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# Lessons learned from hazardous chemical incidents—Louisiana Hazardous Substances Emergency Events Surveillance (HSEES) system

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**Abstract**

Since 2001, the Louisiana Department of Health and Hospitals (LDHH) has participated in the Hazardous Substances Emergency Events Surveillance (HSEES) system. In 2001, there were 815 events qualified for HSEES surveillance. Data for each event was gathered and analyzed. During these hazardous substances events, there were 1164 chemicals released resulting in injuries to 63 people, most with respiratory system irritation. Even though more people were injured in fixed-facility events, injuries were more likely to result from transportation-related events. The quantity and frequency of hazardous substance releases do not always positively correlate with the number of injuries sustained during those releases. A higher percentage of "Rail" transport events was observed in Louisiana when compared with other HSEES states. By collecting and analyzing more data and disseminating results to the public, it is expected that further adverse public health consequences from hazardous releases/spills in Louisiana can be reduced and/or minimized.


*Keywords:* HSEES; Louisiana; Surveillance; Emergency release; Hazardous chemicals

## 1. Introduction

The Hazardous Substances Emergency Events Surveillance (HSEES) system was established by the US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) to collect and analyze information about releases of hazardous substances that require clean up or neutralization according to federal, state, or local laws [1]. Threatened releases that result in a public health action such as an evacuation are also included. The goal of HSEES is to reduce the morbidity (injury) and mortality (death) of first responders, employees, and the general public that can result from hazardous substance events [2].

Since 1990, the ATSDR has maintained an active, state-based HSEES system to describe the public health consequences associated with the release of hazardous substances. The Louisiana Department of Health and Hospitals (LDHH) has participated in this surveillance system since 2001. Currently there are 15 states participating in HSEES [2]. This report describes lessons learned from hazardous chemical release data collected for the surveillance system by the LDHH during 2001.

## 2. Method

A hazardous substance includes, but is not limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through the food chain, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring [3].

In order to qualify a hazardous substance event for the HSEES system, the following criteria must be met.

1. There was an uncontrolled or illegal release or threatened release of one or more hazardous substances; and

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2. the quantity of the hazardous substances which are released, need (or would need) to be removed, cleaned up, or neutralized according to federal, state, or local law (In Louisiana, the reportable quantity from Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) was followed); or
3. there is only a threatened release of hazardous substances, but this threat leads to a public health action (e.g. an evacuation) that can potentially impact the health of employees, responders, or the general public. This action makes the event eligible for inclusion into the surveillance system if the other criteria are also met, even though the hazardous substances are not released;
4. releases of only petroleum are excluded [3].

Various data sources were used to obtain information about these events. In Louisiana, these sources included, but were not limited to, the Louisiana State Police, the National Response Center, US Department of Transportation, the Louisiana Department of Environmental Quality (LDEQ) and news media. For other HSEES participating states, sources also included local hospital, fire departments and Local Emergency Planning Committees [4–6]. Data are then entered by participating state health departments into a web-based application that enables ATSDR to instantly access data for analysis. Information collected for qualified events include the following:

- event identification and notification information;
- time, date, and day of the week;
- event type (fixed-facility or transportation-related event);
- geographical location and place within the facility where the event occurred;
- factors contributing to the release;
- substance released including trade name, chemical form, type of release, and quantity;
- environmental sampling and follow-up health activities;
- specific information on injured persons: age, sex, type and extent of injuries, distance from spill, population group (employee, general public, responder, student), and type of personal protective equipment used;
- information about decontaminations, evacuation orders or shelter-in-place;
- land use and population information to estimate the number of persons at home or work who were potentially exposed;
- whether a contingency plan was followed and which plan.

Emergency events captured by HSEES are classified according to whether they occur at fixed facilities or during transport. Fixed-facility events involve hazardous substances released at industrial sites, schools, farms, or other permanent facilities; transportation-related events involve hazardous material releases that occur during transport by surface, air, or water. Victims are defined as individuals with symptoms (including psychological stress) or injuries (including those which result in death) that result from the event [7,8]. Victims who receive more than one type of injury are counted once in each applicable type of injury.

