP Fast Stats allows up to two drop-down selection options and one radio-button option. Options considered included the hurricane, hospital setting, patient age, patient sex, and condition.
2. Determine how to display information for the user (e.g., graph or table), the specific statistics to present (e.g., counts, rates, percent change), and the timeframe to cover (e.g., days, weeks, months).
3. Develop mock-ups of the web page screens for the web developer and finalize formatting for all information to be presented.
4. Generate statistics and produce the final graphs using the HCUP Hurricane Data Resource data files.
5. Develop detailed user documentation, referred to as "Data Notes & Methods" in HCUP Fast Stats.
6. Develop the web pages and conduct quality assurance testing and review.
7. Deploy the final hurricane topic on the HCUP-US website.

The HCUP Fast Stats hurricane topic was released publicly in two phases, mirroring the two phases of the HCUP Hurricane Data Resource. The first phase provided statistics for the two initial types of clinical conditions available in the data resource—all conditions and injuries—and the second phase added statistics for three other types of conditions: circulatory conditions, infections, and respiratory conditions.

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[2] https://www.hcup-us.ahrq.gov/faststats/HurricaneImpactServlet

[3] https://www.hcup-us.ahrq.gov/faststats/landing.jsp

HCUP Statistical Brief on Injury-Related ED Visits After a Hurricane

Aggregate statistics on hospital use following a hurricane are reported in an HCUP Statistical Brief that was completed as part of this project and is expected to be published in fall 2020. AHRQ's HCUP Statistical Briefs series is used to disseminate concise descriptive statistics on a range of healthcare topics to a broad policy and lay audience. Since 2006, more than 250 HCUP Statistical Briefs have been published online on the HCUP-US website.[4]

The hurricane impact Statistical Brief capitalizes on the analyses of posthurricane hospital utilization conducted by AHRQ in 2017 and 2018, the precursors to the current project. The data are aggregated across nine states for seven hurricanes between 2005 and 2016. The Statistical Brief focuses on injuries in two ED settings—those in which the patient was treated and then released ("treat-and-release ED visits") and those in which the patient was admitted to the same hospital ("ED visits resulting in admission")—across three age groups (0–17, 18–64, and 65+ years).

Quick-Turnaround Requests

A final component of this project involved development of a methodology and SAS program to estimate the impact of a hurricane on hospital use, in order to be able to rapidly predict medical needs in the event of future hurricanes. The methodology was built from the precursor estimation efforts conducted by AHRQ in 2017 and 2018 related to Hurricanes Harvey, Irma, and Florence. These efforts served to help guide the emergency response work of the Office of the Assistant Secretary for Preparedness and Response. The current project as well aims to support emergency response work in real time.

A flexible SAS program was created to estimate the impact of a hurricane on hospital use. The hurricane impact estimation methodology was based on calculating observed event impact ratios of hospital utilization before and after a hurricane (i.e., postevent volume divided by preevent volume). Calculation of the impact ratios was derived from actual data on hospital use following historical hurricanes. The SAS program was created to allow user flexibility in selection of the specific hurricanes, hurricane proximity categories and disaster area designation, unit of time for reporting, age groups, clinical conditions, hospital setting (inpatient, ED), and other factors. This flexibility allows the user to select the prior hurricane factors that are most similar to the impending hurricane in order to approximate similar conditions in producing estimated hospital use.

The hurricane impact estimate SAS program was subsequently tested and evaluated. First, the program was tested by calculating the percent change in predicted hospital inpatient stays for three conditions (all conditions, injury, clostridium difficile infection) among three age groups (0–17, 18–64, and 65+ years) following Tropical Storm Barry, which made landfall in Louisiana in July 2019. This was a simple test that verified that the program could be successfully implemented using the HCUP Hurricane Data Resource files for a new hurricane. Second, a comparative analysis was conducted using the hurricane impact estimate program to generate

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[4] https://www.hcup-us.ahrq.gov/reports/statbriefs/statbriefs.jsp

estimates of change in hospital utilization after each historical hurricane and all historical hurricanes combined.[5] The results were compared with the actual percent change in hospital utilization for Hurricane Irma, a category 4 hurricane that impacted Florida and Georgia in September 2017. Overall, the difference between actual and estimated hospital use was within 10 percentage points for the majority of aggregate comparisons made (across conditions, age, and sex). Variability between actual and estimated values was generally lower for estimates based on data aggregated across multiple hurricanes than from individual hurricanes, although in some cases a single hurricane could provide better estimates. Differences based on individual weeks, conditions, age groups, and sex could range substantially.

