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National surveillance for radiological exposures and intentional potassium iodide and iodine product ingestions in the United States associated with the 2011 Japan radiological incident

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Abstract

Background—In March of 2011, an earthquake struck Japan causing a tsunami that resulted in a radiological release from the damaged Fukushima Daiichi nuclear power plant. Surveillance for potential radiological and any iodine/iodide product exposures was initiated on the National Poison Data System (NPDS) to target public health messaging needs within the United States (US). Our objectives are to describe self-reported exposures to radiation, potassium iodide (KI) and other iodine/iodide products which occurred during the US federal response and discuss its public health impact.

Methods—All calls to poison centers associated with the Japan incident were identified from March 11, 2011 to April 18, 2011 in NPDS. Exposure, demographic and health outcome information were collected. Calls about reported radiation exposures and KI or other iodine/iodide product ingestions were then categorized with regard to exposure likelihood based on follow-up information obtained from the PC where each call originated. Reported exposures were subsequently classified as probable exposures (high likelihood of exposure), probable non-exposures (low likelihood of exposure), and suspect exposure (unknown likelihood of exposure).

Results—We identified 400 calls to PCs associated with the incident, with 340 information requests (no exposure reported) and 60 reported exposures. The majority (n = 194; 57%) of the information requests mentioned one or more substances. Radiation was inquired about most frequently (n = 88; 45%), followed by KI (n = 86; 44%) and other iodine/iodide products (n = 47; 24%). Of the 60 reported exposures, KI was reported most frequently (n = 25; 42%), followed by

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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radiation (n = 22; 37%) and other iodine/iodide products (n = 13; 22%). Among reported KI exposures, most were classified as probable exposures (n = 24; 96%); one was a probable non-exposure. Among reported other iodine/iodide product exposures, most were probable exposures (n = 10, 77%) and the rest were suspect exposures (n = 3; 23%). The reported radiation exposures were classified as suspect exposures (n = 16, 73%) or probable non-exposures (n = 6; 27%). No radiation exposures were classified as probable exposures. A small number of the probable exposures to KI and other iodide/iodine products reported adverse signs or symptoms (n = 9; 26%). The majority of probable exposures had no adverse outcomes (n = 28; 82%). These data identified a potential public health information gap regarding KI and other iodine/iodide products which was then addressed through public health messaging activities.

Conclusion—During the Japan incident response, surveillance activities using NPDS identified KI and other iodine/iodide products as potential public health concerns within the US, which guided CDC's public health messaging and communication activities. Regional PCs can provide timely and additional information during a public health emergency to enhance data collected from surveillance activities, which in turn can be used to inform public health decision-making.

Keywords

National; Poison Data System; Poison; Centers; Radiation

Background

On March 11, 2011, a magnitude 9.0 earthquake struck Japan 45 miles east of the Oshika Peninsula of Tōhoku, leading to a tsunami that caused destruction along the coastal regions in its path. The earthquake and tsunami also damaged the Fukushima Daiichi power plant reactors, creating explosions that resulted in the subsequent release of radioactive material into the environment. This incident marked the world's worst nuclear accident in 25 years and was given the highest severity rating of 7 on the International Nuclear Event Scale by the International Atomic Energy Agency.[1] The last incident given this same rating occurred in 1986 in Chernobyl, Russia, when an explosion at a nuclear reactor resulted in an unintentional release of radioactive materials.

As the crisis unfolded, the US public health authorities (specifically for the west coast states) sought to address public concerns for radiological exposures from atmospheric plumes spreading across the Pacific Ocean and including the United States (US) citizens traveling from Japan. Poison Centers (PCs), state departments of health, and the CDC national hotline received inquiries about the effect of the radiation on residents and whether residents should take any pharmaceutical countermeasure for radiological prophylaxis. The extent of the radioactive release was not yet known and the US authorities including the CDC emergency operations center were interested in proactively identifying health communication needs and accurately targeting and evaluating risk communication messages as part of the public health response. In particular, authorities were interested in tracking individual potential exposures to potassium iodide (KI) and other iodide products consumed as pharmaceutical countermeasures for radioactive iodine and other potential radiological exposures. Past incidents involving uncontrolled radiological release such as the Chernobyl reactor accident showed that prophylaxis using potassium iodide and other iodide containing products can result in adverse reactions including abdominal pain, vomiting, skin rashes, and in some rare cases an exacerbation of chronic obstructive lung disease.[2] For the Japan incident, the public health recommendation was not to take KI or any other pharmaceutical countermeasures for the US. However, there was a perceived risk and fear of radiological poisoning from this event by the public. To assess and identify health communication needs related to the incident for the US residents, the Centers for Disease Control and Prevention (CDC) and the American Association of Poison Control Centers (AAPCC) rapidly identified calls made to poison centers regarding potential exposures to radiation or radiological contamination, potassium iodide, and other iodine/iodide products associated with the Japan incident using the National Poison Data System (NPDS).

