Syndromic Surveillance for Occupational Health Surveillance

Guidance Document and Examples

Council of State and Territorial Epidemiologists

Occupational Health Surveillance Subcommittee

Occupational Syndromic Surveillance Workgroup

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Syndromic Surveillance for Occupational Health Surveillance Guidance Document

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I. Introduction

Non-fatal occupational injuries and illnesses place a significant burden on the United States (U.S.) population. In 2018 the Bureau of Labor Statistics (BLS) estimated that there were 2.8 million non-fatal work-related injuries and illnesses, a rate of 2.8 cases per 100 full-time equivalent workers (BLS, 2019). A 2011 study estimated the economic burden for non-fatal work-related injuries and illnesses in 2007 as $198 billion (Leigh, 2011). Surveillance of work-related injuries and illnesses plays an important part in improving the health and safety of workers by informing intervention and prevention strategies. In the U.S., non-fatal occupational injuries and illnesses are surveilled using a combination of different data sources. Current data sources include Hospital Discharge data, Emergency Discharge data, State Workers' Compensation, and the Survey of Occupational Injuries and Illnesses (SOII), which is conducted annually by the BLS. One resource, which provides some initial guidance on conducting occupational health surveillance using these types of data sources, is the Occupational Health Indicators (OHIs) guidance document compiled by the Council of State and Territorial Epidemiologists (CSTE) in collaboration with the National Institute for Occupational Safety and Health (NIOSH) (CSTE, 2017). Hospital discharge and emergency discharge data are usually filtered by Workers' Compensation as primary payer and results in under-reporting of occupational cases which may not show the true burden. This under-reporting could be due to workers not filing a claim because they may use other insurance to file the claim; they may not want to miss work; are afraid they may lose their job; the injury may not seem severe enough to file a claim; state laws which restrict eligibility for Workers' Compensation; or administrative barriers to filing for Workers' Compensation benefits. (Shannon, 2002; Rosenman, 2000) Another limitation is that there is often a delay in when data are received, the length of which can vary by state and by data source. There may be a lag from three months to two years as seen with the SOII data. Each data source used for occupational health surveillance captures a slightly different population and different information.

Traditionally syndromic surveillance is used as an early warning to respond to potential outbreaks in a community. Syndromic surveillance data differ by state but generally include hospitalizations, emergency department (ED) and clinical visits, collected in near real-time. A few states have begun evaluating the extension of a real-time syndromic surveillance tool to identify work-related ED visits, but syndromic surveillance has not been widely applied by occupational health to identify work related injuries and illnesses. The incorporation of multiple data sources for occupational health surveillance is useful in capturing additional work-related cases and can provide helpful information on the distribution of work-related injuries (Borjan, 2017; Davis, 2014; Kica, 2012). Syndromic surveillance has the potential to capture cases that typically may not be captured by other systems (e.g., self-employed workers). Additionally, syndromic surveillance systems capture data that can be used to identify work-related injuries and illnesses independent of the expected payer information and could be useful in identifying disparities which may exist among vulnerable workers who have larger barriers to filing for Workers' Compensation. Syndromic surveillance can also provide data in real-time allowing for a more rapid response.

The purpose of the Occupational Syndromic Surveillance Working Group is to produce a document that contains a syndromic surveillance primer and guidance for occupational health professionals to explore this new data source for occupational health surveillance in their own states. Additionally, it will provide opportunities for occupational health programs to intersect and work with other public health disciplines and may provide opportunities to collaborate with the CSTE Surveillance/Informatics Steering Committee.

II. Brief syndromic surveillance primer

Overview

Historically, syndromic surveillance has not been used to identify work-related injuries and illnesses and may not be included in state-based occupational safety and health surveillance systems. However, occupational health surveillance is one important aspect of syndromic surveillance. Syndromic surveillance monitors (near) real-time health-related data, reflecting medical encounters that occurred in the previous hour, 12 hours, or 24 hours. These methods are particularly useful for outbreak identification and rapid response by public health professionals, as well as for situational awareness and resource management (ISDS, 2012). Syndromic surveillance methods are also used for disease and injury trend monitoring, as well as tracking of adverse health outcomes potentially related to a specific event or exposure (ISDS, 2012). In instances of work-related exposure, syndromic surveillance is also used for occupational health surveillance. In New Jersey, syndromic surveillance identified work-related injuries to tree workers after Hurricane Sandy as well as occupational chemical exposures (Borjan, 2017; Marshall, 2018). In other states, syndromic surveillance identified occupational carbon monoxide poisoning (personal communication: Derry Stover, Nebraska Department of Health and Human Services; Carol Braun, Missouri Department of Health and Senior Services), heat related illness among workers, (personal communication: Jessica White, Maricopa County Public Health Department) and identification of work-related agricultural injuries (NSSP, 2017).

The primary goal of this document is to provide guidance for occupational health professionals to explore syndromic surveillance as a new method for occupational health surveillance. As there is considerable variation among syndromic surveillance systems within the United States, this document will discuss querying the CDC's National Syndromic Surveillance Program's (NSSP) BioSence Platform ESSENCE tool but and will also describe how to create definitions for specific locations, worker populations, or work-related outcome.

In conclusion, syndromic surveillance is an established tool in the surveillance toolbox for many public health agencies and its use continues to expand to new topical areas (Gould, 2017; Hopkins, 2017). The incorporation of syndromic surveillance into routine occupational health surveillance practices may provide information not available from traditional sources, provide data in near real-time for immediate response, as well as opportunities for occupational health programs to interact and connect with other public health disciplines.

III. Creating an occupational health specific syndrome definition

Identify syndromic surveillance system

Before implementing syndromic surveillance, the syndromic surveillance system being used should be identified as jurisdictions use different systems for this type of surveillance such as homegrown systems specific to their state. For example, New Jersey uses EpiCenter which was developed and is maintained by Health Monitoring; Louisiana developed LEEDS (Louisiana Early Event Detection System); and Georgia uses SendSS (State Electronic Notifiable Disease Surveillance System). At the national level, the CDC's NSSP established the BioSense Platform which uses Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) as its framework for syndromic surveillance. ESSENCE is a web-based disease surveillance information system that allows jurisdictions to monitor and

analyze data for public health events, as well as to share data and analyses (CDC, 2017). ESSENCE groups weighted chief complaint terms from electronic ED data into 'syndrome' categories. This information is used to determine if the number of visits is greater than expected for a facility or jurisdiction based on historical data and statistical algorithms to conduct early event detection. Before implementing syndromic surveillance in state occupational health surveillance, it is important to determine the following: if state healthcare facilities report syndromic data; how many facilities in the state are reporting their data; and if the data are available in either a local syndromic surveillance system or the NSSP BioSense platform.