ACCOMPLISHMENTS BY OBJECTIVES AND FINAL DELIVERABLES

This section provides details on the three objectives and four deliverables (listed in the "Overview and Objectives" section above) that were produced through this project.

Objective #1: Design an improved data reporting system for the collection and dissemination of disaster-related medical encounters.

HCUP Databases

The first project objective was accomplished by expanding the Healthcare Cost and Utilization Project (HCUP) databases to include additional timely quarterly data from HCUP Partners. This expansion comprised two components: (1) the recruitment and processing of quarterly data from States that were not submitting any quarterly data or were submitting only inpatient quarterly data to HCUP and (2) the processing of outpatient quarterly data files from States that were already submitting these files. (Prior to this project, these files were collected but not processed.)

Recruitment efforts were successful, with new quarterly data submissions established for five priority States: Georgia, Maryland, Mississippi, New Jersey, and South Carolina. At the start of the project, three of these States (Georgia, Maryland, and New Jersey) were submitting quarterly files for inpatient data but not for outpatient data. The other two States (Mississippi and South Carolina) were submitting only annual files for both inpatient and outpatient data as part of HCUP. Processing of newly recruited and previously existing ongoing quarterly data submissions was prioritized for States and quarters needed for the HCUP Hurricane Data Resource and for other priority States prone to hurricanes and other natural disasters. In terms of data types, emergency department (ED) data and inpatient data were prioritized above ambulatory surgery data. Over the course of this 2-year project, a total of 63 quarterly data files were processed (47 ED files, 7 ambulatory surgery files, and 9 inpatient files); see Table 1.

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[5] The results of this comparative analysis are available by secure log-in to the HCUP Hurricane Data Resource page on the HCUP User Support (HCUP-US) website: "Memorandum: Comparison of Difference in Hurricane Irma Actual Hospital Use and Estimates from 10 Historical Hurricanes".

Table 1. Quarterly Data Files Processed Under the Assessing and Predicting Medical Needs in a Natural Disaster Project

State	Data Type	Total Files Processed
California	AS/ED	4
Colorado	AS/ED	1
Florida	AS/ED	5
Georgia	AS/ED	6
Indiana	AS/ED	3
Kentucky	AS/ED	5
Maryland	AS/ED	5
Mississippi	ED/IP	12
New Jersey	AS/ED	8
South Carolina	ED/IP	6
Texas	AS/ED	8
Total	**AS/ED/IP**	**63**

Abbreviations: AS, ambulatory surgery; ED, emergency department; IP, inpatient

Objective #2: Create a disaster-relevant analytic platform with two key audiences (access levels): Federal researchers (secure access) and the public.

The second project objective was accomplished by developing two new disaster-relevant analytic data tools: the HCUP Hurricane Data Resource for Department of Health and Human Services (HHS) researchers and the HCUP Fast Stats Hurricane Impact on Hospital Use topic for the general public.

HCUP Hurricane Data Resource

> ➢ **Deliverable #1: Disaster-relevant analytic file accessible through a secure local area network for Federal health services researchers.**

The first disaster-relevant analytic data tool developed through this project is the HCUP Hurricane Data Resource. This data resource comprises a set of data files that include county-level information on hospital utilization the year before and after 11 hurricanes that made landfall in the United States between 2005 and 2017: Dennis, Gustav, Harvey, Ike, Irene, Irma, Isaac, Matthew, Rita, Sandy, and Wilma. The HCUP Hurricane Data Resource can be used to compare interventions and outcomes, analyze and improve disaster response strategies, identify patient needs and trends for long-term recovery, and track the long-term health consequences of a disaster at the county level.

