Using Poison Center Data for National Public Health Surveillance for Chemical and Poison Exposure and Associated Illness

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The National Poison Data System (NPDS) is a national near-real-time surveillance system that improves situational awareness for chemical and poison exposures, according to data from US poison centers. NPDS is the successor to the Toxic Exposure Surveillance System. The Centers for Disease Control and Prevention (CDC) use these data, which are owned and managed by the American Association of Poison Control Centers, to improve public health surveillance for chemical and poison exposures and associated illness, identify early markers of chemical events, and enhance situational awareness during outbreaks. Information recorded in this database is from self-reported calls from the public or health care professionals. In 2009, NPDS detected 22 events of public health significance and CDC used the system to monitor several multistate outbreaks. One of the limitations of the system is that exposures do not necessarily represent a poisoning. Incorporating NPDS data into the public health surveillance network and subsequently using NPDS to rapidly identify chemical and poison exposures exemplifies the importance of the poison centers and NPDS to public health surveillance. This integration provides the opportunity to improve the public health response to chemical and poison exposures, minimizes morbidity and mortality, and serves as an important step forward in surveillance technology and integration. [Ann Emerg Med. 2012;59:56-61.]

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BACKGROUND

On December 18, 2006, Congress and the White House passed the Pandemic and All-Hazards Preparedness Act (SB 3678) that amends the Public Health Service Act to improve situational awareness in public health emergencies.1 According to the act, a near-real-time, electronic, nationwide, public health situational awareness capability was to be established through a network of systems. Information was to be shared to enhance the early detection of, rapid response to, and management of public health emergencies. More recently, the Homeland Security Presidential Directive–21 mandated that the Department of Health and Human Services establish a nationwide biosurveillance system that is built on and integrated with state and local capabilities.2

In accordance with the Pandemic and All-Hazards Preparedness Act and Homeland Security Presidential Directive–21, the National Poison Data System (NPDS) serves as a national biosurveillance tool that enhances national capacity to identify public health threats. Staff from the Centers for Disease Control and Prevention (CDC) have been working with the American Association of Poison Control Centers (AAPCC) since 2000 to develop and implement NPDS as a national system to improve situational awareness and surveillance for intentional and unintentional chemical and poison exposures, according to data from all 57 US poison centers. These centers provide a toll-free number for 24-hour professional assistance that covers the 50 states, District of Columbia, Puerto Rico, US Virgin Islands, the Federated States of Micronesia, American Samoa, and Guam but also can be used internationally. Poison centers also offer access to health care professionals who have specialized expertise in clinical toxicology and who can provide treatment advice by telephone.3

In 2006, NPDS replaced the Toxic Exposure Surveillance System, previously described by Wolkin et al,4 as the nationwide poison center data repository and surveillance system. NPDS incorporated several enhancements, including preserving data from 1985 to the present, making data accessible anywhere through the Internet, enhancing data reporting and analysis capabilities, increasing functionality in data transmission, implementing geographic information system capability, and creating a Web service to allow for data sharing with other surveillance systems. These enhancements in accessibility and flexibility of data retrieval and sharing resulted in a much-improved response time to alerts, completeness of analysis, and an overall more robust system.

NPDS captures documentation on each call to a poison center, using standardized definitions and compatible computer systems. Incoming data are monitored continuously with automated algorithms for anomaly detection. Anomalies,
deviations from established baseline data, generate an automated e-mail alert to the AAPCC, CDC, and state and local health departments or to the designated regional poison center. CDC and AAPCC use NPDS to improve public health surveillance for chemical and poison exposures, identify early markers of chemical events for a rapid and appropriate public health response, and find potential cases of public health significance to enhance situational awareness during an emerging public health event.

The intent of this article is to describe NPDS, illustrate how CDC uses this surveillance system to detect and track illness outbreaks associated with chemical and poison exposures, cite examples of events detected and tracked by NPDS, highlight the importance of health care professional participation in chemical and poison reporting, and illustrate the importance of integrating poison centers into the public health infrastructure.