Substances are grouped into 11 categories: acids, ammonia, bases, chlorine, mixtures, paints and dyes, pesticides, polychlorinated biphenyls, volatile organic compounds (VOCs), other inorganic substances, and other substances. The “Mixtures” category consists of chemicals from different categories that are mixed before release, and the “Other” category consists of chemicals that cannot be classified into any one of the other 10 chemical categories. The category “Other inorganic substances” comprises all inorganic substances except acids, bases, ammonia, and chlorine [9].

## 3. Results

### 3.1. Event type

In 2001, a total of 815 hazardous substances emergency events in Louisiana qualified for the HSEES system. Of those 815 events, 807 (99.0%) were in the category “Substances all actually released into environment”, 6 (0.7%) were in the category “Substances all threatened to be released into environment”, and 2 (0.2%) were in the category “Substances some actually and some threatened to be released”. Out of 815 events, 684 (83.9%) events occurred at fixed facilities, and 131 (16.1%) events were transportation-related events.

### 3.2. Area involved

Identifying the specific location within a facility or the mode of transportation involved in the event is critical when assessing the public health impact of the incident. As shown in Table 1, “Process vessel” was the area/location involved in 266 (38.9%) fixed-facility events. All states HSEES data from 1993 to 1997 reported a similar percentage of events involving the process vessel (36.5%) [10]. Incidents involving “Piping” are more likely to cause injuries (4.4%) than those involved other locations in fixed facility. In transportation-related events, 59 (45.0%) occurred during ground transport (i.e. truck, van, or tractor), and 53 (40.5%) involved transport by rail. For all HSEES states data from 1993 to 1997, approximately 81% of the transportation-related events involved “Ground” and 13% involved “Rail” [11]. In Louisiana, a significantly larger percentage of transportation-related events occur during rail transport. Incidents involving ground transportation are more likely to cause injuries (10.2%) than incidents in other mode of transportation in transportation-related events.

### 3.3. Contributing factors

Recognition of the cause of an incident is essential for preventing repeated occurrences. As shown in Table 2,

Table 1
Area/transport involved by event type

| | Number | Percentage | Without victims | With victims |
|---|---|---|---|---|
| Area/equipment involved in fixed facility | | | | |
| Process vessel | 266 | 38.9 | 261 (98.1%) | 5 (1.9%) |
| Piping | 114 | 16.7 | 109 (95.6%) | 5 (4.4%) |
| Unknown | 96 | 14.0 | 95 (99.0%) | 1 (1.0%) |
| Ancillary process | 90 | 13.2 | 89 (98.9%) | 1 (1.1%) |
| Other | 118 | 17.3 | 117 (99.2%) | 1 (0.8%) |
| Total | 684 | | 671 | 13 |
| Type of transport in transportation-related event | | | | |
| Ground | 59 | 45.0 | 53 (89.8%) | 6 (10.2%) |
| Rail | 53 | 40.5 | 53 (100.0%) | 0 (0.0%) |
| Other (water, air, or pipeline) | 19 | 14.5 | 18 (94.7%) | 1 (5.3%) |
| Total | 131 | | 124 | 7 |

Table 2
Event contributing factors by event type

| Event primary factor | Number | Percentage | Without victims | With victims |
|---|---|---|---|---|
| Fixed facility | | | | |
| Equipment failure | 321 | 46.9 | 316 (98.4%) | 5 (1.6%) |
| System/process upset | 90 | 13.2 | 88 (97.8%) | 2 (2.2%) |
| System start up and shutdown | 79 | 11.5 | 79 (100.0%) | 0 (0.0%) |
| Others | 194 | 28.4 | 188 (96.9%) | 6 (3.1%) |
| Total | 684 | | 671 | 13 |
| Transportation-related | | | | |
| Equipment failure | 36 | 27.5 | 35 (97.2%) | 1 (2.8%) |
| Motor vehicle rollover/derailment | 33 | 25.2 | 29 (87.9%) | 4 (12.1%) |
| Human error | 21 | 16.0 | 21 (100.0%) | 0 (0.0%) |
| Others | 41 | 31.3 | 39 (95.1%) | 2 (4.9%) |
| Total | 131 | | 124 | 7 |

"Equipment failure" was a primary contributing factor in 321 (46.9%) fixed-facility events. Primary factors contributing to transportation events were also reported. "Equipment failure" was a contributing factor in 36 (27.5%) events. The most frequent factor in all HSEES states events (fixed-facility and transportation) 1995–1997 was also "Equipment failure" (67.6%) [11]. Incidents involving "Piping" (4.4%) and "Motor vehicle rollover/derailment" (10.2%) are more likely to cause injuries than those caused by other factors in fixed facility and transportation-related events, respectively.

