Identifying Incidents of Public Health Significance Using the National Poison Data System, 2013–2018

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Data System. The American Association of Poison Control Centers (AAPCC) and the Centers for Disease Control and Prevention (CDC) jointly monitor the National Poison Data System (NPDS) for incidents of public health significance (IPHSs).

Data Collection/Processing. NPDS is the data repository for US poison centers, which together cover all 50 states, the District of Columbia, and multiple territories. Information from calls to poison centers is uploaded to NPDS in near real time and continuously monitored for specific exposures and anomalies relative to historic data.

Data Analysis/Dissemination. AAPCC and CDC toxicologists analyze NPDS-generated anomalies for evidence of public health significance. Presumptive results are confirmed with the receiving poison center to correctly identify IPHSs. Once verified, CDC notifies the state public health department.

Implications. During 2013 to 2018, 3.7% of all NPDS-generated anomalies represented IPHSs. NPDS surveillance findings may be the first alert to state epidemiologists of IPHSs. Data are used locally and nationally to enhance situational awareness during a suspected or known public health threat. NPDS improves CDC's national surveillance capacity by identifying early markers of IPHSs. (*Am J Public Health.* Published online ahead of print August 20, 2020: e1–e4. doi:10.2105/AJPH.2020.305842)

Since 2000, the American Association of Poison Control Centers (AAPCC) and the Centers for Disease Control and Prevention (CDC) have worked together to develop and implement the National Poison Data System (NPDS) as a tool for public health surveillance.[1]

DATA SYSTEM

NPDS data collection started in 1983 with the beginning of the AAPCC national data collection system. Data are available from 2000 onward and are accessible by a secure Web-based interface.[1]

CDC uses NPDS to (1) improve CDC's national surveillance capacity for public health threats, (2) identify early markers of incidents of public health significance (IPHSs), and (3) enhance situational awareness and inform public health response during a suspected or known public health threat.[2] A primary surveillance activity conducted by CDC using NPDS is to identify and track IPHSs associated with chemical, radiological, and infectious exposures. During 2008 to 2012, NPDS surveillance identified 384 such incidents.[3]

DATA COLLECTION/PROCESSING

Members of the public, health care professionals, and other local, state, and federal agencies contact their regional poison center by calling a national toll-free number (800-222-1222). Call topics range from information about a drug, chemical, or poison (information calls) to advice after a known or suspected exposure (exposure calls).[4] All 55 US poison centers are members of the AAPCC. Together, AAPCC member centers provide coverage to all 50 states, American Samoa, the District of Columbia, the Federated States of Micronesia, Guam, Puerto Rico, and the US Virgin Islands. In 2018, NPDS recorded 368 025 information calls and 2 099 751 human exposure calls.[4]

Calls to poison centers are answered by specialists in poison information (SPIs) and poison information providers (PIPs). SPIs are mainly nurses and pharmacists who have received specialized education in toxicology. PIPs are allied health professionals who, under the supervision of an SPI, manage information calls and low-acuity exposure calls. PIPs and SPIs document calls by using 1 of 4 AAPCC-approved electronic medical record systems designed to collect required exposure information. Data elements recorded using standardized guidelines include demographics (e.g., age, gender, geographic location), exposure information (e.g., reason for exposure, exposure duration, location of exposure), clinical effects (e.g., tachycardia, vomiting, agitation), treatments given before the call, treatments recommended, treatments provided according to poison center recommendations (e.g., antiseizure medications, antidotes, antivenoms, and extracorporeal

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Note. *The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.*

treatments), and medical outcomes. Poison centers routinely provide ongoing management guidance and attempt to follow cases to a known medical outcome. If a caller reports an exposure involving multiple persons, additional records are created to reflect the number of persons affected.

NPDS utilizes the POISINDEX products database (IBM Micromedex POISINDEX, IBM Watson Health, Greenwood Village, CO) as its primary products database. The database contains more than 444 000 products, each associated with a unique 7-digit code.[4] SPIs and PIPs choose the most specific product or substance possible. Product codes represent specific substances in multiple broad categories, including name-brand prescription medications, name-brand nondrug products, disease vectors (e.g., mosquito, dog), and infectious diseases (e.g., rabies). Product codes map to 1 of 1112 broader generic codes in a structured hierarchical system.[4] If a specific product name involved in a case is not known, cannot be verified, or is not found in the system, a generic code is selected (e.g., rubbing alcohols: unknown). Signs, symptoms, and laboratory abnormalities (termed "clinical effects"), if known, are chosen from 169 active options. Treatments performed before the call, recommended by the poison center, or recommended and performed are chosen from 112 currently available options.