**DESCRIPTION OF THE SURVEILLANCE SYSTEM**

**Poison Center Call Data**

Poison centers cover the entire United States; some states have more than one poison center, whereas other poison centers respond to calls from more than one state. Callers can contact poison centers by using a national toll-free number (800-222-1222) that connects to the regional poison center serving the calling area. Poison center calls come from persons in the home (76%), health care facilities (16%), workplace (1%), and schools (0.5%). More than half of the calls come from persons in the home (76%).

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Callers seek diagnostic or treatment recommendations, report a suspected or known chemical poison exposure, or request information about a potential exposure, medicine, or product. Most calls are self-reported and reflect only voluntarily provided or partially incomplete information when the public or health care provider reports an actual or potential exposure to a substance. In 2009, poison centers logged 4,280,391 total calls, which are classified as either information (58%) or exposure calls (42%). Information calls have no identifiable exposed person or animal. Exposure calls involve a person or animal with a suspected or known exposure to a chemical or poison. Exposure calls may be self-reported and do not necessarily represent a true exposure or poisoning. For surveillance purposes, an exposure is defined as an actual or suspected contact with any substance that has been ingested, inhaled, absorbed, applied to, or injected into the body.

While providing exposure management instructions, specialists in poison information enter call data into their local computerized case management system. This is done with standard NPDS guidelines and coding procedures maintained by AAPCC. Call data include information about basic demographics (eg, age, sex, weight, ZIP code), clinical and management data, and the exposure. The clinical data include 131 precoded signs, symptoms, and laboratory abnormalities referred to as clinical effects; 72 precoded treatment, decontamination, and management options; and medical outcomes. The poison center attempts to follow up with callers to obtain information about the medical outcome of exposure calls if not known at the initial call. Exposure data include the reason for exposure, acuity, duration, site, and substance. A portion of these data is uploaded, including both new cases and updates to previous cases, on average every 20 minutes with automated data transfer to the NPDS national database. The uploaded data are aggregated and analyzed with automated algorithms to detect anomalies, including 2 types of volume surveillance (total call and clinical effect) and case-based surveillance.

**Call Volume Surveillance**

Each call to the poison center is recorded in the regional poison center database and then uploaded to NPDS. Calls representing several persons from the same event are duplicated in the system to ensure that each person is recorded separately. An automated algorithm identifies anomalies in call volume by comparing the observed number of calls to a threshold based on historical data. The hourly total call volume for each poison center is monitored and compared with historical data for a given poison center, hour, day, and year. The historical baseline is the average call volume for that hour during the same 14-day period (7 days preceding the day of interest, the day of interest, and 6 days after the day of interest) for the preceding 3 years. A call volume anomaly is identified when hourly call volume exceeds the threshold. To limit the number of false positives and improve specificity, the threshold is empirically set as the historical average plus 3 SDs and requires a minimum of 8 calls. NPDS sends automated e-mail notifications listing the poison centers with hourly anomalies to clinical toxicologists and epidemiologists who subscribe to these definitions at AAPCC, poison centers, state and local health departments, and CDC. Anomalies may indicate a potential outbreak and are assessed by AAPCC and CDC staff to determine whether they are of public health significance.

**Clinical Effect Surveillance**

Similar to call volume surveillance, clinical effect (ie, 131 precoded signs, symptoms, and laboratory abnormalities) surveillance is based on call volume; however, this algorithm identifies volume anomalies for individual clinical effects according to the national frequencies of clinical effects reported during a defined period (ie, 1 to 24 hours). For example, CDC and AAPCC monitor all 131 clinical effects with a static 24-hour window. NPDS identifies a clinical effect anomaly when the observed number of calls for a given clinical effect exceeds the threshold (ie, empirically set as the historical baseline plus 2 SDs). NPDS sends daily e-mail notifications indicating the identified anomalies, using data from the previous 24 hours. The e-mail alert includes a deviation bar chart showing increases in all reported clinical effects compared with historical data and lists the individual clinical effects that exceeded the threshold (Figure 1). As with call volume surveillance, these anomalies may indicate a potential outbreak and are assessed by AAPCC and CDC staff, who determine their public health significance.