### 3.4. Substance

Of all events, 74.2% involved the release of only one substance. Two substances were released in approximately 15.7% of the events, and the remainder 10.1% involved the release of more than two substances. During the 815 events, there were 1164 chemicals released. Out of 1164 chemicals released, 1150 (98.8%) were actually released and 14 (1.2%) were threatened to be released. (The number of substances released was higher than the number of events, because as mentioned above, some of the events involved more than one substance.) Most substances released were air emissions (71.9%), followed by spills (20.7%) or fires (1.0%). Of the air emissions, 96.2% were from fixed-facility events. Of the spills, 60.7% were fixed-facility events. Of the fire events, 70.0% were from the fixed-facility events.

As shown in Table 3, of the 11 categories into which HSEES substances were grouped, those most commonly released substances in fixed-facility events included "Other inorganic substances" (34.7%), "VOCs" (29.3%) and "Other" (16.7%). In transportation-related events, "Other" (26.2%), "VOCs" (18.4%) and "Other inorganic substances" (15.6%) were most frequently released.

### 3.5. Morbidity and mortality

Out of 815 events, there were a total of 63 victims in 20 events (2.5% of all releases). Of the events with victims, 70% involved only one victim, and 80% involved either one or two victims. Of the transportation events, 5.3% involved victims, while only 1.9% of the fixed-facility events involved victims. Approximately 13% of the victims were injured in transportation-related events and 87.3% were injured in fixed-facilities.

Table 3
Distribution of the number of substances released, by substance category and type of event

| Substance category | Type of event | | | | | |
|---|---|---|---|---|---|---|
| | Fixed facility | | Transportation | | All events | |
| | Number of substances | Percentage | Number of substances | Percentage | Number of substances | Percentage |
| Acids | 45 | 4.4 | 21 | 14.9 | 66 | 5.7 |
| Ammonia | 58 | 5.7 | 10 | 7.1 | 68 | 5.8 |
| Bases | 17 | 1.7 | 12 | 8.5 | 29 | 2.5 |
| Chlorine | 35 | 3.4 | 3 | 2.1 | 38 | 3.3 |
| Mixtures[a] | 13 | 1.3 | 1 | 0.7 | 14 | 1.2 |
| Other inorganic substances | 354 | 34.7 | 22 | 15.6 | 376 | 32.3 |
| Other substances | 170 | 16.7 | 37 | 26.2 | 207 | 17.8 |
| Paints and dyes | 2 | 0.2 | 2 | 1.4 | 4 | 2.6 |
| Pesticides | 23 | 2.3 | 7 | 4.9 | 30 | 0.3 |
| Polychlorinated biphenyls | 4 | 0.4 | 0 | 0.0 | 4 | 0.3 |
| Volatile organic compounds | 300 | 29.4 | 26 | 18.4 | 326 | 28.0 |
| Total | 1021 | 100.0 | 141 | 100.0 | 1162[b] | 100.0 |

[a] Mixtures of substances from different categories.
[b] Type of category was indeterminate in 2 releases.

Substances with a higher frequency of release do not necessarily lead to more injuries, suggesting that some chemicals are more likely to cause injuries than others. As shown in Table 4, "Other inorganic substances" were released during 376 events; however, only 3 (0.8%) of these events resulted in adverse health effects. Conversely, chlorine was released in only 38 events, and 5 (13.2%) of these events resulted in adverse health effects, indicating its greater potential for immediate harm. Also, the quantity of hazardous substance release does not always positively correlate with number of injuries. Large quantity releases are mostly due to process upset or mechanical failure and therefore these releases usually do not pose immediate danger because of the process safety mechanism like flaring, auto-shut down and re-direct, etc. Conversely, small quantity releases due to leakage or during transportation often result in injuries because people are usually in close proximity to the releases. For example, for chlorine releases with victims, the release quantities ranged from 13 to 79 pounds, while the maximum chlorine releases was 300 pounds and no people was injured.

