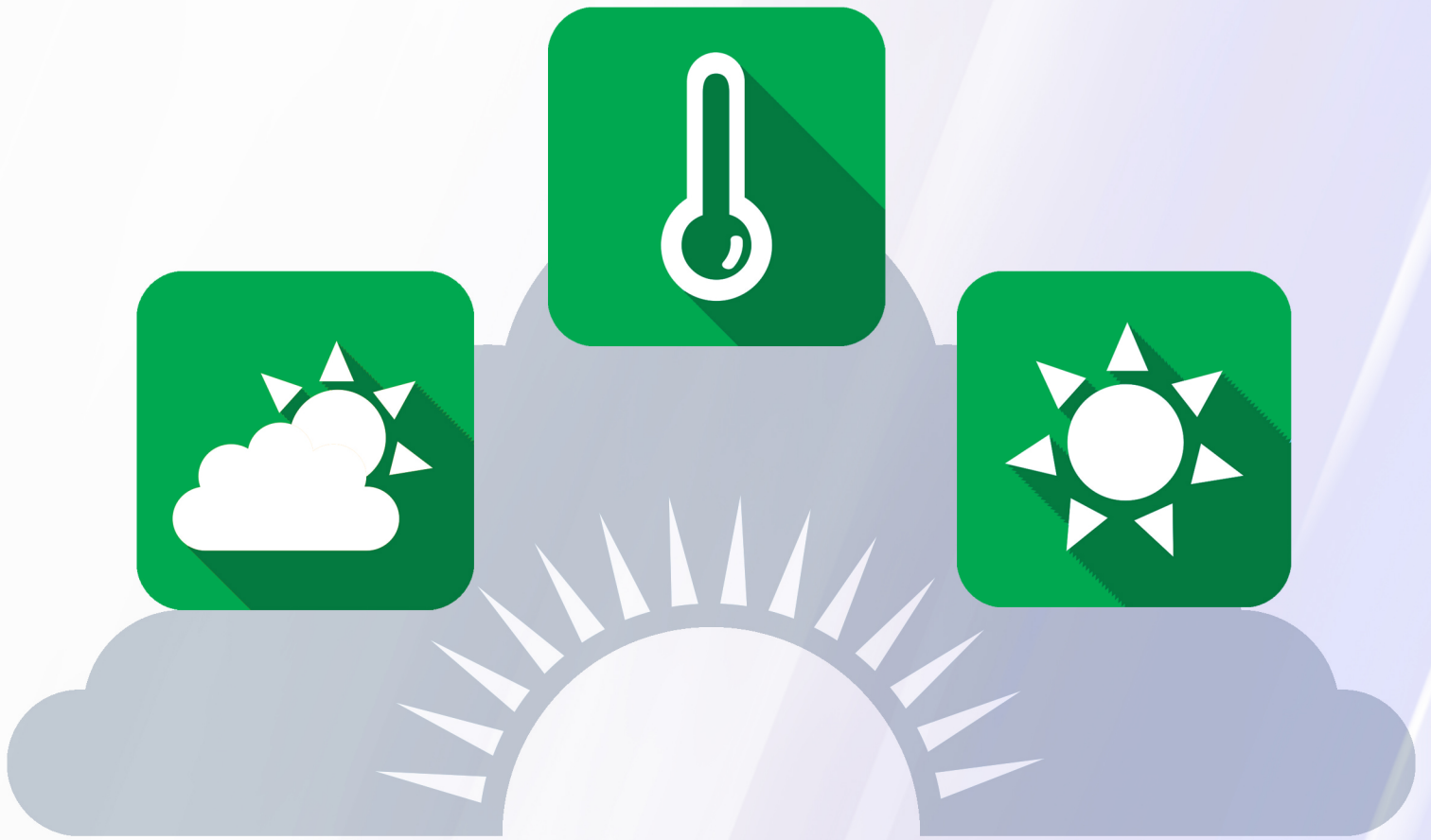




HEAT-RELATED ILLNESS SYNDROME QUERY: A GUIDANCE DOCUMENT FOR IMPLEMENTING HEAT-RELATED ILLNESS SYNDROMIC SURVEILLANCE IN PUBLIC HEALTH PRACTICE