**Case-Based Surveillance**

The final automated algorithm is based on identifying cases meeting a specified definition and enables the system to detect
an event involving a single case. Whereas call volume and clinical effect surveillance both require an increase in volume, case-based surveillance is triggered by a single case matching a specified definition. Such definitions may include clinical effects, demographic characteristics, specific products, or AAPCC generic codes or other particular exposure parameters. Any time a call matches a case definition, NPDS sends out an automated e-mail alert. CDC staff currently run 11 definitions (Table) that are considered high priority exposures and used to detect sentinel events. Definitions may also be created extemporaneously in response to a known outbreak (eg, salmonella in peanut butter). During a known outbreak, CDC uses NPDS to detect additional cases and to track the geographic and temporal extent of exposures possibly associated with the outbreak. Potential cases identified by case-based surveillance are reviewed to determine whether they are of public health significance.

### Determining Public Health Significance

Anomalies do not necessarily signal an outbreak; approaches to detect them described here are intended for use in conjunction with close communication with the regional poison center. Applying the approaches described previously, reviewers (a group of clinical and medical toxicologists and epidemiologists from AAPCC and CDC) analyze the processed data and apply their expertise to determine whether the anomalies indicate an event of potential public health significance and whether further public health follow-up is required. AAPCC and CDC reviewers determine the public health significance of an anomaly or identified case by using the following criteria:

- reported symptoms are associated with a reportable disease;
- potential exposure involves a chemical or poison that can be used for terrorism;
- reported exposure is related to a commercial product that is part of an ongoing public health investigation because of its potential adverse health effects;
- anomaly includes multiple persons with evidence of exposure to the same substance; or
- anomaly includes illness not normally associated with a particular substance.

The reviewer then classifies and records the anomaly’s public health significance, the reason for the event (eg, food poisoning, adverse drug reaction), and the number of calls associated with the anomaly. This information is stored in NPDS. The reviewer then classifies and records the anomaly’s public health significance, the reason for the event (eg, food poisoning, adverse drug reaction), and the number of calls associated with the anomaly. This information is stored in NPDS. The reviewer then classifies and records the anomaly’s public health significance, the reason for the event (eg, food poisoning, adverse drug reaction), and the number of calls associated with the anomaly. This information is stored in NPDS. The reviewer may contact the regional poison center to gather additional information. Staff from the poison center or CDC notify local or state health departments if the information suggests an event warranting further public health involvement. Figure 2 illustrates the flow of data from the caller (ie, general public or health professional/hospital) to the poison center to NPDS. This figure also illustrates the data users and at what point they access the data.

### PUBLIC HEALTH EFFECT

We describe several examples of using NPDS to track a known outbreak. To understand the types of events that NPDS captures, we also examined the NPDS clinical effect anomalies from January 1, 2009, to December 31, 2009, and described the detected anomalies and their public health significance.

#### Outbreak of Selenosis, 2008

In March 2008, the Food and Drug Administration began receiving numerous reports of illness among patients who had consumed certain dietary supplements labeled “total body formula” and “total body mega formula.”6 Persons exposed to these products reported various signs and symptoms, including significant hair loss, muscle cramps, diarrhea, joint pain, and fatigue. During this time, state health departments and poison centers in Florida, Georgia, and Tennessee received similar reports. The outbreak was ultimately determined to be the result of excessive exposure to selenium because of misformulation of one of the ingredients in the implicated products. CDC scientists used NPDS to identify potential cases of illness from selenium associated with these products and to track the geographic extent of the outbreak. The product distributor reported shipments to 16 states. As of June 4, 2008, there were 170 calls in NPDS related to this outbreak from 8 states. Eighty percent (136) of these reported adverse clinical effects included generalized pain (25%), diarrhea (24%), and nausea (12%). No deaths or hospitalizations were reported to NPDS. Using NPDS to enhance situational awareness for individual poison centers and state health departments allowed staff to rapidly identify calls from newly affected states and enabled public health officials to conduct detailed follow-up with persons reporting exposures to these products.