Data collection using NPDS is a public health surveillance activity conducted by public health authorities (poison centers). Per the Health Insurance Portability and Accountability Act privacy rule, 45 CFR 164.512(b), authorization is not required to disclose information for this purpose.[5] Data are automatically uploaded to NPDS in near real time with a median time of 7.72 minutes (interquartile range = 6.90–12.0 minutes).[4]

DATA ANALYSIS/ DISSEMINATION

Automated algorithms continuously monitor NPDS data using call volume, clinical effects, and case-based definitions. When an anomaly of any of the 3 types is detected, an alert is sent to the AAPCC surveillance team and CDC staff members, who then review the exposure calls within the anomaly to determine if they represent an IPHS. The AAPCC surveillance team includes medical and clinical toxicologists and is a distributed system with team members located across the United States.

Call volume anomaly detection compares the volume of calls to a historical baseline for each poison center to detect unusual increases in call volume. The classical historical baseline is defined as the average call volume at a specified poison center, at the same hour, during the same 14-day period, over the preceding 3 years. A call volume anomaly is defined as an hourly call volume more than 3 SDs above the historical baseline, with at least 8 calls.

Clinical effect anomaly detection is triggered when the number of calls with a given clinical effect nationwide within the previous 24 hours exceeds 2 SDs above the classical historical baseline. Similar to call volume surveillance, the historical baseline is defined as the average clinical effect frequency, per 24 hours, for the same 14-day period over the preceding 3 years.

Case-based anomaly detection identifies individual exposure calls matching a specified definition. These definitions are designed to detect specific exposures that have already been identified by the caller (via product or generic codes), as well as clusters of clinical effects suggestive of an exposure (often referred to as a toxidrome). CDC staff currently monitor 9 definitions considered high-priority exposures that might represent a sentinel event: arsenic, botulism, ciguatera, ricin, paralytic shellfish poisoning, pufferfish, radiation, nerve agents, and weapons of mass destruction.

Any of the 3 anomaly types might indicate a potential outbreak, but manual review is required to determine whether they represent IPHSs. When an anomaly is detected, the NPDS surveillance team reviews all anomalies for public health significance (PHS) according to consensus criteria and confers with the regional poison center within 24 hours. Anomalies matching the weapons of mass destruction definition are reviewed more rapidly, within 6 hours. These findings are then shared with the CDC. The criteria for an anomaly to be of PHS are the following:

- importance to the appropriate state or national public health entity (e.g., a reportable disease),
- a case or calls of unusual severity involving more than 1 household (or exposure site outside the home) and with clinical effects reported,
- association with a known or suspected terrorism event,
- part of a state or national public health investigation,
- a pattern not normally attributable to the implicated exposure,
- a geographic or spatial pattern, and
- a high index of suspicion, credible threat, or other rationale in the judgment of the NPDS surveillance team member.

The AAPCC surveillance team member contacts the poison center to obtain additional information about the call(s). After review, anomalies are classified as PHS "yes," "no," "unknown," or "other." When a PHS "yes" anomaly is identified, CDC generates a notification detailing the identified incident and sends it to the regional poison center and state public health department for situational awareness and appropriate public health action.

Interpretation Issues

Several interpretation issues temper the use of poison center data as a public health surveillance tool. In particular, poison centers rely on voluntary reporting (NPDS is a passive reporting system) of exposures by members of the public and health care providers. Variability in exposure reporting is well documented and can vary significantly by geographic region.[6] As a result, NPDS likely will only detect a portion of the total exposures associated with a given incident.