The HCUP Hurricane Data Resource includes 25 analytic data files of four types:

- 22 hurricane-specific files containing daily hospital use counts derived from the HCUP State databases with counts aggregated based on either patient or hospital county
- 1 file containing county-level storm and community characteristics for the year of each hurricane
- 1 file containing county-level population statistics for the year of each hurricane
- 1 file containing hospital-level information for the year of each hurricane

The first set of files can be used to assess a hurricane's impact on hospital utilization in affected areas. There are two sets of 11 files (one for each hurricane) that contain HCUP tabulated daily hospital counts by county for each of the 365 days prior to and following the hurricane. The first set of HCUP data files is based on the county of patients who reside in States impacted by the hurricane, and the second set of HCUP data files are based on the county of hospitals located in States impacted by the hurricane. Counties are classified based on their proximity to the hurricane (direct path, near path, remote from the hurricane) and Federal Emergency Management Agency (FEMA) disaster designation (disaster, not a disaster). Each file includes aggregated daily hospital use counts for each county based on the hospital encounter type (inpatient and two types of ED visits), condition (all conditions, injuries, circulatory conditions, infections, and respiratory conditions), patient age group, and sex.

Second, the data resource includes one file that can be used to identify counties within and across hurricanes that had similar storm and resource characteristics. The file contains hurricane characteristics (e.g., storm characteristics, hurricane wind speed) for each impacted county and community characteristics (e.g., housing occupancy rates, medical providers per capita) in the county during the year of the hurricane.

Third, the data resource includes one file that can be used to calculate population-based utilization rates or population-weighted averages. The file contains population counts from the U.S. Census Bureau by age group and sex for all counties in States with at least one county affected by a hurricane for the year of the hurricane.

Finally, the data resource includes one file that can be used to identify the characteristics of hospitals that treated patients from hurricane States and to examine hospital volume around the time of the hurricane. The file contains characteristics of each hospital in the hurricane year and monthly hospital utilization derived from the HCUP State databases in the 12 months before and after each hurricane by county.

Data on hospital utilization were obtained from the HCUP State Inpatient Databases (SID) and State Emergency Department Databases (SEDD). External data at the county level (e.g., storm and community characteristics, population counts) and hospital level (e.g., hospital characteristics) were obtained from various publicly available external data sources, summarized in Table 2.

Table 2. External Data Sources Used in HCUP Hurricane Data Resource

Data Source	Type of Data Included in HCUP Hurricane Data Resource
American Hospital Association Annual Survey Database	Hospital characteristics
Bureau of Labor Statistics	Unemployment rate
Centers for Disease Control and Prevention (CDC) Social Vulnerability Index	Community vulnerability after a disaster
CDC National Environmental Public Health Network	Flood vulnerability
Federal Emergency Management Agency Disaster Declaration Data	County disaster designation
Health Resources and Services Administration Area Health Resources Files	Number of physicians per 100,000 population by specialty
National Center for Health Statistics Urban-Rural Classification Scheme for Counties	Urban-rural designation
National Oceanic and Atmospheric Administration (NOAA) Best Track	Hurricane activity timeframe, windspeed, and pressure
NOAA National Weather Service StormReady® Program	Designation as hurricane ready
NOAA Office for Coastal Management	Coastal county indicator
NOAA Storm Events	Observation of storm characteristics in a county
Trauma Information Exchange Program	Trauma center level indicator
U.S. Census Bureau American Community Survey	Population and home usage statistics
U.S. Department of Agriculture Economic Research Service Rural-Urban Continuum Codes	Rural-Urban Continuum Code
U.S. Department of Housing and Urban Development Comprehensive Housing Affordability Strategy Data	Owner- and renter-occupied housing information

AHRQ has made the HCUP Hurricane Data Resource accessible to Federal health services researchers. Specific access instructions are provided in a separate AHRQ memo.