#### Outbreak of Salmonella Typhimurium, 2009

In November 2008, CDC PulseNet staff detected a multistate cluster of S. Typhimurium reported from 12 states.7 In January 2009, staff confirmed peanut butter and products containing peanut butter to be the source of the outbreak. Responding to these findings, CDC staff began monitoring
NPDS for daily reports of calls about peanut butter and products containing peanut butter. During January and February 2009, CDC staff identified 1,998 calls that were possibly related to the outbreak. Twenty-eight percent (564) of these were for information and 72% (1,434) were reported exposure calls (Figure 3). Among callers reporting exposure, 1,028 (72%) reported at least 1 clinical effect, including the following: diarrhea (41%), vomiting (35%), nausea (25%), abdominal pain (24%), and fever (10%). One death was reported. Most calls were not referred to a health care facility. Aggregate data from NPDS were reported daily to the Division of Foodborne and Mycotic Diseases at CDC to enhance outbreak situational awareness. Through NPDS surveillance, CDC staff identified exposures in 5 states that CDC had not previously recognized through other surveillance mechanisms.

**Clinical Effect Anomalies, 2009**

In 2009, NPDS identified 567 clinical effect anomalies on 273 of 365 days (75%). The median number of these anomalies each day was 2 (range 1 to 8). Reviewers classified the 567
anomalies and found that 540 (95%) were not of public health significance, 22 (4%) were of public health significance, and 1 (1%) was of unknown public health significance. The 22 events of public health significance were product contamination or food poisoning (n = 14), school outbreaks to various chemical exposures (n = 3), exposures to fumigants (n = 2), environmental exposure to mold (n = 1), exposure to ciguatera fish toxin (n = 1), and exposure to multiple chemical irritants at the workplace (n = 1). Diarrhea was the most commonly reported clinical effect related to an event of public health significance (32%).

**DISCUSSION**

To our knowledge, NPDS is the only US national surveillance system that can provide near-real-time information about chemical or poison exposures and their associated illnesses. Tracking human health effects of events, such as the multistate outbreak of *S. typhimurium* infections associated with peanut butter products, exemplifies the usefulness of NPDS as an important part of the public health surveillance network infrastructure.

NPDS’s strength is its capability for near-real-time data transfer, analysis, visualization, and reporting from the 57 US poison centers. NPDS can compare national data with historical baselines to detect anomalies and to identify cases with illnesses or exposures of particular interest. Its Internet platform with automated anomaly identification and notification affords AAPCC, CDC, poison centers, and state and local health departments the ability to view NPDS call data from anywhere in the world. Single-case recognition is a unique aspect of this surveillance system and is important for exposures that occur rarely. Because case definitions are customized and can include partial recognition of potential exposure or a constellation of symptoms, sensitivity of the surveillance system is increased. Stimulated passive surveillance of chemical and poison exposures can be conducted by encouraging the public to contact their poison center through press releases and state and local health department notifications. Previous uses of poison center data during events have shown that press releases advising the public to contact their regional poison center if they think they have been exposed can increase the capacity for case finding. Further, CDC staff can obtain additional information and subject matter expertise to guide follow-up investigations by having access to the individual poison centers providing data to NPDS.

Despite the strengths of NPDS, there are inherent limitations in the data, some of which can be resolved. The number of chemical and poison exposures reported to a poison center per 1,000 population varies across the country and among ethnic groups; therefore, calls to poison centers do not include all chemical and poison exposures. Although no one knows the actual exposure case incidence, the Institute of Medicine estimates that the incidence of exposure calls is underreported by half. In addition, not all areas of a state may equally use the poison center for reporting chemical and poison exposures. We cannot determine whether this is a result of lack of awareness about poison center services, capabilities, and capacity or of differences in the actual rate of chemical and poison exposures. Individual and regional poison center use varies across the country because of many factors. Studies have demonstrated that poison center penetrance depends on the region’s population, distance to poison center, English-speaking proficiency, and race. Another important factor to poison center penetrance is the regional poison center’s capabilities to conduct outreach for poison center awareness in the community.