In addition, states implementing syndromic surveillance in occupational health surveillance should know which data elements of the state's syndromic surveillance system are available and what fields can be queried directly. Fields such as the chief complaint, diagnosis codes, and triage notes are often used to search for specific keywords and text patterns and ICD-10-CM codes to query the system for specific syndromes. ICD-codes can be searched in the discharge diagnosis field and are sometimes present in the chief complaint and admit reason fields. This information will allow states to decide if the syndrome definition will be based on keywords, diagnosis codes or both. Table 1 presents examples of the different systems and key data elements that are used by different states. Emergency department data is the primary source of data for syndromic surveillance.

Table 1. State Systems and Key Data Elements

	New Jersey	Oregon	Louisiana	Washington	Texas	Georgia
System	EpiCenter (developed and maintained by Health Monitoring)	NSSP BioSense ESSENCE	LEEDS – Louisiana Early Event Detection System (system created in LA)	NSSP BioSence ESSENCE	3 separate systems that share information: TxS2 (statewide); NTXSS (Tarrant County); Houston DOH syndromics system	SendSS Syndromic Surveillance Module
Data	79 of 80 ED facilities submit; a subset of state poison control data is automatically downloaded once a day in EpiCenter	ED; some urgent care (~10% of facilities); poison control data; weather data; death records	ED	ED and HD data; outpatient data from 922 clinics (primary, urgent, medical specialty care)	Eligible and participating ED hospitals, urgent care, standard ED, Poison Control, and EMS	135 of 140 ED and Urgent Care Facilities sending data on a daily basis
Key Data Elements	Chief complaint, discharge diagnosis code, age, gender, race/ethnicity, facility, county, 49 ED's are submitting triage notes	Chief complaint, discharge diagnosis codes, age, gender, race/ethnicity, facility, county	Chief complaint, admit reason, discharge diagnosis description and codes (a lot of null codes), facility name, DOB, gender, race/ ethnicity	Chief complaint, triage notes, procedure codes	Chief complaint, clinic/facility, data source, diagnosis codes and description, triage notes, gender, age in years, race/ethnicity	Name of facility; date/time of visit; age; gender; race; zip code of residence; chief complaint; triage notes; discharge diagnosis and disposition
Smallest Geographic Level Available	Zip Code	Zip Code	Zip Code		Zip Code	Zip Code
Real-time	Data received in real-time; a few facilities send in 24 hours	24 hours	24 hours		24 hours	24 hours
Local Syndrome Definitions*	Work-related injuries; Chemical exposures; Tree-related injuries; (severe weather)	OH query and ICD-10-CM pesticide query created; working on back injuries	Amputations Work-related Heat illness Pesticide, chemical, and heavy metal exposures	OH query created	Currently, no environmental or occupational queries have been created or used	Working on work-related injuries; heat Illness; pesticide exposures; amputations; asthma

Additional Notes	Have direct access to EpiCenter to pull data or receive e-mail alerts based on threshold levels. These data are fed into NSSP BioSense Platform	The pesticide query in use is only ICD codes and not syndromic (T60 and T59) so that the results meet criteria for suspected pesticide poisoning cases	Syndrome definitions are pulled from chief complaint, admit reason, and discharge diagnosis. Syndromic surveillance coordinator pulls data and sends an excel file to the OH program biweekly. LEEDS data is also sent to the NSSP to be uploaded to ESSENCE	Syndrome has been developed, but not yet formally evaluated or used to track work-related visits	OH program has access to ESSENCE system, to create and implement a query. More information can be found at https://www.dshs.texas.gov/txs2/ Data from 3 systems are fed into NSSP BioSense Platform	Data feed is also sent to ESSENCE on a daily basis

*See next section and appendix for examples, and development, of syndrome definitions.

Determine keywords and/or diagnosis codes

States participating in the Workgroup were asked to provide their states' syndrome definitions (Tables 2-4) for occupational health. These syndrome definitions were developed by the state agency. The inclusion keywords should retrieve most of the occupational-related illnesses and injuries, but it is also possible non-occupational cases will also be retrieved. Therefore, a list of exclusion keywords (Tables 3) should also be included in the query. For example, if trying to identify work-related cases and the keyword is "work", an exclusion keyword such as "bloodwork" or "workout" would be used to exclude those non-work-related cases.

The keywords included below are intended to be a starting point for states to begin creating their own set of keywords for their state's syndrome definition. Data will vary state-to-state as different regions of the country experience different types of work-related injuries and illnesses. For example, one state's primary industry may be agriculture while another state may see more injuries related to fisheries or transportation. Also, some states may experience more heat-related injuries because they are in areas of the country with a warmer climate. Therefore, syndrome definition development is an iterative process. When determining the keywords to use from the data it is often easier to start with a broad definition such as "job" or "work". This broad definition will cast a wide net in capturing cases and will also likely capture false positive cases, but these cases can be helpful to narrow down the definition and minimize false positives. Diagnosis codes can also be used to help identify keywords if your outcome has a well-defined diagnosis code. If your syndromic surveillance system receives diagnosis codes, you can identify cases based on ICD-10-CM codes and use the chief complaint fields or triage notes to help identify additional keywords.