> ➢ **Deliverable #3(a): User guidance, related technical support materials, and other documentation on the disaster-relevant restricted-access researcher analytic file.**

To accompany the data files that constitute the HCUP Hurricane Data Resource, a detailed 90-page user documentation is provided. This documentation includes the following:

- Quick-Start Guide: summary of files and critical information to start use
- Data Dictionary: data elements for each of the four types of data files
- Methods: counties included in the files, disaster and proximity designations, patient and hospital county definitions, hospital definition, condition definitions, data limitations
- Hurricanes: details of the 11 hurricanes, county population-at-risk maps
- Data Sources: HCUP databases, external data sources

- Example SAS Code: SAS code examples for using each data file type
- Appendices: background, data availability, clinical condition diagnostic criteria, HCUP Partners, SAS code to estimate hospital utilization trends using the data resource

The user documentation is available to HHS researchers by secure log-in to the HCUP Hurricane Data Resource page on the HCUP User Support (HCUP-US) website. This web page also includes technical support materials related to the data resource files; in particular, a listing of the contents and summary statistics for each file (e.g., count of observations and descriptive statistics—minimum, maximum, mean, and distribution—for each variable) is provided.

Additional user guidance is available through a PowerPoint presentation slide deck that provides an overview of the HCUP Hurricane Data Resource and its use in producing estimates of hospital use following a hurricane. This presentation will be shared in late 2020 or early 2021 with HHS researchers who may utilize the HCUP Hurricane Data Resource, as well as with the States' HCUP Partners that provided the hospital utilization data that is included in the data resource.

HCUP Fast Stats Hurricane Impact on Hospital Use Topic

> **Deliverable #2: Disaster-relevant statistics accessible through a public-facing statistical query system.**

The second disaster-relevant analytic data tool developed through this project is the HCUP Fast Stats Hurricane Impact on Hospital Use topic, accessible through the following link on the HCUP-US website: https://www.hcup-us.ahrq.gov/faststats/HurricaneImpactServlet. Through the public HCUP Fast Stats tool accessible on the HCUP-US website, users can obtain statistics on the percent change in population rates of inpatient stays and ED visits following a hurricane. The Fast Stats hurricane topic allows users to select from the following options:

- Hurricane (one of 11 hurricanes that impacted the United States between 2005 and 2017)
- Patient age group (all ages, 0–17 years, 18–64 years, 65+ years)
- Type of condition (all conditions, circulatory conditions, infections, injuries, respiratory conditions)
- Hospital setting (ED treat and release, inpatient)

The results are presented in a graph (see sample in Figure 1) that shows the percent change in the population rate of inpatient stays or ED visits for the week of the hurricane and the following 7 posthurricane weeks, based on the proximity of the patient's county of residence to the hurricane:

- In the direct path of the hurricane based on longitude and latitude of a measurement point from the National Oceanic and Atmospheric Administration Best Track dataset and the status and/or wind speed indicating hurricane activity

- <u>Near the path</u> of the hurricane based on speed of the wind within the wind radii indicating hurricane activity
- <u>Remote</u> from the hurricane but declared a major <u>disaster area</u> by FEMA; in these cases, counties may have been impacted by flooding or secondary storm damage
- <u>Remote</u> from the hurricane and <u>not a FEMA disaster area</u>; this categorization was applied to other counties in States impacted by the hurricane but not classified in one of the other three proximity categories

Consistent with the format of the Fast Stats tool, the user can select two different sets of options and view two graphs side by side (e.g., to compare two different hurricanes, age groups, conditions, hospital settings).