NPDS is a data repository and web-based public health (PH) surveillance system owned and operated by the AAPCC. It consists of data collected and uploaded from calls to the 57 contributing, regional PCs regarding potential exposures to chemicals and poisons. These PCs provide 24-hour clinical consultation and triage by phone to the public and to healthcare facilities and respond to information requests regarding chemical and poison exposures to anyone in the 50 United States (US), District of Columbia, Puerto Rico, US Virgin Islands, the Federated States of Micronesia, American Samoa, and Guam. Since 2003, the National Center for Environmental Health (CDC) has used NPDS to improve PH surveillance for chemical and poison exposures and illnesses by identifying early markers of chemical incident for a rapid and appropriate PH response, and finding potential cases of public health significance to enhance situational awareness during an emerging public health incident.[3] Previous successful examples of this last objective include surveillance for chemical and oil exposures from the 2010 Deepwater Horizon oil spill, cases of illness associated with a 2009 Salmonella outbreak from peanut butter, and carbon monoxide poisonings resulting from generator use after numerous hurricanes.[4] Our objectives are to describe the self-reported exposures to radiation, radioactive materials, KI and other iodine/iodide product exposures associated with the 2011 Japan Radiological Incident detected by NPDS and to discuss their public health impact.

Methods

Daily surveillance

Analysis of ongoing poison center data surveillance was conducted during the activation of the CDC emergency operations center from March 11, 2011 to April 18, 2011. The NPDS surveillance team consisted of clinical toxicologists and epidemiologists from both CDC and AAPCC. AAPCC disseminated an incident-specific code for all PCs to use whenever a caller reports an exposure or requests information about the Japan incident. Using this incident specific code, the team identified, classified, and analyzed all calls to PCs associated with the Japan incident daily on the basis of the reason for the call: a simple request for information and no hazardous exposure (information call) or a request for guidance on how to manage a possible hazardous exposure (reported exposure). All calls were also identified by the state where the call originated, caller location (primary residence or healthcare facility), and if one of the following was the reason for the call: unintentional radiological exposure, intentional KI ingestion, or other iodine/iodide product ingestion. For all reported exposure calls, team members contacted the appropriate regional PC to request any additional information not reported to NPDS (sometimes entered in a free text field and stored on the local PCs server as the call narrative) and reviewed these data to categorize the reported exposure calls as probable exposures, probable non-exposures, or suspect exposures. The categorization scheme based on the reported exposure is detailed in Table 1. Individuals in which additional narrative data suggest an actual KI or other iodine/iodide product ingestion were classified as probable ingestions of that product. Alternatively, reported ingestions in which additional narrative data suggest that the ingestion did not occur were classified as probable non-exposures.

Any reported ingestion that upon additional narrative data review still cannot determine whether an actual ingestion occurred is classified as a suspect exposure. For radiation, individuals who reported a radiological exposure but had no travel to or from Japan during the response period were categorized as probable non-exposures. Persons reporting a radiological exposure who had traveled to or from Japan during the response period were categorized as suspect exposures due to the absence of environmental or laboratory testing data available to confirm exposure.

For all KI and other iodide product ingestions classified as probable exposures, clinical outcome, clinical effects contained in NPDS as pre-existing options (131 pre-coded clinical signs, symptoms and laboratory abnormalities) and patient demographics were tabulated, stratified by substance of interest. Clinical outcomes were classified by the severity of the clinical effects. Where the patient exhibits only some symptoms as a result of the exposure and which are minimally bothersome to the patient is defined as Minor effect. Moderate effect is defined as the patient exhibiting symptoms as a result of the exposure which are more pronounced or more prolonged than minor symptoms. Data and their interpretation were shared daily with the CDC emergency operations center managing the response.