Table 2. Work-Related Syndrome Definitions by State, Inclusion Keywords and Diagnosis Codes*

	Inclusion Keywords	Diagnosis Codes
New Jersey	"at work"; "@work"; "@ work"; "work related"; "work acc"; "work inj"; "while work"; "workers comp"; "worker comp"; "worker's comp"; "work mans comp"; "workmens comp"; "occupa"; "accident work"; "job"	
Louisiana	"work"	
Washington**	"at work"; "work related"; "work acc"; "work inj"; "workers comp"; "worker comp"; "workmans comp"; "workmens comp"; "occupa"; "accident work"; "job related"; "on the job"; "OJI"; "OTJ"; "labor and industry"; "LNI"; "L and I"	Z04.2; Z042; Y99.0; Y990; Y92.6; Y926; Y92.7; Y927
Georgia	"work"; "occupa"; "job"; "OJI"; "OTJ"	Y99.0; Y99.1; Y92.61; Y92.62; Y92.63; Y92.64; Y92.65; Y92.69; Y92.71; Y92.72; Y92.73; Y92.74; Y92.79; Z04.2; Z57.6; Z57.8

* Record can have keyword OR diagnosis code.

** "labor and industry"; "LNI"; "L and I" are specific to WA as their Workers' Compensation system is administered by Labor and Industries/L and I/LNI, etc.

Table 3. Work-Related Syndrome Definitions by State, Exclusion Keywords

	Exclusion Keywords
New Jersey	"workout"; "work up"; "work note"; "labwork"; "lab work"; "bloodwork"; "blood work"
Louisiana	"bloodwork"; "blood work"; "labwork"; "lab work"; "paperwork"; "paper work"; "work note"; "firework"; "fire work"; "return to work"; "work excuse"; "work clearance"; "workup"; "work up"; "work-up"; "workout"; "working out"; "social work"; "dental work"; "letter for"; "not working"
Washington	"workout"; "working out"; "work up"; "work note"; "labwork"; "lab work"; "bloodwork"; "blood work"
Georgia	"bloodwork"; "blood work"; labwork"; "lab work"; "paperwork"; "paper work"; "work note"; "firework"; "fire work"; "work up"; "work-up"; "work out"; "working out"; "social work"; "dental work"; "blood work"

Table 4. Examples of Work-Related Queries Used in NSSP BioSense ESSENCE

	Based on Chief Complaint (CC) and Discharge Diagnosis (DD)	Based on Triage Notes
Oregon*	(((([CCANDDD="*WORK RELATED INJURY*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])) OR (([CCANDDD="*AT WORK*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])) OR (([CCANDDD="*JOB*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])) OR (([CCANDDD="*OJI*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])) OR	[TRIAGENOTE="*at work*"] OR [TRIAGENOTE="*co worker*"] OR [TRIAGENOTE="*coworker*"] OR [TRIAGENOTE="*co-worker*"] OR [TRIAGENOTE="*employee exposure*"] OR [TRIAGENOTE="*exposure employee*"] OR [TRIAGENOTE="*exposure occupation*"] OR [TRIAGENOTE="*injured at work*"] OR [TRIAGENOTE="*injury at work*"] OR [TRIAGENOTE="*job*"] OR [TRIAGENOTE="*job injur*"] OR [TRIAGENOTE="*occupational exposure*"] OR [TRIAGENOTE="*OJI*"] OR [TRIAGENOTE="*on the job*"] OR [TRIAGENOTE="*return to work*"] OR [TRIAGENOTE="*sent by work*"] OR [TRIAGENOTE="*while working*"] OR [TRIAGENOTE="*work burn*"] OR [TRIAGENOTE="*work comp*"] OR [TRIAGENOTE="*work injury*"] OR [TRIAGENOTE="*work place injury*"] OR [TRIAGENOTE="*work relate*"] OR [TRIAGENOTE="*workcomp*"] OR [TRIAGENOTE="*worker s comp*"] OR [TRIAGENOTE="*worker s comp*"] OR [TRIAGENOTE="*worker s comp*"] OR [TRIAGENOTE="*workers comp*"] OR [TRIAGENOTE="*workman comp*"]

	(([CCANDDD="*OTJ*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])) OR (([CCANDDD="*Y990*"]) AND ([CCANDDD<>"*CLEARANCE*"] OR [CCANDDD<>"*RETURN TO WORK*"] OR [CCANDDD<>"*STAT WORK*"] OR [CCANDDD<>"*RECHECK*"] OR [CCANDDD<>"*NOTE*"])))	OR [TRIAGENOTE="*workmans comp*"] OR [TRIAGENOTE="*workmen comp*"] OR [TRIAGENOTE="*workmens comp*"] OR [TRIAGENOTE="*workplace injury*"] OR [TRIAGENOTE="*work-relate*"] OR [TRIAGENOTE="*works with*"] AND [TRIAGENOTE<>"*working on his*"] AND [TRIAGENOTE<>"*working on her*"] AND [TRIAGENOTE<>"*while working on her*"] AND [TRIAGENOTE<>"*while working on him*"] AND [TRIAGENOTE<>"*while working out*"] AND [TRIAGENOTE<>"*working out at*"] AND [TRIAGENOTE<>"*at gym working out*"] AND [TRIAGENOTE<>"*while working in yard*"] AND [TRIAGENOTE<>"*overdose*"] AND [TRIAGENOTE<>"*over dose*"] AND [TRIAGENOTE<>"*dr. oji*"] AND [TRIAGENOTE<>"*doctor oji*"] AND [TRIAGENOTE<>"*dr oji*"]

* In Oregon's data a doctor with the last name Oji led to false positive results and, therefore, was added as an exclusion criteria.
Note that < > means "AND NOT" in the Oregon queries.

Validate keywords and diagnosis codes

Note: Please refer to CSTE, 2016 and Morano, 2017 for more detailed explanations on validating keywords, diagnosis codes, and data.

Once keywords and diagnosis codes have been identified and a syndrome definition has been developed, it is important to validate and determine how effective the syndrome definition is in identifying cases. There are several ways to do this:

- Manually review the records that were identified by the syndromic surveillance system. This involves reviewing the chief complaint, diagnosis codes, and triage notes (when available) to determine if the visit meets the syndrome definition criteria.
- Calculate the positive predictive value by comparing emergency department visits identified with the final diagnosis that was assigned after the visit. Note that this can be difficult to do with syndromes that are just capturing work-related visits and may not generate satisfactory measures of sensitivity and positive predictive values. Calculating positive predictive value may be more useful when hospitals are providing ICD-10-CM codes or for more outcome specific syndrome definitions with specific ICD-10-CM codes. Please refer to Tsai, 2016 and Borjan, 2017 for additional background and examples of calculating positive predictive values.
- Compare the syndromic data to emergency department discharge data. Data may be difficult to match due to lack of personal identifiers in the syndromic surveillance data, and identical trends

are not expected given differences in case identification. However, trends can be compared between the discharge data and the syndromic surveillance data. For example, for tree-related injuries, similar spikes in cases were seen between tree-related injuries in the syndromic surveillance system compared to work-related hospitalizations in emergency discharge data during Hurricane Sandy and several Nor'Easters that occurred in New Jersey.