Possible solutions to low poison center penetrance include increasing the public knowledge of poison centers and their role in the community and enhancing outreach activities to address language and cultural barriers, which were found to be the largest factors to low poison center use.

Additionally, laws that require reporting cases of illness associated with chemical and poison exposures vary by state. For example, in some states, pesticide exposure is a reportable condition, whereas other states do not have such requirements. These case reports may go directly to state or local health departments and not to poison centers, even in states in which pesticide exposure reporting is required. Further, physicians and hospitals treating patients exposed to chemicals and poisons may not call the poison center to report an exposure. Often, physicians do not call poison centers if they can manage the effects of the exposure without toxicologic consultation and the exposure is not a reportable condition. Also, most calls to poison centers involve acute exposures to chemical and poisons and are less likely to involve long-term exposures and their associated clinical effects. Therefore, NPDS data are not representative of all chemical and poison exposures. Possible solutions to the lack of representativeness of NPDS data include initiating a targeted education effort to improve health provider awareness of NPDS data and NPDS surveillance activities so that a provider may report an exposure even if a toxicologic consultation is not necessary. The number of calls to poison centers most likely underrepresents the true number of exposures to chemicals and poisons; data referenced from NPDS should not be used to represent the complete incidence of national exposures to any chemical or poison. Because there is no other system to our knowledge that captures this type of information, the sensitivity and specificity of NPDS data cannot be calculated.

Despite NPDS’s ability to automatically generate alerts, the system does not stand alone and there is a human component of the surveillance system. The toxicologists and epidemiologists reviewing the anomalies must apply judgment to determine whether an anomaly (1) is an actual deviation from what is expected, (2) represents true exposures to chemicals and poisons, and (3) is truly an event of public health significance. Because many calls to poison centers are self-reported, it is vital that the reviewers take into consideration that reported exposures may not be true exposures. In collaboration with the regional poison center, reviewers may consult the detailed case notes, laboratory results, or medical records, if available, to determine whether the reported exposure is likely to be of public health importance.
As is true with most public health surveillance systems, the detection of an event by NPDS depends on either a grouping of exposures or illness occurring together in time or geography (ie, multiple calls reporting similar symptoms) or a single call matching a predetermined case definition. Therefore, the capturing of a novel exposure would most likely not be detected by NPDS. Once a new exposure has been discovered by an astute clinician or other reporting mechanism, NPDS can be used to search for additional cases and to track these cases nationally, which was demonstrated during the outbreak of selenosis. After the Food and Drug Administration began to receive reports of illness, CDC used NPDS to search for additional cases nationally.

Individual poison centers are crucial to detecting and responding to illness from intentional and unintentional chemical and poison exposures. A cohesive public health response can be fostered by improving situational awareness and communication between poison centers and federal, state, and local public health agencies. NPDS plays a crucial role in enhancing public health surveillance and highlights the importance of including poison centers in the public health infrastructure. A call to a poison center may be the first public health or medical contact about an exposure or illness of public health significance. Public and health care professionals treating patients with potential chemical and poison exposures should report these events to their regional poison centers. Enhanced reporting can identify emerging public health events and track the occurrence of chemical and poison exposures.\(^{10-12}\) Physicians can benefit from the poison center by access to health care professionals with specialized expertise in clinical and medical toxicology. The medical toxicology expertise in poison centers is also able to provide insight to the latest clinical recommendations and findings and the usual course of similar patients to further support the treating physician. During a known event, communication with the public and the medical community is integral for identifying cases. Such communications can alert clinicians for patients displaying symptoms consistent with exposure and remind them that the poison centers are an excellent resource for information about case management.

NPDS is an important tool for national surveillance and is the only system of its kind that captures information from across the country about chemical and poison exposures in near real time. The implementation of this system serves as an important step forward in surveillance technology and integration. Rapidly identifying these illnesses with NPDS and incorporating poison centers into the public health surveillance infrastructure provides the opportunity to improve public health response and minimize morbidity and mortality associated with chemical and poison exposures.

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