Figure 1. Sample Fast Stats Hurricane Graph for Injury-Related Treat-and-Release ED Visits Among Patients Aged 65+ Years for Hurricane Harvey (August 2017)
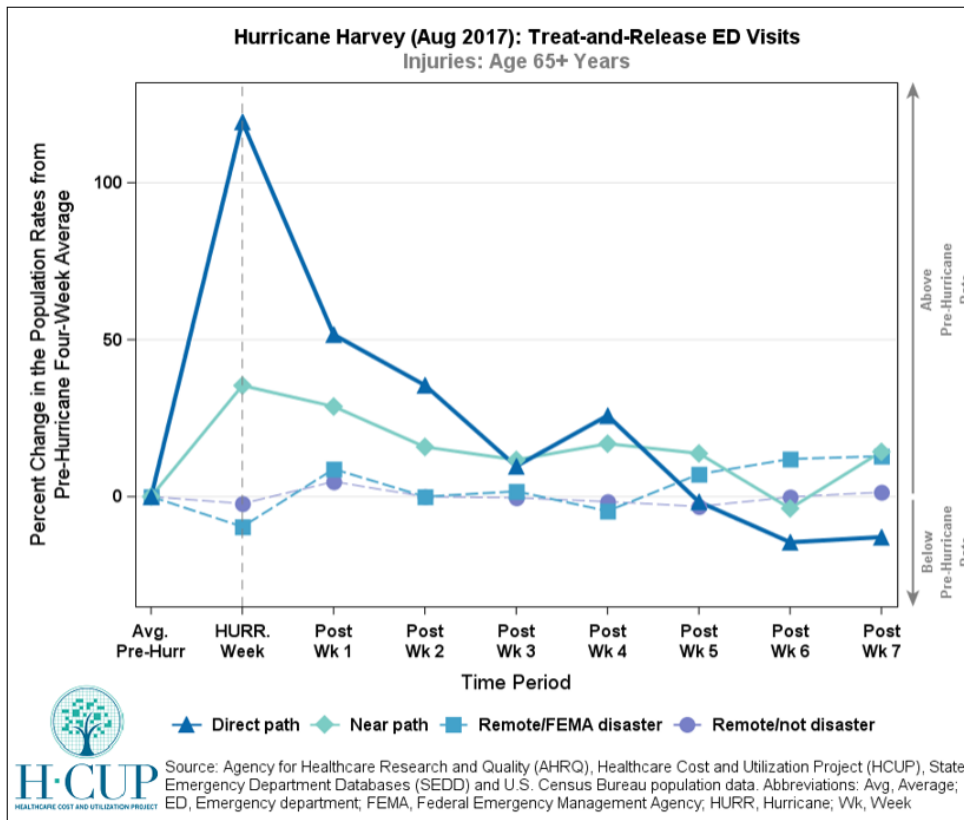
The HCUP Fast Stats tool also allows the user to obtain underlying details on the reported hurricane statistics through web-based data tables containing the values depicted in the selected graph. Users can also obtain further details through a downloadable Excel data file that includes the underlying hospital utilization counts and rates, the percent change values, and population counts. In addition, maps for each hurricane are provided that depict the impact areas for each hurricane as well as areas with available HCUP data.

> ➢ **Deliverable #3(b): User guidance, related technical support materials, and other documentation on the disaster-relevant public statistical query system.**

As part of the HCUP Fast Stats hurricane topic, detailed user documentation is provided in the form of "Data Notes & Methods" that are accessible directly on the web page. The Data Notes & Methods provide details on the following:

- List of States included for each hurricane
- Definition of hurricane proximity categories
- Patient county assignment methodology
- Unit of analysis
- Percent change calculation, including data suppression rules
- Details on HCUP data sources for inpatient stay and treat-and-release ED visit data
- Clinical codes used to define specific conditions
- Description of age groups
- Caveats on data analysis

Objective #3: Perform analyses on disaster-related outcomes using HCUP data from the analytic data platform.