- Review medical records and compare to the chief complaint fields.

It is also possible to use machine learning as an alternative to SAS or SQL to reduce the burden of manual review of cases for verification. Creating algorithms allows for more flexibility when creating a syndrome definition since the key characteristics are defined by the computer algorithm when it is trained. (CSTE, 2016)

Running queries and setting thresholds

Once a syndrome definition has been established, it is necessary to determine how often a query should be run and how often to interpret the data. As stated earlier, these parameters also depend on the jurisdiction and the syndromic surveillance system used. Another consideration is how many facilities are reporting their ED data and if hospitals who are reporting have sufficient data (i.e., admissions information) for daily reporting.

Some systems are able to send an alert via e-mail when the number of cases exceeds the established threshold limit. Setting this threshold often involves a retrospective analysis of the syndromic data and, based on the number of cases seen in the ED for a specific syndrome, a threshold can be set to trigger an alert. For example, an email is sent when there are more than two cases classified as chemical exposure within 24-hours in the same county or same ED in New Jersey. Queries can also be set to run on a daily or weekly basis or can be set to run during certain public health events like severe weather events or large public gatherings. For instance, some states may only use the heat-related illness definition during specific months of the year (i.e., June through August) or closely monitor tree-related injuries during severe weather events such as clean-up after a hurricane.

Based on how data are received, states should also determine:

- How often syndromic data should be reviewed (i.e., seasonally, daily, weekly, monthly, or as they are alerted).
- If follow-up should be conducted with the ED's for further information to help determine if the cases were work-related.

IV. Outcome specific syndrome definition

The previous section discussed how to create a general syndrome definition for work-related illnesses and injuries, but there are a number of health outcomes related to work-related injuries and illnesses for which narrower syndrome definitions can be created, such as heat-related illness, tree-related injuries, chemical exposures, etc.

Syndromic surveillance in action

The following examples detail how syndromic surveillance has been used in states for occupational health surveillance and current syndrome definitions that are being developed.

The table in the Appendix contains a list of additional keywords to help states create more specific syndrome definitions. These keywords are intended to be used as a starting point for states to create their own syndrome definitions.

New Jersey

The New Jersey Department of Health (NJDOH), Occupational Health Surveillance Unit (OHS) has used EpiCenter, the NJDOH's existing real-time surveillance system, which was developed and is maintained by Health Monitoring Systems, Inc. to track a variety of work-related ED visits, including chemical exposures and tree-related injuries, throughout the state.

Work-Related Injuries: Over 20,000 non-fatal work-related injuries were reported via EpiCenter from 2015-2017. In 2017, of the 6,834 work-related cases, the most frequent cause of injury were falls/slips/trips (from ladder, from roof); the body part most frequently affected was the back due to fall; and the most common type of injury was a cut or laceration, usually to the hand, finger, or thumb.

Number of Non-Fatal Work-Related Injuries by Case Characteristics, New Jersey, 2017 (n=6,834)

Event of Exposure		Part of Body Affected		Nature of Illness or Injury	
Fall Slips Trips	643 (9.4%)	Back	698 (10.2%)	Cut/Laceration	594 (8.7%)
Assault	92 (1.3%)	Head	594 (8.7%)	Burns	116 (1.7%)
MVA	87 (1.3%)	Knee	276 (4.0%)	Contusion	33 (0.5%)
Bite (human & animal)	82 (1.2)	Eye	222 (3.2%)	Sprain Strains Tears	62 (0.9%)
Struck By	8 (0.1%)	Wrist	177 (2.6%)	Fracture	15 (0.2%)
Forklift	3 (0.04%)	Neck	121 (1.8%)	Amputation	3 (0.04%)

Chemical Exposures: Work-related chemical exposures are also captured through EpiCenter. This real-time surveillance of occupational events has detected numerous diverse exposures including the following examples:

- Employees exposed to bear repellent that discharged when a shipment fell off a shelf at a warehouse.
- Chemical (naphtha) leak at a refinery across from a high school which was subsequently evacuated.
- Glycol leak from a heating system at an elementary school that was evacuated.

The syndrome definition has allowed staff to identify chemical events early so a rapid response can be initiated by the Occupational Safety and Health Administration (OSHA) or Public Employee OSHA, reducing further risk of occupational injuries and illnesses.

Staff are also able to characterize type of exposure through the chief complaint text. For example, of the 292 exposures in 2017, the body part most affected was the eye (22.6%) and 45 (15.4%) of the cases were exposed to bleach. Once staff have been alerted of a chemical exposure, they often contact the ED

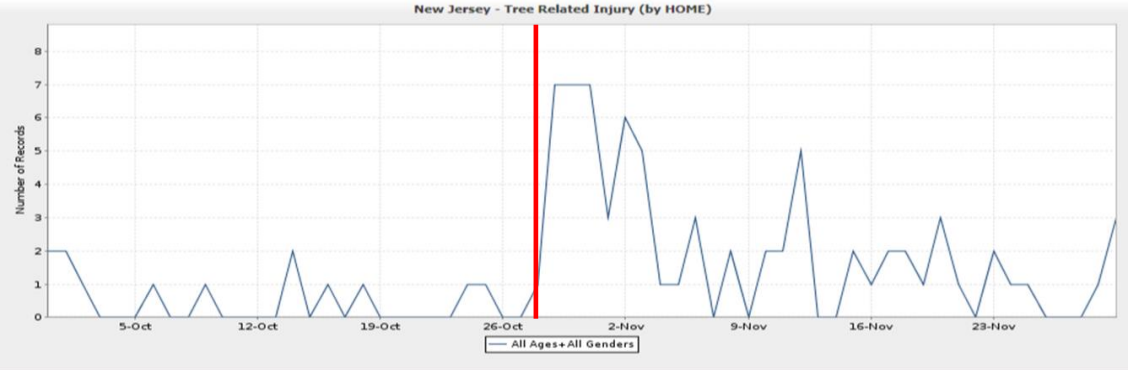
charge nurse to verify the exposure occurred at work and obtain employment and occupation information if available.