Results

Between March 11 and April 18, 340 (85%) requests for information and 60 (15%) potential exposures to the substances of interest were captured by PCs and identified as associated with the Japan incident. Fig. 1 shows the daily call volume for the incident. The highest volume of calls originated from the west coast states including California (n = 161; 40%), Washington (n = 48; 12%), and Oregon (n = 19; 5%).

Of the 340 information calls, most (n = 229; 67%) came from a residence, followed by unknown sites (n = 97; 29%), and a healthcare facility (n = 14; 4%). The majority (n = 194; 57%) of the information calls mentioned a specific substance or more than one substance. Among these, radiation (n = 88; 45%) was reported most frequently, followed by KI (n = 86; 44%), and other iodine/iodide products (n = 47; 24%).

Of the 60 reported exposures, the majority (n = 54; 84%) came from a residence, a smaller number (n = 8; 13%) from a healthcare facility, and the rest were unknown (n = 2; 3%). Of the reported exposures, KI (n = 25; 42%) was reported most frequently, followed by radiation (n = 22; 37%), and other iodine/iodide products (n = 13; 22%).

Of the 25 reported KI exposures, most were classified as probable ingestions (n = 24; 96%) and one was classified as a probable non-exposure. Of the 13 reported other iodide/iodine product ingestions, most were classified as probable ingestions (n = 10, 77%) and the rest were suspect exposures (n = 3; 23%). Of the 22 reported radiation exposures, most were classified as suspect exposures (n = 16, 73%) and the rest (n = 6; 27%) were classified as probable non-exposures. None of the radiation exposures were classified as probable exposures (Table 2).

Of the 34 probable exposures, all involved KI (n = 24; 71%) or other iodine/iodide products (n = 10; 29%). Table 3 summarizes the characteristics of the probable exposures. Most involved females (n = 21; 62%) and most were greater than 20 years of age (n = 22; 65%). Only a small portion of all the probable exposures (n = 9; 26%) reported any signs or symptoms from the exposure. Of these 9 probable exposures reporting signs and symptoms, 5 were from other iodide/iodine products and 4 were from KI. The most commonly reported signs or symptoms included nausea (n = 2), vomiting (n = 2), dizziness/vertigo (n = 2), and abdominal pain (n = 2).

Discussion

Following a radiological or nuclear event, radioactive iodine may be released into the air. When radioactive materials get into the body through breathing, eating, or drinking, internal contamination occurs. In the case of internal contamination with radioactive iodine, the thyroid gland quickly absorbs this chemical. Radioactive iodine absorbed by the thyroid can then injure the gland. Because non-radioactive KI acts to block radioactive iodine from being taken into the thyroid gland, it can help protect this gland from injury.[5]

Pharmacotherapy with KI or any other iodine/iodide product for radioactive iodine exposure was never indicated or recommended for US residents.[5] However, surveillance efforts identified intentional ingestions of KI and other iodide products due to the perceived risk of the incident as a potential public health issue. The majority of the probable KI exposures were callers who had ingested KI tablets and were inquiring whether the dosage would lead to iodine poisoning. Even though there were very few adverse effects reported with these probable KI ingestions, the clinical effect patterns were similar to those reported after mass prophylaxis with KI in Poland during the Chernobyl reactor accident.[2] CDC also identified 10 probable exposures to various iodine/iodide products such as kelp and imported iodide-containing products such as “Rabano Yodado”, a Mexican nutritional supplement containing KI and tincture of iodine.

The perceived risk to health from this incident by US citizens calling PCs for information affirmed the need for effective health messaging against taking KI and against taking any iodine/iodide product that is advertised for radioactive iodine prophylaxis. Early review of various information sources such as calls to the CDC hotline and hits to the CDC website by communications staff indicated that individuals were actively seeking information about KI and its use. The NPDS data validated reports from these sources and substantiated the need for specific health information to address both the perception of risks associated with the incident and the actual risks associated with unnecessary consumption of KI and other iodine/iodide products. This need drove CDC's initial health messaging in response to the incident, which included the primary development of informational materials about KI, as well as its pharmacological action, efficacy, and contraindications. Much of this information was already available in the CDC website, but specific messaging and FAQs focusing on the incident was crafted and disseminated for PC and federal, state and local public health use. This ensured consistent and accurate messaging to address public concerns, regardless of the public health agency or PC responding to the inquiry.