In most cases, poison center data are also limited by a lack of objective (laboratory) confirmation in most exposures, introducing the possibility that an exposure might be misclassified. In addition, the clinical effect and case-based surveillance definitions rely on analysis of coded data. Transcription error might occur, and coding might differ between poison centers when data are entered into the poison center electronic medical record. Human review of all anomalies, including direct communication between the NPDS surveillance team and poison centers, helps to minimize this risk. Lastly, not all persons exposed to a potential hazardous substance will call a poison center. Therefore, poison centers are not a representative data source to calculate burden of illness or absolute numbers of persons exposed to a particular substance of interest. There are only estimates of the denominator of all poison exposures.

In total, 1431 of the 39 107 anomalies identified by case volume, clinical effects, and case-based surveillance during 2013 to 2018 were determined to represent IPHSs, a positive predictive value (PPV) of approximately 3.7% (range for individual years = 3.2%–4.3%; Table A, available as a supplement to the online version of this article at http://www.ajph.org). Despite iterative improvement by the NPDS surveillance team to refine anomaly detection algorithms, the overall PPV did not significantly change; a Poisson regression by year for annual PPV from 2013 through 2018 yielded a *P* value of .11. It is notable that the PPV did improve from 3.2% in 2017 to 4.1% in 2018; this is likely attributable to a restriction in specific case-based surveillance algorithms in 2018 that required treatment information be recorded to increase likelihood that the exposure did occur. This low PPV is expected because the surveillance anomaly definitions have intentionally low thresholds to increase the system's sensitivity to detect IPHSs. However, this low detection threshold must be weighed against the work required to review a high number of false-positive anomalies. At present, the scope of this work lies entirely within the NPDS surveillance team. Anomalies that do not meet the threshold for IPHSs are not forwarded to public health officials. Therefore, the present system allows a high sensitivity and high quality of data without work on the part of the end users. Finally, while NPDS captures many incidents called to poison centers in near real time, the statistical methods employed may not capture all IPHSs called to poison centers.

Data Linkage and Accessibility

In addition to CDC and AAPCC, 28 poison centers, at least 5 state public health departments, 1 county public health department, and 1 state police department conduct surveillance activities using NPDS.[4] Several state public health organizations actively integrate these data with emergency medical services and emergency department systems to form a robust syndromic surveillance system.[7–9] CDC and AAPCC have published multiple studies attesting to the utility of poison center data as a national public health surveillance tool.[1,3,10,11] Patient-level data for poison center electronic medical record encoded fields can be obtained through a standardized request form to AAPCC.[12]

IMPLICATIONS/IMPACT

The primary strength of NPDS is its ability to identify IPHSs for federal, state, and local public health situational awareness through multiple methods of anomaly detection. Overlap between the call volume, clinical effect, and case-based surveillance methodologies is minimal: among 39 107 total anomalies, there were only 16 IPHSs that triggered 2 or more anomaly types, supporting the use of all 3 methodologies. The total number of call volume anomalies detected between January 1, 2013, and December 31, 2018, was 26 833, of which 850 (3.2%) were determined to represent IPHSs. In some cases, more than 1 call volume anomaly was associated with a single incident. In total, 278 distinct IPHSs were identified (Table 1).

On an annual basis and overall, the most commonly reported agent associated with an IPHS identified using call volume-based surveillance was carbon monoxide, which was reported in 59 distinct incidents (21.2%). The most common location for an IPHS identified using case volume–based surveillance was a workplace, which was reported in 104 distinct incidents (37.4%; Table B, available as a supplement to the online version of this article at http://www.ajph.org). Several IPHSs were associated with anomalies over a period of days to weeks and therefore aided in situational awareness, including a 2014 chemical spill in West Virginia,[13] a 2015 outbreak of synthetic cannabinoid–related illness,[14] and a 2016 outbreak of listeriosis resulting from contaminated salad products.[15] Further details regarding each anomaly type, on a yearly basis and overall, are available in Table B.

Among the 5862 clinical effect anomalies detected during the study period, 174 (3.0%) were determined to represent 44 distinct IPHSs (Table 1). The reported agent most frequently leading to an IPHS identified via clinical effect–based surveillance was carbon monoxide, which was reported in 7 distinct incidents (16%). The most frequent body system affected was neurologic (43%), and the most common reported symptom was dizziness/vertigo (16%; Table C, available as a supplement to the online version of this article at http://www.ajph.org). Clinical effect anomalies were particularly useful as a public health surveillance tool in 2018, providing situational awareness during an outbreak of bleeding caused by contaminated synthetic cannabinoids.[16] More than 90 clinical effect anomalies were recorded in association with this outbreak.