HCUP Statistical Brief on ED-Related Injuries After a Hurricane

> ➢ **Deliverable #4: Public report or manuscript of publishable quality that uses HCUP data to examine health utilization and/or outcomes relevant to a disaster**

A new HCUP Statistical Brief on hospital utilization following a hurricane was developed under this project and will be published on the HCUP-US website[6] in September 2020: *Impact of Hurricanes on Injury-Related Emergency Department Visits, 2005–2016.* Aggregated statistics are presented across seven U.S. hurricanes from 2005–2016. Building off the manuscript entitled *Effects of Hurricanes on Emergency Department Utilization: An Analysis Across Seven U.S. Storms*,[7] the Statistical Brief provides the percent change in the population rate of injury-related treat-and-release ED visits and ED visits resulting in admission during the week of the hurricane and the following 3 posthurricane weeks, distinguishing by proximity of the patient's county of residence to the hurricane (in the direct path of the hurricane, in the near path of the hurricane, or remote from the hurricane path), and by three patient age groups (0–17, 18–64, and 65+ years).

Key findings presented in the Statistical Brief include the following:

- The rate of injury-related ED visits resulting in hospital admission increased the most during the week of the hurricane for people of all ages living in the direct path: 22.6

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[6] https://www.hcup-us.ahrq.gov/reports/statbriefs/statbriefs.jsp

[7] Heslin KC, Barrett ML, Hensche M, Pickens G, Ringel JS, Karaca Z, Owens PL. Effects of hurricanes on emergency department utilization: an analysis across seven U.S. storms. Disaster Medicine and Public Health Preparedness. In press.

percent increase for children aged 0–17 years, 13.2 percent increase for adults aged 18–64 years, and 53.2 percent increase for adults aged 65 years and older compared with prehurricane levels.

- Regardless of county proximity to the hurricane, the rates of injury-related ED visits increased for adults aged 65 years and older during the week of the hurricane. However, the impact lessened the farther away that older adults resided from the hurricane's path.
- Children were most affected if they lived in the direct path of the hurricane during the week of the hurricane and the first 2 weeks following the hurricane. The rate of injury-related ED visits resulting in admission among children aged 0–17 years increased 22.6, 15.6, and 26.3 percent, respectively, over these 3 weeks compared with prehurricane levels.

Quick-Turnaround Requests

In late August 2020, the Office of the Assistant Secretary for Preparedness and Response (ASPR) requested that the Agency for Healthcare Research and Quality (AHRQ) conduct an analysis of the expected post-hurricane impact on hospital use in Texas and Louisiana prior to Category 4 Hurricane Laura making landfall in Louisiana on August 27, 2020. The hurricane impact estimate SAS program and the HCUP Hurricane Data Resource files were used for this analysis. Five historical hurricanes that had characteristics in common with Hurricane Laura were used to estimate the percent change in emergency department (ED) visits and inpatient hospitalizations for the week of impact of Hurricane Laura and each of the 3 weeks following the hurricane. The predicted hospital use impact was presented as a minimum and maximum change in the number of weekly ED visits or inpatient stays from baseline and summarized as a percentage change. These estimates were delivered by AHRQ as a report to ASPR prior to Hurricane Laura making landfall in the United States.

LESSONS LEARNED AND CONSIDERATIONS FOR FUTURE WORK

This project focused on building a data resource that can be used to assess and predict medical needs following one particular type of disaster—hurricanes. However, the methodologies, tools, and reporting mechanisms that were developed can be applied to a range of other types of natural disasters, such as earthquakes and wildfires, as well as to other types of medical emergencies, such as the COVID-19 pandemic. There are several lessons learned and recommendations for future work based on this project.

First, there is substantial complexity and challenge involved in clearly defining the population impacted by a natural disaster. For example, who is specifically impacted by the disaster—only those who live directly in the eye of the hurricane or the path of a wildfire? What about those who live farther from the direct path of the disaster and are potentially affected by hurricane-related winds, storms, and flooding or those affected by poor air conditions caused by fire-related smoke?

In this project, the population impacted by a hurricane was separated into four groups: (1) in the direct path of the hurricane, (2) near the path of the hurricane, (3) remote from the hurricane

path and declared a disaster area by the Federal Emergency Management Agency (FEMA), and (4) remote from the hurricane path and not a FEMA disaster area. Data from the National Oceanic and Atmospheric Administration (NOAA) were used to determine which counties were in the direct and near path of the hurricane. NOAA's Best Track dataset provides measurement points taken every 6 hours that include the location of the hurricane and wind measurements in four directions. ArcGIS® software was used to infer the hurricane trajectory between measurement points (to define the direct path) and to determine concentric wind radii around each measurement point (to define the near path).