The types of adverse health effects sustained by victims are shown in Table 5. Some victims had more than one adverse health effect. The most commonly reported adverse health effect in fixed-facility events was respiratory system problems (83.6%). Trauma was reported in 37.5% of all transportation-related events, but was not reported in any fixed-facility events. The trauma may have been caused by the sequence of events (for example, a motor vehicle accident) leading to the release of a hazardous substance, and not by exposure to the hazardous substance itself.

Out of 63 victims, 16 (25.4%) were male and the sex of the other 47 (74.6%) victims was unknown. Age was unknown

Table 4
Number of substances released in all events and events with victims, by substance category

| Substance category | Total releases | | Releases with victims | | |
|---|---|---|---|---|---|
| | Number | Percentage of total releases | Number | Percentage of all releases with victims | Percentage of releases in substance category |
| Acids | 66 | 5.7 | 4 | 17.4 | 6.1 |
| Ammonia | 68 | 5.9 | 6 | 26.1 | 8.8 |
| Bases | 29 | 2.5 | 1 | 4.3 | 3.5 |
| Chlorine | 38 | 3.3 | 5 | 21.7 | 13.2 |
| Mixtures | 14 | 1.2 | 1 | 4.3 | 7.1 |
| Other inorganic substances | 376 | 32.4 | 3 | 13.0 | 0.8 |
| Other, not otherwise specified | 207 | 17.8 | 2 | 8.7 | 1.0 |
| Paints and dyes | 4 | 0.3 | 0 | 0.0 | 0.0 |
| Pesticides | 30 | 2.6 | 0 | 0.0 | 0.0 |
| Polychlorinated biphenyls | 4 | 0.3 | 0 | 0.0 | 0.0 |
| Volatile organic compounds | 326 | 28.1 | 1 | 4.3 | 0.3 |
| Total[a] | 1162[b] | 100.0 | 23 | 100.0 | |

[a] Total of 1162 releases exceeds the total number of 815 events because the events at which more than one substance was released were counted more than once.
[b] Substance category was indeterminate in two releases.

Table 5
Distribution of type of adverse health effect, by type of event

| Type of adverse health effect | Type of events | | | | | |
|---|---|---|---|---|---|---|
| | Fixed facility | | Transportation | | All event | |
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Chemical bums | 2 | 3.3 | 2 | 25.0 | 4 | 5.8 |
| Heart problems | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Dizziness/CNS[a] | 5 | 8.2 | 0 | 0.0 | 5 | 7.2 |
| Eye irritation | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Headache | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Heat stress | 1 | 1.6 | 0 | 0.0 | 1 | 1.4 |
| Gastrointestinal problems | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Respiratory problems | 51 | 83.6 | 2 | 25.0 | 53 | 76.8 |
| Shortness of breath | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Skin irritation | 1 | 1.6 | 0 | 0.0 | 1 | 1.4 |
| Thermal burns | 1 | 1.6 | 1 | 12.5 | 2 | 2.9 |
| Trauma | 0 | 0.0 | 3 | 37.5 | 3 | 4.3 |
| Other | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 61 | 100.0 | 8 | 100.0 | 69[b] | 100.0 |

[a] Central nervous system symptoms.
[b] The total number of injuries is greater than the total number of victims, because a victim could have had more than one injury.

for all but 2 victims. Among the 63 victims, 22 (34.9%) were treated on scene (first aid), 27 (42.9%) were treated at a hospital but not admitted, 9 (14.3%) were treated at a hospital and admitted, 1 (1.6%) was observed at a hospital with no treatment, 2 (3.2%) were fatalities, and for 2 (3.2%) the details surrounding their treatment were unknown.

Among the 63 victims, 60 (95.2%) were "Employees", 1 (1.6%) was a "Responder", 1 (1.6%) was "General public" and 1 (1.6%) was a "Police officer". Out of the 60 employees, 39 (65.0%) were reported as wearing personal protection equipment (PPE), 19 (31.7%) had not worn any form of PPE, and for 2 (3.3%) victims it was not known whether PPE was worn. Of the 39 employee victims wearing PPE, 37 (94.9%) were wearing unknown type of protection, 1 (2.6%) was wearing level "A" protection and 1 (2.6%) was wearing a hard hat.

Of the two persons who died as a result of hazardous substances releases, one was a driver of a truck loaded with phosphoric acid. The victim suffered from severe burns when the truck overturned and caught fire. The other fatality resulted from a chemical release in a hospital X-ray room. The victim was an employee of the hospital and suffered from a respiratory system problem.