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TERRITORIAL EPIDEMIOLOGISTS

SEPTEMBER 2016
VERSION 1.0

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Acknowledgements

This document was a result of work completed by the Council of State and Territorial Epidemiologists (CSTE) Heat Syndrome Workgroup; part of the CSTE Climate Change Subcommittee. This publication was supported in part by Cooperative Agreement Number 1U38OT000143 from the Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC. The workgroup included the following members:

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Introduction

During an average year, environmental heat is associated with more death in the United States, than any other type of extreme weather event. [1] As the climate warms, extreme heat is expected to pose an even larger threat to health. [2] Many public health departments track heat-related illness (HRI) and death to inform prevention efforts. An increasing number of jurisdictions use syndromic surveillance to identify HRI within emergency department (ED) and inpatient hospital data. In a 2015 nationwide survey of climate-related syndromic surveillance, 16 of 35 (46%) state and local health department respondents reported tracking HRI. [3]

Syndromic surveillance is defined by the Centers for Disease Control and Prevention (CDC) as “public health surveillance that emphasizes the use of near “real-time” pre-diagnostic data, primarily from emergency departments, and statistical tools to detect and characterize unusual activity for further public health investigation or response”. [4] These data tend to be the most timely health information available to inform public health action. The availability of these data may be available on the same day as a patient visit or the following day, depending on technology available to the health agency. Although systems differ, a “syndrome” is frequently defined by a combination of keywords and diagnostic codes. Chief complaint data can be queried to identify words that are suggestive of a certain type of illness. In some cases, diagnostic codes may be available in the data.

Despite the growing use of syndromic surveillance, the current literature is lacking formal guidance for explaining how state and local health departments may define HRI, interpret results, and/or use the data. To that end, the Council of State and Territorial Epidemiologists (CSTE) Climate Change Subcommittee formed a workgroup in 2014 to collect case definitions from jurisdictions across the country and discuss best practices in implementing syndromic surveillance of illness associated with exposure to environmental (i.e., natural) heat.

The goals of this report are to (1) provide a novel syndromic surveillance query for HRI and (2) provide guidance to public health professionals as they adapt the query and implement a HRI syndromic surveillance program in their own jurisdictions. The report includes methods for building the novel HRI query, a description of regional variation, a list of recommended inclusion and exclusion terms for a standard HRI query, suggestions for using HRI syndromic surveillance in practice, guidance for validating the syndrome in practice, and limitations of the query.

Methods

The CSTE Heat Syndrome Workgroup asked state and local health departments to provide syndromic surveillance queries used for identifying HRI. As of June 2015, 14 state and local agencies provided examples of their HRI syndrome queries (Appendix 1). Some agencies provided syndrome queries that were pre-defined by the two most common syndromic surveillance systems, i.e., the National Syndromic Surveillance System (NSSS) BioSense Platform and the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE). These syndrome queries are provided in Appendix 2. Other jurisdictions provided custom HRI queries that were developed locally by the health agency (not provided in this document).

Terms from each syndrome query were added to a master list of heat-related query terms. Some custom queries utilized exclusion criteria to prevent non-heat-related records from being retrieved during

the search. Neither the BioSense nor ESSENCE syndrome queries included exclusion criteria for making the query more specific. The workgroup reviewed all of the terms in the master list, and considered the most common and relevant terms. These are the terms that the group is recommending for use as the standard HRI syndrome query provided in Tables 1 and 2.