However, the 6-hour intervals between measurement points in the NOAA Best Track dataset could result in considerable gaps in information if the storm was fast moving, so the exact hurricane trajectory had to be estimated, which could result in imprecision. Similarly, the use of geographic circles defined by wind radii to classify counties as impacted by the hurricane may be overgenerous in identification (e.g., when only the outside edge of the wind radii circle touches the border of the county or one small coastal island) and may not identify counties that would have been detected if a shape other than a circle was used. For some hurricanes, there is incomplete wind radii information as a storm nears dissipation, making the temporal and spatial terminus of the hurricane difficult to determine.

One area for future development of this work on hurricane-related medical needs could involve exploring more sophisticated approaches for defining the hurricane proximity areas. For instance, more precise hurricane wind areas could be determined by using complex shapes, rather than concentric circles, because hurricane wind radii are not the same in all directions.

Second, identifying those potentially impacted individuals in the defined disaster areas who seek medical treatment also is not straightforward. What happens to patients who have evacuated and seek care at hospitals outside of their county of residence or even outside of the disaster area entirely? How are patients counted who are not residents of the county but were visitors to the area during the disaster? In this project, we created two different county-level versions of the Healthcare Cost and Utilization Project (HCUP) hospitalization data files. The first version (patient county) included records for patients residing in a hurricane-impacted State who were treated at a hospital within the patient's State of residence or who were treated out of State at a hospital within 250 miles of the patient's residence. The second version (hospital county) included records for patients who were treated at a given hospital in a hurricane-impacted State whether or not they were residents of the State in which the hospital is located. Population at-risk data were based on the U.S. Census Bureau's resident population for each county. Future research could explore refinements to identifying the impacted population (e.g., what were the State- or county-specific evacuation orders and is the radius of 250 miles too large or too small) and the at-risk population (e.g., explore population movement such as typical number of visitors in and residents out of a county at different times of year).

Third, the time period for the potential medical needs arising from the natural disaster is not necessarily clearly defined or limited. Initially, following an event, one might expect to see an increase in visits to the emergency department (ED) for direct disaster-related injuries, such as being struck by debris after a hurricane or smoke inhalation after a wildfire. However, the

expected time period for other disaster-related medical needs, such as heart attacks from disaster-related stress and respiratory problems following extended exposure to disaster-related debris or smoke, may be more difficult to determine. Moreover, medical needs associated with mental and substance use disorders, such as depression, may not emerge for weeks or months after the immediate impact of the disaster has passed. In this project, hospitalization use statistics in the public HCUP Fast Stats tool are presented for the hurricane week and following 7 weeks for all conditions and four specific conditions (circulatory conditions, infections, injuries, and respiratory conditions). Future work can explore these and other conditions in the inpatient and ED settings to assess the short- medium-, and long-term impact of natural disasters and medical emergencies on hospital utilization.

Fourth, accurately predicting the medical needs of future natural disasters is complex. How well does the past predict the future? Can medical needs following a past hurricane in the Carolinas accurately predict medical needs following a hurricane of today in Texas? Clearly, future estimates will be only as valid as the assumptions underlying the prediction model. The prediction estimation methodology built into the hurricane impact estimate program that was developed as part of this project involves a simple calculation of a ratio that compares the pre- versus post-hurricane hospital utilization based on actual data from prior hurricanes. The results of a comparative analysis of actual versus estimated percent change in hospital use for Hurricane Irma demonstrated that the estimates based on this approach are reasonably accurate—in aggregate, across all conditions, ages, and sex, within 10 percentage points of the actual percent change in hospital use. These overall estimates were generally more accurate when using data aggregated across multiple hurricanes, but an individual hurricane did in some cases produce better estimates. Specific estimates could vary substantially by hurricane, week, condition, age, and sex. The hurricane impact estimate program allows the user to select certain options, such as the specific prior hurricanes and proximity categories to include in the estimates, in order to base estimates for a future hurricane on experience from past, similar hurricanes. However, the developed program does not take into account variation in hurricane characteristics and changes in the population or area density. Hurricane characteristics are available for past hurricanes but are hard to define for impending hurricanes. Historical population data are available, but real-time utilization is not readily available, and difficult to estimate.