### 3.6. Evacuations

Evacuations were ordered in 22 (2.7%) events. Among the 22 evacuations, 11 (50.0%) were of a building or the affected part of a building, 5 (22.7%) were of an affected circle or radius, 4 (18.1%) were reported as having no criteria, and 2 (9.1%) were down wind/down stream. The numbers of people evacuated were known in three events and they were 12, 20, and 40. The median length of evacuation was 2 h (range: 1–24 h). In 17 additional events, in-place sheltering was ordered by an official and instructions regarding precautions to take during in-place sheltering were provided by an official in 16 (94.1%) of the events.

### 3.7. Contingency plans

The types of contingency or preparedness plans used during an event varied. Five hundred forty-one (72.2%) events were reported as using "Company's operation procedures", and 7 (1.3%) of them involved victims. Eighty-two (11.0%) employed "Incident specific ad hoc plan", and two (2.4%) of them involved victims. Eight-one (10.8%) employed "Hazardous materials/response team's standard operating procedures" and 11 (13.6%) of them involved victims. Three (0.4%) employed "Resource Conservation and Recovery Act (RCRA) contingency plan" and no victim was reported. Information on the type of contingency plan was unknown for 42 (5.6%) of the events and no victim was reported. Events which "Hazardous materials/response team's standard operating procedures" was employed are more likely (13.6%) to involved with victims than others.

## 4. Conclusions

In 2001, there were several chemical industries in the state of Louisiana that accidentally release significant amounts of chemicals into the environment everyday. These unplanned chemical releases can affect the health of industry workers, the general public, first responders, and health care providers. Based on analysis of the 2001 Louisiana's HSEES data, several lessons can be learned:

1. Even though more people are injured in fixed-facility events, injuries are more likely to result from transportat-

ion-related events. Based on the most frequent adverse effects reported (respiratory system irritation for fixed-facility and trauma for transportation events), proper PPE and respirator training are recommended for fixed-facility employees. For the transportation-related employees, PPE and proper handling techniques are recommended.

2. Although "Equipment failure" was the number one contributing factor for both fixed-facility and transportation-related events, in transportation-related events, the second and third factors "Motor vehicle rollover/derailment" and "Human error" together account for about 41% of the incidents. This demonstrates that more driver/operator training could be beneficial to workers involved in transporting hazardous chemicals.
3. The quantity and frequency of hazardous substance releases do not always positively correlate with the number of injuries sustained during those releases. Some small spills caused as many injuries as larger spills did. Location and type of release are better indicators of potential danger to public health. In Louisiana, emergency releases were mostly from petroleum refineries or chemical industries. These releases were very frequent and often in large quantity. However, the released substances usually do not pose an immediate danger to the public health because of the process safety mechanism (flaring, auto-shut down, re-direct, etc.). Conversely, small quantity releases in storage areas or during transportation due to gas leakage, a liquid spill or a loose valve often result in more injuries perhaps because people are usually in close proximity to the release and not wearing any PPE.
4. Results indicate a higher percentage of "Rail" transport events in Louisiana than in all HSEES states. Employees in this field often have to manage multiple tank cars and different hazardous substances. These substances are often in large quantities and in close proximity to other chemicals. Emergency events in this field could involve not only large quantities of hazardous substances, but also the possibility of chemical reactions from the mixing of different chemicals. Therefore, proper handling techniques for hazardous substances and education about their chemical properties are recommended for employees in the rail transport field.

Surveillance is very important when assessing the correlation between a hazardous substance release and its potential public health impacts. Despite the quantity released, events with or without injuries often have similar causes. Therefore, in order to reduce injuries, lessons can be learned from all incidents. Over the last decade, HSEES data from other participating states has been utilized by ATSDR and other federal agencies for trend analysis resulting in a number of publications (Hall et al. [12], Orr et al. [13], Hall et al. [14]). Participating states have also developed successful prevention outreach programs based on their data (Welles et al. [15,16]). Information presented in this paper is from the first year of data collection in Louisiana. By collecting and analyzing more data and disseminating results to the public, it is expected that further adverse public health consequences from hazardous releases/spills in the state of Louisiana can be reduced and/or minimized.

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