Regional variation of syndromic surveillance terms used for HRI

The master list of heat-related query terms was stratified by geographical region to determine whether inclusion or exclusion terms varied by region. Key findings were as follows:

- “Dehydration” was included in the HRI query as an inclusion term for three Northeastern jurisdictions (Maine, New Hampshire, and Philadelphia) and two Midwestern states (Ohio, Michigan) but not in the other jurisdictions. Some jurisdictions tracked dehydration separately from HRI.
- Two Southern states (North Carolina and Florida) provided the ESSENCE query, which includes “sun” terms, such as “sun poison”, “sun rash”, and “sunstroke”
- The BioSense query incorporated Spanish terms in their inclusion terms, but the other queries did not. Examples of these Spanish terms include:
 - Demasiado caliente [English translation: too hot]
 - Ensolacion OR Insolacion [English translation: insolation]
 - Sobre calentado OR Sobre caliente [English translation: overheated or overheat]

Novel query for heat-related illness

The novel HRI query searches the chief complaint text field for specific heat-related terms and the diagnosis field for numerical codes (Table 1). Both ICD-9-CM and ICD-10-CM (International Classification of Diseases, Clinical Modification, Ninth and Tenth Revisions) are provided below. The inclusion criteria in Table 1 should retrieve most of the heat-related cases in the system, but may also return non-heat-related cases. To make the query more specific, the exclusion terms in Table 2 should be included in the query.

Table 1. Inclusion criteria for the novel heat-related illness syndrome

Category	Terms to include in query
Chief complaint search terms	“heat ”, heatcramp, heatex, heatst, heat-exhaust, heat-related, heat-stroke, hypertherm, overheat, “over heat”, “sun stroke”, sunstr, sun-str, “to hot”, “too hot”, ((heet OR hot) AND (excessive OR exhaust OR expos OR fatigue OR cramp OR stress OR “in car” OR outside OR prostration))
ICD-9-CM diagnosis codes	992 (Effects of heat and light) E900 (Accident caused by excessive heat)
ICD-10-CM diagnosis codes	T67 (Effect of heat and light) X30 (Exposure to excessive natural heat)

Notes: 1) Misspelled words in the table were included intentionally

2) The chief complaint search term “heat ” is equivalent to the word “heat” immediately followed by a space. For instance the terms, “heat cramp” and “heat syncope” would be captured by the query.

Table 2. Exclusion criteria for the novel heat-related illness syndrome

Category	Terms to exclude from query
ICD-9-CM diagnosis codes	1992; 6992; (Misclassification related to 992 ICD9 code) E900.1; E9001 (Accidents due to excessive heat of man-made origin)
ICD-10-CM diagnosis codes	T50.992A (Misclassification related to 992 ICD9 code) W92 (Exposure to excessive heat of man-made origin)
Feeling heat, swelling, redness, and/or pain	allerg; “feeling hot”; “feels hot”; “felt hot”; hot AND sensation; “heat sensation”; inflam; pain AND (limb OR arm OR shoulder OR elbow OR wrist OR hand OR leg OR hip OR groin OR thigh OR knee OR ankle OR foot OR feet); pain AND red; radiat; redness; swell; swollen; surg; “post op”
Using heat / ice for therapeutic reasons	ibuprofen; ibuprophen; alieve; motrin; tylenol; injur; trauma; heat AND ice; heat AND (applied OR tried OR used OR using); “heat pack”; “heating pad”; pain AND (back OR neck OR flank); lumbago; relief; resolve; relieve; releive

Table continued on following page.

Category	Terms to exclude from query
Dental pain and sensitivities to hot / cold temperatures	dental; heat AND cold; hot AND cold; oral AND surg; pain AND (jaw OR mouth OR teeth OR tooth); sensitiv AND (heat OR hot)
Hot food or liquid	hot AND coff; “hot dog”; “hot grease”; “hot peppers”; “hot tea”
Misspelled “heart”, “head”, or “health”	“heat ache”; heatache; “heat attack”; “heat beat”; heatbeat; “heat burn”; heatburn; “heat flutter”; “heat racing”; “heat rate”; heatrate; heatlh; heath; heatth; “hitting heat”; palpitation
Includes the letters “heat”, “heet”, “hot”, or “sun”	cheat; heated; heater; Heather; heating; hotel; lithotr; methotr; photo; psychotic; sheath; sheet; shot; Sunday; theat; wheat
Miscellaneous	accident; alcohol; burn AND mouth; distress; fever; gets hot; “heat flash”; “hot flash”; heat AND rash; “heat sensation”; hives; hot AND shower; “hot tub”; “no heat”; oven; suicid

Notes: 1) Misspelled words in the table were included intentionally

2) Because the workgroup was active before experiencing a warm season when ICD10 codes were used, exclusions based on ICD codes were not explored in depth. Jurisdictions should examine data for potential exclusions related to ICD10 codes.