Expanding the set of hurricane events (beyond the existing 11) as hurricanes occur in the future could improve selection options, potentially enhancing the representativeness of the data on which prediction can be based. Additionally, alternative impact methodologies could be explored, such as sophisticated modeling that accounts for a range of hurricane characteristics. Indeed, the HCUP Hurricane Data Resource includes a large array of data that can be considered in assessing and predicting medical needs following a hurricane, including county-level storm-related characteristics for each hurricane (e.g., occurrence of heavy rain, flooding, high winds, and tidal surges from the storm), hurricane-relevant county environmental features (e.g., area of county in a flood plain, coastal county, designation as a storm-ready county), and other county-level attributes that may relate to medical needs (e.g., housing occupancy, medical professionals per capita).

Finally, future work can explore medical needs following other natural disasters besides hurricanes, such as wildfires and earthquakes, as well as medical emergencies such as mass shootings and the COVID-19 pandemic. The Agency for Healthcare Research and Quality (AHRQ) continues to use HCUP data to conduct this type of research. For example, in 2019, AHRQ conducted analyses on the impact of wildfires that occurred in California in the fall of 2017 and 2018 on ED visits. The analysis focused on comparing air quality before, during, and after the fires with the number of ED visits for fire-related conditions such as smoke inhalation, respiratory conditions, and burns.[8,9] The frequency and severity of natural disasters and the occurrence of medical emergencies such as COVID-19 clearly demonstrate a substantial need for planning for the healthcare system to be prepared to respond quickly and effectively to the ensuing medical needs caused by these events.

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[8] Wildfires in Northern California: Emergency Department Visits in 2017. Healthcare Cost and Utilization Project. ONLINE. August 19, 2019. Agency for Healthcare Research and Quality. www.hcup-us.ahrq.gov/reports/ataglance/HCUPanalysisCA2017Wildfires.pdf. Accessed April 10, 2020.

[9] Wildfires in California: Emergency Department Visits Around November 2018. Healthcare Cost and Utilization Project. ONLINE. November 7, 2019. Agency for Healthcare Research and Quality. www.hcup-us.ahrq.gov/reports/ataglance/HCUPAnalysisCA2018Wildfires.pdf. Accessed April 10, 2020.

APPENDIX A: HCUP PARTNERS

This project would not be possible without the contributions of the following data collection Partners from across the United States that contributed the hospital inpatient and emergency department data included in the HCUP Hurricane Data Resource:

Arizona Department of Health Services
Arkansas Department of Health
Colorado Hospital Association
Delaware Division of Public Health
District of Columbia Hospital Association
Florida Agency for Health Care Administration
Georgia Hospital Association
Illinois Department of Public Health
Indiana Hospital Association
Kansas Hospital Association
Kentucky Cabinet for Health and Family Services
Louisiana Department of Health
Maine Health Data Organization
Maryland Health Services Cost Review Commission
Massachusetts Center for Health Information and Analysis
Michigan Health & Hospital Association
Mississippi State Department of Health
Missouri Hospital Industry Data Institute
New Jersey Department of Health
New Mexico Department of Health
New York State Department of Health
North Carolina Department of Health and Human Services
Oklahoma State Department of Health
Rhode Island Department of Health
South Carolina Revenue and Fiscal Affairs Office
Tennessee Hospital Association
Texas Department of State Health Services
Vermont Association of Hospitals and Health Systems
Virginia Health Information
West Virginia Department of Health and Human Resources, West Virginia Health Care Authority