The decline in all PC calls on March 17th and 18th as seen in Fig. 1 occurred after CDC had disseminated health messages that better characterized the risks associated with the incident and addressed public concerns about KI and radiological contamination. This decline in calls coincided with other decreases in information-seeking behavior as measured by CDC website traffic, public inquiries, and media inquiries. Consequently, these information sources suggested that the information needs of the public for this incident were being met by federal, state and local public health programs and PCs. Together, these factors influenced CDC's evolving risk communication strategy which shifted from addressing public perceptions about radiation risk and the prophylactic use of KI to messages that focused on issues directly linked to the unfolding events, such as airport screening and environmental testing results.

Further categorization of radiation exposure calls proved difficult upon review of the limited information obtained directly from PCs. In the absence of objective radiological screening in the individual or the environment of the exposed individual, CDC could not determine which, if any, were likely to be probable exposure to radiation or radioactive contamination. As such, no exposures were categorized as probable exposures. For preparedness in future radiation incidents, a standardized response by PC staff to potential radiation or radiological exposures should be considered to ensure that any objective screening, possibly available through community reception centers or other population monitoring stations, are documented.

This event response demonstrated that the NPDS surveillance team could report beyond the total number of calls about an incident as it had been used in previous events by CDC. Individual PCs can be contacted for additional information to be used by the team to further classify the likelihood of exposure. This process can be replicated for future event responses as needed and even expanded upon. Software changes that give coding options which allow rapid exposure classification and confirmation at the PC level would enable NPDS users to automatically classify calls as suspect, probable or confirmed exposures. If a reported exposure could be classified sooner, then NPDS users can, based on the presence and absence of clinically compatible illness, use case definitions for reporting. This report represents the next step in the continuous evolution of NPDS as a surveillance system.

Limitations

Individual and regional PC utilization varies across the country; therefore, calls to PCs may not include all potential exposures or requests for information associated with the incident. Although the true exposure incidence to hazardous substances is unknown, the Institute of

Medicine estimates that total exposure calls underreport the incidence of true poisonings by half.[6] During public health incidents such as the Japan response, media coverage of the incident or advertising of the PC toll-free number can significantly influence call volume. Constant media coverage may have resulted in an increased volume of calls.

Because calls to PCs are self-reported, reported exposures may not be true exposures. Callers that falsify information to report an exposure would be categorized in the analysis like any actual exposure, although there is little evidence that these instances occur often. Further review of PC case notes can filter out caller scenarios where the exposure likely did not occur, but this process cannot definitively confirm or deny an exposure.

NPDS identifies substances of exposure by a predetermined list of all possible exposure substances compiled by a third party. These substance names are extremely specific, updated regularly, and were used effectively to identify KI and other iodine/iodide product exposures during the response. However, the current substance list related to radiation or radioactive materials is outdated, and as a result many of the incident-related radiation exposure calls had little detail beyond just a reported exposure to “radiation”. The NPDS surveillance team was only able to identify whether an individual reported exposure to radiation, but was not able to discern any reported radiation dose or radioactive material involved in the potential exposure or contamination. Review of the case notes often included some information of the isotope and dose that was otherwise not in NPDS, but oftentimes this information was not mentioned at all. Even though the majority of calls to PCs originates from a residence and is thus unlikely to have the specific dose and isotope of the radiation exposure, the NPDS team recommends that PCs have tools available to accurately identify radiation calls in case a domestic radiation incident occurs and detailed information is available through environmental or population monitoring stations. This incident highlighted the need for a revision of the current radiation-related substances list to increase the detail of radiation exposure call information in NPDS.

Conclusion

Surveillance activities using the NPDS identified intentional ingestions of KI and other iodine/iodide products as a potential public health concern within the US during the Japan incident response. This guided CDC’s public health messaging and communication activities with timely information for an appropriate response. Regional PCs can provide timely information during a public health emergency to enhance data collected from surveillance activities, which in turn can be used to inform public health decision-making. Surveillance using NPDS demonstrated utility for conducting human health effects and exposure surveillance to assess perceived and actual risk associated with a known public health emergency.