Steps for implementing heat-related illness syndromic surveillance in practice

1. Determine a data source and method for searching clinical records

This query was developed for ED visit and inpatient hospital admission data but was designed to be flexible. The workgroup recognizes that not all jurisdictions have access to inpatient hospital records. It is possible that the query could be adapted to identify HRI in other sources of clinical data that use free text, such as nurse hotlines, emergency medical services (EMS), and triage notes.

A syndromic surveillance system will be needed to search for text and/or diagnosis codes within a clinical dataset. Popular syndromic surveillance systems include the BioSense Platform (CDC, National Syndromic Surveillance Program) and ESSENCE (The Johns Hopkins University Applied Physics Laboratory). Some jurisdictions have syndromic surveillance systems that are specific to their state or local health department.

Each syndromic surveillance system will have different methods for building a query. For example, BioSense includes applications where either R code or MySQL programming language may be used to query data. Other jurisdictions may query data with SAS or other software. Refer to documentation within the agency to determine appropriate querying methods.

2. Formally validate the query with local data

Described in *Syndrome Validation* section below

3. Decide how often the query will be run and analyzed by the public health agency

Agencies must decide how frequently they will run the query and interpret the data. This will vary depending on the agency's geographical region, relative historical climate, and public health priorities of a given jurisdiction. For example, some agencies may closely monitor HRI throughout the entire heat season, while others may elect to monitor the data more closely during heatwaves. This is described in *Potential Uses of the Data* section below.

4. Decide how the resulting dataset will be analyzed

Methods for analyzing the HRI data include: producing descriptive statistics to summarize demographics and risk factors for HRI cases; monitoring trends over time (vertical bar chart of case counts by day or week); comparing current trends to historical trends using similar time frames from previous years; time-series analysis of HRI; or time-series correlation of HRI incidence data with a measure of heat.

There are a number of ways to measure environmental heat. These include: daily maximum and minimum temperatures; daily average temperatures; daily heat index (which combines air temperature and relative humidity); days with an excessive heat warning; days with a heatwave; and days above a given threshold temperature (e.g., days $\geq 110^{\circ}\text{F}$). Temperatures should be obtained from a reliable source, such as the National Weather Service, and should be consistent with the heat experienced by the population. Different regions have different standards for declaring excessive heat warnings and heatwaves. Some jurisdictions also model the relationship between heat illness, weather and time of year using time series regression models. This can inform timing of surveillance and interpretation of data.

Syndromic data may also be used to identify individual patients, obtain medical records, and perform an in-depth review. However, it may be difficult to obtain a medical chart. HRI is not a communicable disease and most jurisdictions do not mandate reporting of the condition. Before requesting records, check local policies and data use agreements between the public health agency and the submitting facility.

5. Decide how the data will be used to make decisions and take public health action

Described in *Potential Uses of the Data* section below

Syndrome validation

Accuracy of syndromic surveillance case definitions

One way to check a syndrome query's accuracy is to compare ED visits identified by the query with the final diagnosis assigned after the visit and calculate the positive predictive value (PPV). Chief complaints often represent a patient's self-diagnosis, which may lack accuracy compared to a more formal evaluation by a healthcare professional. Therefore, syndrome queries that do not include ICD codes and rely solely on chief complaint text, tend to have misclassification and low PPV. [5] Despite this potential for individual misclassification and lower PPV, syndromes may have a similar temporal pattern to visits observed in hospital discharge data. [6]

The PPV of a syndrome may vary due to the frequency and complexity of the condition under surveillance, characteristics of the population, and the timing or setting of the study. Berry, *et al.* found that PPV of their HRI syndrome improved during a major heat event. [7] When a syndrome was less prevalent, PPV was also lower. [5] Guasticchi, *et al.* found higher PPV between a syndrome and final diagnosis when the signs, symptoms, and exposures histories of a condition were less complex. [5] A study by Cadieux, *et al.* concluded that chief complaints and physician claims were more correlated when physicians treated several patients for the same syndrome in a short time period, as would happen during an extreme heat event. [8] In the same study, PPV was higher for less complex patients, which were defined as those who were younger and those who were less socially deprived.