Table 2 shows details of the 6412 case-based anomalies detected during the study period. Arsenic was the most common case-based anomaly detected, with 1873 anomalies (29% of all case-based anomalies). Of the case-based anomaly definitions, botulism had the highest PPV: 131 out of the 332 (40%) botulism-based anomalies were associated with an IPHS, and 90 (27%) were associated with a unique IPHS not identified by another anomaly. No IPHSs were associated with the weapons of mass destruction case-based anomaly definition. This was expected because the algorithm is designed to detect what is currently only a theoretical scenario. The remainder of the case-based anomaly definitions are designed to detect unusual or rare diagnoses. Notably, the botulism case-based anomaly did detect an outbreak of botulism linked to illicit alcohol,

TABLE 1—Incidents of Public Health Significance Associated With National Poison Data System Surveillance Anomalies, Stratified by Anomaly Type: United States, 2013–2018

	Call Volume	Clinical Effect	Case-Based	Total
Total anomalies, no.	26 833	5 862	6 412	39 107
Anomalies representing IPHSs, no.	850	174	407	1 431
Distinct IPHS identified, no.	278	44	221	543
Positive predictive value, %	3.2	3.0	6.3	3.7

Note. IPHS = incident of public health significance.

TABLE 2—Incidents of Public Health Significance Associated With National Poison Data System Case-Based Surveillance Anomalies: United States, 2013–2018

	Arsenic	Botulism	Ciguatera	Ricin	Paralytic Shellfish Poisoning	Pufferfish	Radiation	Nerve Agents	Weapons of Mass Destruction	Total
Total anomalies, no.	1873	332	1096	814	697	153	1029	141	277	6412
Anomalies representing IPHSs, no.	33	131	135	14	55	7	30	2	0	407
Distinct IPHS identified, no.	13	90	57	7	30	2	20	2	0	221
Positive predictive value, %	1.8	39.5	12.3	1.7	7.9	4.6	2.9	1.4	0.0	6.3

Note. IPHS = incident of public health significance.

known as "pruno," in a Mississippi correctional facility in 2016.[17]

From 2015 to 2016, CDC surveyed state epidemiologists regarding the effect of NPDS surveillance notifications.[11] Among the 59 survey respondents, 49 (83.1%) took public health action in response to an incident. Although many were already aware of the incident before receiving a notification from CDC, 27 (45.8%) said they did not previously know about the incident. Within the subset of respondents who did not know about the incident before notification, 17 (63.0%) said that CDC notification contributed to initiating public health action.

Situational awareness is perhaps NPDS's greatest asset. NPDS surveillance can be used to track the status of an ongoing incident to inform the public health response. Besides the incidents mentioned previously, NPDS data provided critical situational awareness during the 2010 Deepwater Horizon oil spill of the progression of the incident at the national level.[11] Multiple agencies also used these data to create public health messaging about the spill. NPDS surveillance data have also informed recommendations from Consumer Reports on the safety of laundry detergent pods and legislative actions to protect children from exposure to liquid nicotine used in electronic cigarettes.[11]

CONCLUSIONS

NPDS surveillance activities have been able to identify incidents called to poison centers in near real time and communicate about incidents to state and local public health. During the study period, this surveillance identified and tracked several important incidents associated with industrial chemical releases, drugs of abuse, and even infectious diseases. Although the PPV of the surveillance activities is low, standardized, internal review of potential IPHSs provides high-quality data to inform state and local public health personnel as they respond to outbreaks and epidemics. AJPH

CONTRIBUTORS

J. E. Carpenter performed the data analysis and wrote the article. R. K. Law originated the study and contributed to data collection, analysis, and writing of the article. A. S. Chang, A. C. Bronstein, and R. G. Thomas contributed to interpretation and revising the article. All authors approved the final article and agreed to be accountable for all aspects of the work.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

HUMAN PARTICIPANT PROTECTION

This project was not human participant research and was determined to be exempt from review by the Centers for Disease Control and Prevention institutional review board.

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