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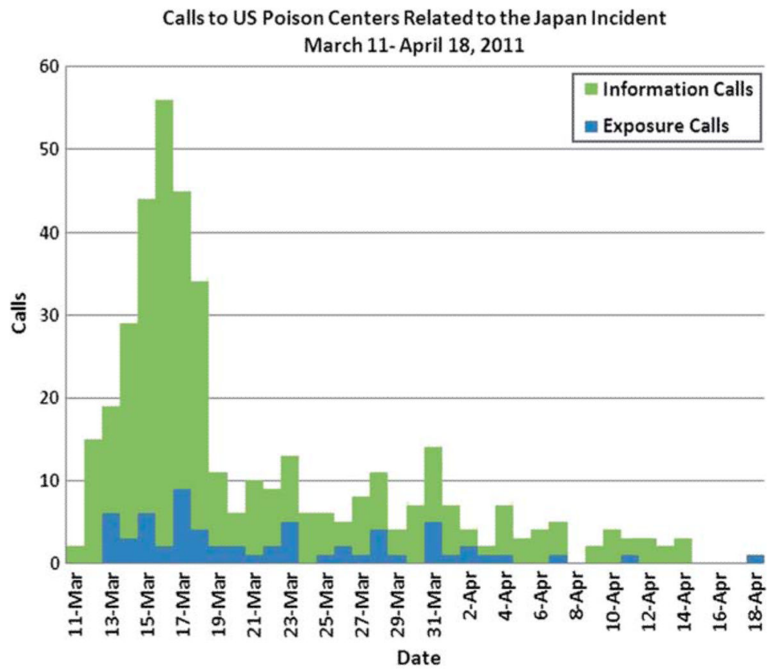

Fig. 1.

Daily volume of calls to PCs associated with the Japan incident from March 11 to April 18, 2011 (N = 400). (colour version of this figure can be found in the online version at www.informahealthcare.com/ctx).

Table 1

Exposure call categorization scheme by substance.

Substance	Probable exposure	Probable non-exposure	Suspect exposure
Potassium Iodide (KI) ingestions	Reported exposure to potassium iodide in which PC follow up via review of the call narrative suggests that an ingestion of KI containing product occurred.	Reported exposure to potassium iodide in which PC follow up via review of the call narrative suggests that an ingestion of KI containing product did not occur. Example: individual opens KI bottle and gets light-headed without ingesting any tablets	Any reported exposure that upon PC follow up via review of the call narrative still cannot determine whether an actual exposure occurred.
Other iodine or iodide product ingestions	Reported exposure to other iodine/ iodide products in which PC follow up via review of the call narrative suggests that an ingestion of such product occurred.	Reported exposure to other iodine/ iodide products in which PC follow up via review of the call narrative suggests that an ingestion of such products did not occur.	Any reported exposure that upon PC follow up via review of the call narrative still cannot determine whether an actual exposure occurred.
Radiological exposures	Reported exposure to radiation or radioactive material in which PC follow up via review of the call narrative strongly suggests that radiation exposure or contamination occurred, including documented travel to Japan, radiation measurements of the exposed individual, urine assay test results, and/or additional examinations.	Reported exposure to radiation or radioactive material in which PC follow up via review of the call narrative suggests that radiation exposure or contamination did not occur. Exposed individuals who did not report any travel to or from Japan since March 11, 2011 are classified in this category.	Any reported exposure that PC follow up via review of the call narrative still cannot determine whether an actual exposure or contamination occurred. Exposed individuals who reported travel to or from Japan since March 11, 2011 but have no objective evidence of a true radiation exposure or contamination (radiation measurements, urine assay test results, and/or additional examinations).

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Table 2

Categorization scheme of reported exposures separated by substance associated with the Japan response.

	Probable exposures	Probable non-exposures	Suspect exposures	Total
Potassium Iodide ingestions	24	1	0	25
Other iodine/iodide product ingestions	10	0	3	13
Unintentional radiological exposures	0	6	16	22
Total	**34**	7	23	60

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Table 3

Descriptive characteristics of probable ingestions of KI and other Iodide products associated with the Japan incident, 11 March – 18 April 2011 (N = 34).

Characteristic	N (%)
Sex	
Male	13 (38)
Female	20 (59)
Unknown	1 (3)
Age	
0–10 years	6 (18)
10–20 years	6 (18)
> 20 years	22 (65)
Outcomes	
Moderate effect	1 (3)
Minor effect	0 (0)
No effect/not followed	28 (82)
Unrelated effect	4 (12)
Unknown/unable to follow up	1 (3)
Most common clinical effects	
Nausea	2 (6)
Vomiting	2 (6)
Dizziness/vertigo	2 (6)
Abdominal pain	2 (6)
Agitated/irritable	1 (3)
Oral irritation	1 (3)
Rash	1 (3)
Tachycardia	1 (3)