Data Validation

Depending on local climate and priorities, jurisdictions may elect to utilize or modify the queries provided in this document. Users of this document should validate each syndrome with their own local data to assess their accuracy and utility. There are several options for validating syndrome definitions, a few of which are briefly described below.

Review syndromic surveillance records

One strategy is to manually review records identified with syndromic surveillance. Analysts can review the full text in the chief complaint field and diagnostic code (if available) and make an informed judgment as to whether or not it meets their heat illness case criteria. Discharge diagnosis codes may not be available, or may only be available in a subset of syndromic records. If ICD codes are available, analysts can evaluate the PPV, sensitivity, and specificity of syndromes by comparing cases identified using chief complaint algorithms with the associated ICD discharge code. [6] While manual review of chief complaint data without associated diagnostic codes may be the only tool available in a timely fashion for some jurisdictions, it should be noted that the review may be subject to misclassification. Due

to the nature of categorizing ED complaint data, these visits likely will not represent all potential cases of HRI, and may include non-heat-related illnesses. However, if the contribution of “noise” or error is not excessive, then the data can be used as an indicator of HRI and help describe trends in illness over time.

Comparison with hospital discharge data

Syndromes can also be validated by comparing cases identified using syndromic surveillance to those identified in hospital discharge data over the same time period. This could be done with 1) individual-level matching of cases, 2) time-series correlation without lag, 3) calculation of the predictive value, sensitivity, and specificity of syndromes by comparing with hospital discharge data, and/or 4) an assessment of the relationship between daily counts across data sources to determine if they follow the same temporal pattern and whether they have similar relationships to weather conditions. Understanding the number of cases identified in syndromic data in relation to hospital discharge data can also help analysts understand the extent of under- or over-counting of heat illness when they are using syndromic surveillance in near-real time.

Comparison with medical chart data

Validation of chief complaint data can also be done by reviewing medical charts to identify whether the same syndrome stated in the chief complaint is present in the medical chart. The methods for this comparison could be similar to those used for comparing cases identified using syndromic surveillance with hospital discharge data mentioned above. Validation using medical chart data may compensate for diagnostic coding errors or diagnostic coding differences among health care providers and lead to increased accuracy of predictive values of syndromic case definitions.

*Case study: New Jersey Department of Health
Validation of Heat Syndrome*

Some jurisdictions have already evaluated their heat syndromes by comparing results with hospital discharge data. The New Jersey Department of Health examined HRI counts detected in syndromic surveillance data during the 2009-2011 warm seasons (May-September) with patient billing data. The analysis found that heat syndromic surveillance was relatively insensitive overall (16%) with a positive predictive value (PPV) of 40%, but the sensitivity (23%) and PPV (59%) improved during heat events, and identified all major episodes of HRI in billing data. [7] This also supports the use of heat syndromic surveillance as an indicator of illness, rather than using it as a comprehensive method to count cases.

Potential uses of the data in responding to extreme heat events

Since syndromic surveillance systems provide health data in near real-time, they can help guide public health action. Potential uses of syndromic surveillance data during emergencies may include:

- Assessing the severity of an ongoing heat event with statistical models or aberration detection
- Augmenting public health messages during an ongoing heat wave or targeting messaging to specific sub-populations or areas
- Providing evidence for needing additional response resources in a jurisdiction (e.g., requesting additional cooling center hours or water distribution sites)
- Preparing emergency department staff for visit surges during severe, prolonged heat waves

Syndromic surveillance data are available quickly and provide a valuable source of locally-specific information on heat-health burden and risk factors, but should serve as just one component of a broader surveillance program for heat-related health outcomes. Data from hospital discharges, Vital Statistics, child fatality review, and the Medical Examiner's office can be used to inform longer-term heat response efforts, as these data are more complete and can yield more information on circumstances of exposure and risk factors. Jurisdictions that do not have access to hospital discharge data can examine demographic information and location of cases identified in syndromic surveillance data to inform outreach, messaging, or other heat interventions throughout the warm season.