Work-Related Chemical Exposures, New Jersey, 2017 (n=292)	
Eye	66 (22.6%)
Bleach	45 (15.4%)
Burn	35 (12.0%)
Ingested	19 (6.5%)
Inhaled	7 (2.4%)

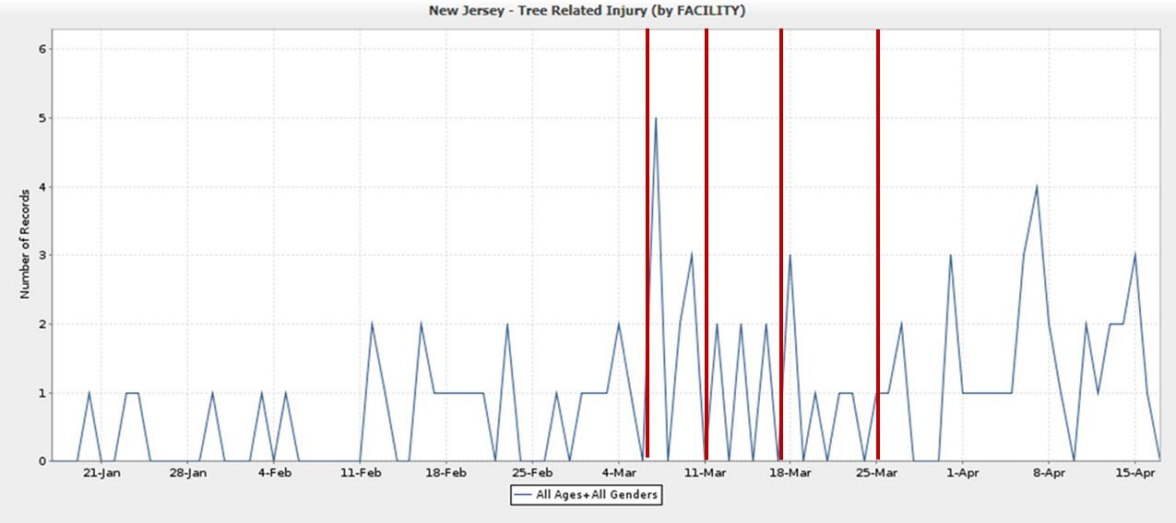
Within EpiCenter, analyses are ongoing, and the system has been set to send e-mail alerts when more than two chemical exposure cases are seen in 24-hours in the same county or hospital. The system sends real time alert e-mails to state and, by request, local staff. The alerts are generated using three analysis methods (Cusum EMA, Recursive Least Squares, and Exponential Moving Average) as applied to a list of surveillance classifiers for patient's home locations and the facility locations where the patient presented for care.

Tree-Related Injuries (Severe weather events): Surveillance is also important to help with prevention planning during and after extreme weather conditions which usually require extensive tree removal and disposal, tasks associated with severe injury risks among workers and residents. Chief complaint fields were used to assess tree-related injuries during severe weather events in NJ. Increase in tree-related and chainsaw injuries to the legs and hands were observed. When creating syndrome definitions for severe weather events, it is useful to extract data from the syndromic surveillance system after an event has occurred to analyze the data for specific keywords that can be used to create severe weather syndrome definitions to monitor for future events. Epidemiologists can prepare for monitoring future events by developing syndrome definitions based on the syndromic surveillance data from past events, including key words.

Hurricane Sandy Tree-Related Injuries (2012)



March 2017 Nor'Easter Tree-Related Injuries



*Red lines indicate landfall

New Jersey Poison Control: New Jersey recently worked with Health Monitoring, NJDOH Communicable Disease Service, and the New Jersey Poison Information and Education System (NJPIES) to incorporate NJPIES work-related call data into EpiCenter. An excel file is uploaded daily with new cases from NJPIES for monitoring. The NJPIES data is also used to supplement the chemical exposure cases.

Oregon

The Oregon Health Authority (OHA), Occupational Public Health Program (OPHP) has been investigating the use of ESSENCE as a tool to enhance the state's occupational surveillance system. To create this system, the Oregon Health Authority collaborated with The Johns Hopkins University Applied Physics Laboratory. This system provides real time data from urgent care facilities, hospitals, and the Oregon Poison Center for epidemiologists. Previous work includes the development of queries for work-related emergency room visits as well as queries to identify more specific events and injuries, including pesticide exposures and low back injuries.

Work-Related Injuries

OPHP's initial effort to investigate the utility of ESSENCE for occupational surveillance involved identifying work-related ED visits. Separate queries were developed to examine chief complaint, discharge diagnosis and triage notes fields. The query identified 56,329 unique ED visit records (1.7% of all ED visits) which occurred between 2016 and 2017. There was little overlap between the records identified by the three queries. Only 0.6% of all records were found by 3 queries while 14% were identified by 2 of the queries. This inconsistency between information in fields within visit records illustrates why multiple field queries are necessary to effectively characterize work-related emergency department visits.

Low Back Injuries

Due to difficulties in constructing a query that could identify the initial encounter for a work-related low back injury, efforts to develop and implement this query have been abandoned.

Pesticide Exposures

OPHP's most recent investigation focused on identifying emergency room visits for pesticide exposure events. Currently OPHP staff are evaluating the results that ESSENCE is returning from a query that queries discharge diagnosis and triage and one that examines Poison Control records. The results have allowed OPHP staff to identify events that were not reported through traditional reporting sources. OPHP has also implemented data streaming from ESSENCE into the reportable conditions database, (Orpheus) for suspected pesticide poisoning cases. These cases legally could not have false positives in order to meet data use agreements since Oregon's reportable conditions data base has a data use agreement that allows for suspect or confirmed cases of reportable conditions only. For that reason, staff limited the query to encounters with ICD10 codes T60 (pesticide poisoning) and T59 (chlorine exposure). This reduces the sensitivity of the query but also restricts false positives. Staff are also using ICD10 codes to identify silicosis cases.

Louisiana

Syndromic surveillance HL7 messages are sent from facilities throughout the state on a daily basis to Louisiana Office of Public Health via SFTP. The data are uploaded every day to a database by the Infectious Disease Epidemiology (ID Epi)'s syndromic surveillance system, Louisiana Early Event Detection System (LEEDS). LEEDS is a near real-time reporting syndromic surveillance system that receives data from 76 of the 113 EDs in the state, with ongoing efforts towards onboarding all EDs. The system also receives data from 12 inpatient facilities and is piloting receipt of data from 13 urgent care facilities.

A syndrome is assigned to each LEEDS record based on the text contents of the chief complaint, admit reason, and discharge diagnosis fields. The Occupational Health Program receives a subset of LEEDS data biweekly from the Louisiana Department of Health's Infectious Disease Epidemiology Program, containing potentially work-related syndromes. All of the HL7 data received by ID Epi is also sent to NSSP (National Syndromic Surveillance Program) to be uploaded to ESSENCE.

Amputations

A pilot project evaluated the usefulness of LEEDS in identifying work-related amputations in a sufficiently timely manner to make case referrals to OSHA feasible. While evaluation of the LEEDS data was the primary goal of this project, Louisiana Hospital Inpatient Discharge Database (LAHIDD) (2000-2014) and ED (2010-2012) data was summarized to provide a snapshot of the scope of work-related amputations in the state. The site of amputation for most inpatient hospitalizations (n=682) was finger/thumb (62.0%), followed by lower limb (18.3%), and toe amputations (13.0%). Upper limb amputations and multiple site amputations each comprised less than 5% of work-related amputation hospitalizations. The amputation site for nearly all ED visits (n=515) was finger/thumb (92%), followed by lower limb amputations (3.3%); all other sites each comprised less than 3% of work-related ED amputation visits. Table 1 displays the distribution of work-related amputation hospitalizations and ED visits stratified by sex, age, and race as well as crude rates and rate ratios with 95% confidence intervals (CI). Table 2 shows the final determination of work-relatedness for the LEEDS data set (n=46) stratified by sex, age group, race, and body part. Eleven work-related amputation cases were identified from LEEDS data (n=1) or by physician's note and/or workers' compensation as payer in the medical record (n=10).

Table 1. Distribution, Crude Rates and Ratios of Work-Related Amputation Hospitalizations and ED Visits by Sex, Age, and Race - Louisiana, 2000-2014

	LAHIDD, 2000-2014			ED, 2010-2012		
	Count	Rate *	Rate Ratio (95% CI)	Count	Rate *	Rate Ratio (95% CI)
Louisiana	682	2.36	--	515	8.96	--
Sex						
Male	633	4.16	**11.62 (8.69, 15.88)**	467	15.34	**8.64 (6.41, 11.89)**
Female	49	0.36	Reference	48	1.78	Reference
Age Group (Years)						
16-24	86	4.21	**2.39 (1.47, 4.05)**	95	12.89	**2.45 (1.42, 4.56)**
25-34	149	2.35	1.38 (0.84, 2.21)	115	8.98	1.71 (0.99, 3.15)
35-44	165	2.42	1.37 (0.87, 2.28)	114	8.79	1.67 (0.97, 3.09)
45-54	167	2.53	1.43 (0.91, 2.38)	123	9.55	**1.82 (1.06, 3.35)**
55-64	94	2.48	1.41 (0.87, 2.38)	53	6.18	1.18 (0.65, 2.25)
65+	21	1.76	Reference	15	5.25	Reference
Race^						
White	362	1.77	Reference	317	7.86	Reference
Black	157	2.01	2.01 (0.93, 1.37)	110	7.08	0.90 (0.72, 1.12)
Other	79	11.89	**6.71 (5.19, 5.58)**	49	30.49	**3.88 (2.81, 5.26)**

*Within each stratification, a reference group is identified. Rate ratios compare the rate of each sub-strata to the reference group. Bold rate ratio indicates statistical significance; *Rates are per 100,000 Louisiana workers; ^ Does not include cases where race was unknown (n=34). For rate calculation, Louisiana's employed population was obtained using the National Institute of Occupational Safety and Health Work-related Injury Statistics and Resource Data System's Employed Labor Force application, which utilizes data from the BLS Current Population Survey.*

Table 2. Amputations by Work-Relatedness, Age, Sex, Race, and Body Part, LEEDS, 9/17/2017-11/01/2017

	Total	Work-Related	Not Work-Related	Undetermined*
Louisiana	46	11	11	24
Sex				
Male	43	11	10	22
Female	3	0	1	2
Age Group (Years)				
16-24	7	3	2	2
25-34	9	1	2	6
35-44	10	4	1	5
45-54	7	2	4	1
55-64	7	1	1	5
65+	6	0	1	5
Race				
White	25	4	8	13
Black	6	2	0	4
Other	2	1	1	0
Unknown	13	4	2	7
Body Part				
Finger/Thumb	42	10	10	22
Upper Limb	1	0	0	1
Toe	3	1	1	1
Lower Limb	0	0	0	0

** Undetermined includes medical records that were not received as well as those for which work-relatedness was still unclear after medical record review.*

Additional Resources for Creating Syndrome Definitions

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V. Using a syndromic surveillance definition

How syndromic surveillance can be used for occupational health surveillance

- Currently there is a lag time of a few months to a few years when collecting occupational health data. Syndromic surveillance can provide data in real-time to help guide public health action and allow for a more rapid public health intervention when required, reducing further risk of occupational injuries and illnesses.
- Evaluating the ability and performance of a new and existing surveillance data source to capture work-related injuries and illnesses may lead to enhancements in current data collection methods. For example, identifying gaps can lead to improved, standardized methods, including better case definitions, reporting procedures, and data collection tools.
- Data can be analyzed using descriptive statistics; observing trends over time; comparing current data to historical data; and comparing data to other established occupational data sources, such as emergency discharge data.
- These systems can improve case-finding for reportable and nationally notifiable conditions. These reportable conditions often have an occupational component, and work-related cases can be included with surveillance of conditions such as silicosis or pesticide poisoning. This method is especially useful for conditions that lack lab tests as many reportable conditions use lab reports to find cases.