It is important to consider all available data, even non-health data, before making public health decisions. One of the best predictors of heat-related health outcomes is the weather forecast. As such, the most important criterion for guiding a response to an ongoing heat event is a review of historical, current and future weather conditions. Many jurisdictions use local National Weather Service (NWS) heat advisories, watches, and warnings to determine whether there is a heat emergency. It should be noted that heat wave definitions vary across regions and may depend on different criteria for time frame and temperature metrics. Therefore, jurisdictions may also have different criteria for defining health-related heat emergencies. Some localities have examined the relationship between weather conditions and heat-related mortality to help inform local heat emergency criteria. [9] Providing guidance on how to evaluate heat emergency thresholds is outside the scope of this guidance document.

In summary, the absence of a signal in the heat syndromic data should not outweigh real-time weather data that forecast and describe an extreme heat event. Syndromic surveillance data have limitations (discussed below), that must be considered before scaling down a response or downplaying the potential severity of a prolonged extreme heat event. Due to lag time, persistent dehydration, elevated temperature and hypotension may manifest in the ED a few days after the initial heat warning. Since syndromic surveillance availability lags compared to weather forecast data, it may be most useful in providing situational awareness during a multi-day heat event.

Limitations

The syndrome includes many exclusion terms, which may result in the exclusion of true HRI cases. However, syndromic surveillance is often used as an indicator of HRI incidence. It is not necessarily meant to be a full tally of cases, which can be determined more reliably and accurately using hospital discharge data. Jurisdictions that do not have access to hospital discharge data for ED visits and rely on syndromic surveillance to track HRI may elect to utilize fewer exclusion terms. The tradeoff will be the inclusion of more records that are not cases. As the quality of syndromic data improves with more widely available and reliable diagnostic codes, exclusion criteria can be reevaluated.

The workgroup was active before experiencing a warm season with ICD-10-CM codes in use. Therefore, few exclusion terms were included to correct for ICD-10-CM codes unrelated to heat. However, one jurisdiction reviewed non-warm season records in 2016, and identified the following terms as potentially useful exclusions when searching for ICD-10-CM codes in the chief complaint and diagnostic code fields: HRS, HOURS, MIN, X30M, X30D, SEC, DAY, O992, S992, Z992. They are related to use of time (for example, records noting that patients have had symptoms for "X30MIN") and to misclassification related to ICD-9-CM codes, which may still be employed. ICD-10-CM exclusions should be tested for utility before being used.

There are also limitations to using a pre-defined case definition. While using keywords in an SQL statement represents a quick and straightforward way of retrieving records from the NSSP database (SyS-P), a pre-defined case definition has some serious limitations that can affect the value of the retrieved information. In many cases the PPV of the query is low. This can be alleviated by continually assessing and adjusting the query statement and the keywords, but this process may be labor intensive. In addition, this technique does not allow the user to systematically detect when new words or codes have been introduced into the reports, which could degrade the effectiveness of the queries.

An alternative to using SQL or SAS queries based on pre-defined keywords is to use machine learning (ML) algorithms. These algorithms allow a greater flexibility in defining the syndromes because the key features are determined by the computer algorithm once it has been trained. In order to train an ML algorithm, one needs to feed clearly defined and labeled cases to the machine, such as those identified by the current algorithm. Some conditions are so rare and clear cut that a simple keyword search statement is sufficient to provide all the information needed. However, syndromic surveillance technology is constantly improving, and artificial intelligence, machine learning and other data mining techniques may improve accuracy and efficiency. [10-18] Further, natural language processing (NLP) could help account for “negation terms” that negate nouns or verbs (e.g., “no heat”, “denies heat cramp”).

Potential for expanding the syndrome to include additional symptoms

Dehydration and sunburn are public health concerns that may occur more frequently during the heat season but require different public health messaging / initiatives for prevention. Syndrome definitions for dehydration (Table 3) and sunburn (Table 4) are provided. Jurisdictions may elect to track these conditions independently or in combination with the novel HRI definition. These terms are not be specific to heat and could identify many patient records that are not related to an environmental heat exposure.