Challenges for using syndromic surveillance for occupational health

There are challenges to using syndromic surveillance systems for occupational health surveillance. States should assess which resources are available to monitor the data, and the state's priorities for surveillance (CSTE, 2016). Some challenges of using syndromic surveillance for occupational health surveillance include:

- There may not be established relationships between those who manage or conduct syndromic surveillance and those conducting occupational health surveillance as this may vary across states.
- The development of a local work-related syndrome definition can be daunting, especially for those who have not used or are new to syndromic surveillance systems. Querying the NSSP BioSense ESSENCE Platform may lack specificity as it picks up many false positives which makes it difficult to use for identifying trends and is a better tool for case finding.
- In many cases, it can be difficult to ascertain work-relatedness from the information provided in the syndromic surveillance record. It may be necessary to contact the ED to confirm cases or request medical records. Unlike hospital and emergency discharge data, Workers' Compensation as primary payer cannot be used to identify work-related cases unless Workers' Compensation is used in the chief complaint or other submitted field.

- Emergency Department data sources are often different from each other even within the same state. There can often be inconsistencies with coding and reporting.
- Due to the relatively few examples of syndromic surveillance in the occupational health field, greater investigation is needed of which methods are most effective to incorporate syndromic surveillance into occupational health surveillance. Additionally, states can consider establishing conditions in which syndromic surveillance can be used, how to analyze the results, and how those results can be used to improve the health and safety of workers.
- There may be added costs associated with states maintaining their syndromic surveillance system.
- While syndromic surveillance may not capture all work-related visits, it is a useful tool for monitoring trends and providing situational awareness of work-related injuries and illnesses in near real-time for a more rapid response.

Addressing these barriers require a community approach such as those which were taken by other public health areas when advocating for syndromic surveillance usage or developing syndrome definitions (CSTE, 2016; Harduar Morano, 2017; Gould, 2017).

VI. Partnership development

How Occupational Health Programs access syndromic surveillance data

There is substantial variation across states in how they obtain their syndromic surveillance data. Some states have homegrown systems and others use national databases such as ESSENCE to obtain their data. State syndromic surveillance systems are usually housed with communicable and infectious disease programs. Therefore, state Occupational Health Programs should consider the importance of a partnership with these programs as they have knowledge in:

- Gaining access to the syndromic surveillance data either through the state syndromic surveillance system or help with accessing data in NSSP BioSense ESSENCE;
- On-boarding facilities such as EDs, Urgent Care clinical, Poison Control Centers, etc.;
- Running data queries;
- How ED data is submitted from facilities; and
- Setting up syndrome definitions to identify visits potentially associated with specific injuries and conditions.

In summary, once states have identified appropriate contacts, they can be beneficial in accessing the data so syndromic surveillance can be conducted on occupational illnesses and injuries.

In addition to greater partnership with communicable and infectious disease programs, staff can also strive to have regular contact with the facilities in their jurisdiction to maintain a working relationship with the personnel responsible for surveillance activities.

For more information on NSSP's BioSense Platform and obtaining access to the data please visit:
https://www.cdc.gov/nssp/biosense.html
https://www.cdc.gov/nssp/new-users.html

How Occupational Health Programs work with their partners to use the data

Depending on the event or syndrome under surveillance, syndromic surveillance presents opportunities to collaborate with others outside of occupational health. Examples of possible collaborations include:

- **Occupational Safety and Health Administration (OSHA)**: Once it is determined a case is work-related, OSHA state area offices can be contacted to investigate. For example, in New Jersey, when a chemical exposure is determined to be work-related staff contact either the area OSHA office, or if the case involves a public employee, then the Public Employee OSHA (PEOSH) can conduct further investigation and help prevent others from becoming sick or injured .
- **State Poison Control Centers**: If poison data is integrated in the state syndromic surveillance system, OH programs can work with poison centers on several aspects, including collaborations for prevention, education, and outreach. Work-related radiation exposures are also often captured in poison center data. In such instances, staff can work with respective state's radiation safety or corresponding programs at the state health department. For example, Texas has reviewed and worked on several potential radiation exposure cases in collaboration with their Radiation program. In New Jersey, work-related poison case reports are reviewed daily, and exposures of interest are reported to OSHA for immediate investigation.
- **Pesticide Related Illness**: Occupational health programs can work with respective state's Department of Agriculture and Environmental Health Agency as needed, since federal OSHA does not investigate incidents involving pesticide chemicals.
- **Emergency Preparedness**: Syndromic surveillance is not only used to prepare for infectious disease outbreaks but can also be used to develop syndrome definitions during severe weather events and man-made disasters. For example, New Jersey developed a syndrome definition for tree-related injuries after Hurricane Sandy to help in prevention planning during and after severe weather conditions for workers who help in recovery efforts during these events.

VII. Conclusion and recommendations

This document provides guidance for jurisdictions that aim to build or improve syndromic surveillance of occupational-related injuries and illnesses in their state. Depending on local climate and priorities, states 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.

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IX. Appendix

This table includes additional keywords to help create more specific syndrome definitions. As previously mentioned, the keywords included below are meant to be a starting point for states to begin creating their own set of keywords for their state's syndrome definition. States must still analyze their own data for appropriate keywords and conduct their own validation of the keywords.

	Inclusion Keywords	Exclusion Keywords
Chemical Exposures	"hz mat"; "haz mat"; "hazmat"; "hazmat"; "vapor"; "\bfume"; "toxic gas"; "inhaled? Gas"; "\bchem\b"; "chemical"; "hazard"; "chlorine"; "bleach"; "benzene"; "butane"; "chemical"; "chlorine"; "chlorox"; "chorine"; "cleaner"; "dizz"; "ethylene glycol"; "fume"; "head ache"; "headache"; "Lysol"; "propane"	"withdraw"; "hazard to"; "detox"; "depend"; "chem screen"; "chem panel"; "chem dep"; "chem [0-9]"; "cbc"; "blood chem"; "abuse"; "\bon chem"; "perfume"; "vehicle"; "vick"; "hit head"; "hit in head"; "motor vehicle"; "mva"; "perfume"; "vacuum"
Tree-Related Injuries	"saw"; "branch"; "wood chip"; "woodchip"; "tree"	"saw pmd"; "saw nurse"; "branchial"; "allerg"; "branch ave"; "branch ct"; "bundle"; "distree"; "extreme"; "md"; "peds"; "respiratory"; "saw blood"; "saw doc"; "saw dr"; "saw ped"; "spots"; "streep"; "street"; "table saw"; "tree dr"; "tree lane"
Carbon Monoxide	"carbon monoxide"; "carbonmonoxide"; "exposure to gas"; "carbon dioxide"; "co poison"; "carbon mon"; "co exp"; "toxic fume"; "smoke inhal"; "carbon mono"; "exhaust gas"; "exhaust"; "CO EXP"; "CO INTOX"; "CoPoisoning"; "EXHAUST GAS"; "MONOXIDE"; "POISON CO"; "carbon"; "monoxide"; "co exposure"; "co exposure"; "co poisoning"; "co2 poisoning"; "o2 poisoning" ICD discharge codes: T58	"r/o"; "exhaustion"; "exhausted"
Heat-Related Illnesses	"heat ex"; "heatex"; "overheat"; "overheat"; "over heat"; "hot outside"; "heat-related"; "heat related illness"; "heat stress"; "heat fatigue"; "calenta"; "calientar"; "caliente"; "ensolacion"; "heat"; "heatcramp"; "heat cramps"; "heat edema"; "heat"; "exhaustion due to salt depletion"; "heat exhaustion, anhydrotic"; "heat exhaustion, unspecified"; "heat exshaustion"; "heat fatigue, transient"; "heat stress"; "heat stroke"; "heat-stroke"; "heat stroke and	"cheat"; "diarrhea"; "heatbeat"; "heater"; "heat blisters"; "heat cramp"; "allergic reaction"

	Inclusion Keywords	Exclusion Keywords
	sunstroke"; "sun stroke"; "sunstr"; "heat syncope"; "hyperthermia"; "hyperthermia"; "hypertherm"; "insolacion"; "overheated"; "sun stroke"; "sunstroke"; "got over"; "heated"; "got overheated"; "to hot"; "too hot" ICD discharge codes: "T67"; "X30"; X32"	
Burn	"burns"; "flame"; "hot liquid"; "hot stove"; "hot water"; "burn"; "burned"	"bathroom"; "burning"; "friction"; "heart"; "heartburn"; "inflamed"; "peeing"; "private"; "rash"; "urin"; "vagina"; "when I pee"
Explosion	"blew up"; "blow up"; "disaster"; "explode"; "explos"	"about to"; "disorder"; "explosive diar"; "feels like"; "going to"; "personality"
Fracture	"broke"; "broken bone"; "dislocation"; "fractura"; "fracture"; "fratura"; "fx"	"broke out"; "infx"; "water"
Heavy Metals	"arsenic"; "cadmium"; "heavy metal"; "lead"; "mercury"; "radioa"	"cheerlead"
Laceration	"abraision"; "abrasion"; "cut"; "gash"; "incision"; "inflicted"; "lacc"; "lacertn"; "laceration"; "laceration"; "open wnd"; "penny nail to R hand"; "poke"; "poked"; "prick"; "stab"; "stabbed"; "step"; "stepped"; "stepped on a nail"; "stepped on glass"; "stick"; "wound"; "cortadura"; "lac"; "laceracion"; "puncture"; "puncture wound"; "punsada"; "punzada"; "pw"	"acute"; "anaphylactic"; "black"; "cutaneous"; "cute"; "lack"; "lactic"; "lumbar"; "place"; "poisoning"; "replace"; "stable"; "without mention of open wound"; "wound care"; "wound check"; "wound recheck"
Pesticide	"ant spray"; "bug spray"; "coumadin"; "coumadin"; "deet"; "fogging"; "fumigat"; "herbicide"; "insect repellent"; "insect spray"; "insecticide"; "malathion"; "moth ball"; "mothball"; "organophosphate"; "paraquat"; "pest control"; "pesticide"; "rat bait"; "rat poison"; "roach fogger"; "roach spray"; "round-up"; "roundup"; "wasp spray"; "weed killer"; "weed spray"; "carbamate"; "fungicide"; "herbicide"; "disinfectant"; "rodenticide"; "ant spray"; "bug spray"; "fumigant"; "insect repellent"; "bug repellent"; "insect spray"; "thalium"; "zinc phosphide"; "bromethalin"; "pyrethroid"; "pyrethrins"; "butoxide"; "boric acid"; "metaldehyde"	

	Inclusion Keywords	Exclusion Keywords
	ICD-10-CM codes: T60 and T59	
Poisoning	"aceta"; "aceto"; "adverse effect"; "ibuprofen"; "ingest"; "lamicital"; "Lamictal"; "multiple meds"; "nail polish"; "poison"; "posion"; "propane"; "poisoning"; "toxic"; "toxic effect"; "Tylenol"; "med dose"; "O.D."; "overdose"; "poisoning"; "reaction"; "sleeping pills"; "took"; "took pills"; "toxicity"	"a fall"; "allerg"; "alleri"; "anaphylactic"; "anxiety"; "episode"; "food"; "insect"; "intox"; "non toxic"; "non-toxic"; "nontoxic"; "peanut"; "poison ivy"; "poison oak"; "staples"; "stress"; "venom"
Sprains Strains	"sprain"; "strain"	"restrain"
Amputate	"amputate"	
Tool	"balcony"; "door"; "elevator"; "fork"; "glass"; "glue"; "hammer"; "knife"; "knitting needle"; "lawn mower"; "nail"; "needle"; "power"; "roof"; "rusty"; "screw driver"; "screwdriver"; "skewer"; "spatula"; "thumb tack"; "weed eater"; "window"; "wood"	"crusty"; "fingernail"; "grown"; "ingrow"; "ingrown"; "nail problem"; "roof of mouth"; "skin and nails"; "toe nail"; "toenail"

* Note that < > means "AND NOT" in the Oregon ESSENCE queries.