Depending on local climate and public health priorities, health departments may elect to explore the utility of these alternate syndrome definitions. Steps may be taken to improve their specificity. For example, adding the terms “heat” and “hot”, may help jurisdictions gain additional situational awareness and understand the true burden of disease during extreme heat events. Also, adding an age filter could help remove older adults who experienced dehydration due to kidney problems.

Table 3. Possible inclusion criteria for a dehydration syndrome

Category	Terms to include in query
Chief complaint search terms	dehy; dehidration; “dry mouth”; drymouth; electrolyte AND (abnormal OR imbalance); hypovolemia; “volume depletion”
ICD-9-CM diagnosis search terms	276.5; 2765 (Volume depletion)
ICD-10-CM diagnosis search terms	E86 (Volume depletion)

Note: Misspelled words in the table were included intentionally

Table 4. Possible inclusion criteria for a sunburn syndrome

Category	Terms to include in query
Chief complaint search terms	sunburn; sun AND (burn OR ex OR poison OR rash)
ICD-9-CM diagnosis search terms	692.71; 69271 (Sunburn first degree) 692.76; 69276 (Sunburn second degree) 692.77; 69277 (Sunburn third degree)
ICD-10-CM diagnosis search terms	L55 (Sunburn) X32 (Exposure to sunlight)

Conclusions and recommendations

Heat-related morbidity and mortality are preventable but common. Health departments may benefit from monitoring real-time HRI data, in combination with weather forecasts, so they may modify public health messaging or initiate additional prevention efforts. Since few jurisdictions mandate HRI reporting, data may be difficult to obtain. Syndromic surveillance provides an opportunity to maintain near real-time situational awareness from emergency departments and other healthcare facilities. This document provides guidance for jurisdictions that aim to build or improve syndromic surveillance of HRI in their region. Depending on local climate and priorities, jurisdictions may elect to utilize or modify the queries provided in this document. Though the workgroup has begun validating these syndromes in various jurisdictions, users of this document should validate each syndrome with their own local data to assess their accuracy and utility.

Appendix 1. Number of queries for heat-related illness submitted to the CSTE Heat Syndrome Workgroup by type of query

	BioSense Platform	ESSENCE	Custom
Atlantic Coast Maine, New Hampshire, New York City, New Jersey, Philadelphia, North Carolina*, Florida	0	2	6
Midwest Michigan*, Missouri, Ohio*	2	0	3
Mountain Arizona, New Mexico	1	0	1
Pacific Coast Los Angeles, San Diego	0	0	2
Total	3	2	12

*Jurisdiction submitted both a pre-defined heat-related illness (HRI) query from a commercial syndromic surveillance system (i.e., BioSense or ESSENCE) and a custom HRI query

Appendix 2. Diagnosis and chief complaint search terms in the BioSense “heat, excessive” query and the ESSENCE “excessive heat” query

Syndromic Developer	Syndromic Name	Query Terms
National Syndromic Surveillance Program (NSSP); BioSense Platform	“heat, excessive”	<p>Diagnosis search terms: 992, E900, T67, X30</p> <p>Diagnosis text search terms: demasiado caliente, to hot, too hot, excessive + heat, heat apoplexy, heat collapse, heat cramps, heat edema, heat effects, heat exhaustion, heat fatigue, heat prostration, heat pyrexia, heat stroke, heat syncope, over + heated</p> <p>Chief complaint search terms: demasiado caliente, to hot, too hot, enlosacion, heat, hypertermia, hyperthermia, insolacion, over + heated, overheated, sobre calentado, sobre caliente</p>
Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE)	“Excessive Heat”	<p>Chief complaint search terms: heat casualty, heat cramp, heat cramping, heat emergency, heat exacerbation, heat exhaustion, heat exposure, heat fatigue, heat illness, heat injury, heat prostration, heat rash, heat related, heat stress, heat stroke, heat syncope, heat syndrome, heat trauma, over heat, over heated, over heating, sun exposure, sun poison, sun poisoning, sun rash, sun stroke</p>

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