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The public health consequences from acute chlorine releases, 1993–2000

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Abstract

Chlorine, a commonly used hazardous substance, can be harmful to human health when improperly released. Data from the Agency for Toxic Substances and Disease Registry's Hazardous Substances Emergency Events Surveillance system were used to conduct a retrospective analysis on the public health consequences from acute chlorine releases in 16 states during 1993 through 2000. There was an overall decline in the number of chlorine events during the period analyzed; however, chlorine events were more likely to result in events with victims, evacuations, and decontaminations when compared with non-chlorine events (relative risk [RR] = 4.5, 95% confidence interval [CI] = 4.1-5.0; RR 4.8, CI 4.3-5.3; and RR 2.0, CI 1.7-2.4, respectively). Most chlorine victims were employees and members of the general public. The predominant symptoms sustained were respiratory and eye irritation. Equipment failure and human error were the most frequent factors leading to an event. Continuous employee training and preventive equipment maintenance can help prevent chlorine releases from occurring and minimize exposure to the general public.

Introduction

Chlorine, a highly reactive inorganic gas, is one of the top ten chemical substances produced in the United States; approximately 25 billion pounds are produced annually (*1*). It is widely used as a water disinfectant and as a bleaching agent for paper and cloth. It is also used as an intermediate in the manufacture of many organic products including rubber, cleaning agents, and pharmaceuticals (*2, 3*). While uses of chlorine are numerous, acute releases can lead to adverse public health consequences including injuries, evacuations, and possible loss of life. Most notably was the 1996 60 ton chlorine release that occurred from a derailed freight train near Alberton, Montana, in which a large percentage of evacuated residents reported adverse health effects (*4, 5*).

Human exposure to chlorine releases occurs primarily through inhalation, skin, and/or eye contact (*6*). Acute exposure tends to cause mostly respiratory symptoms. Documented symptoms resulting from acute chlorine exposure include burning eyes, nose, mouth; lacrimation, rhinorrhea, cough, choking, substernal pain; nausea, vomiting; headache, dizziness; syncope; pulmonary edema; pneumonitis; hypoxemia; dermatitis; and frostbite (*6*). Additionally, chlorine is a nonflammable gas but is considered a strong oxidizer that will react vigorously or explosively with many materials, including fuels (*6, 7*).

Data from the Agency for Toxic Substances and Disease Registry's (ATSDR) Hazardous Substances Emergency Events Surveillance (HSEES) system were used to conduct an in-depth analysis of the public health consequences from acute chlorine releases in 16 states during the years 1993 through 2000. Chlorine was chosen for this analysis because of its potential for having a proportionally higher percentage of releases with victims when compared with non-chlorine releases with victims (*8-10*). The purpose of this paper is not to debate chlorine's effectiveness as a disinfectant or a bleaching agent, but rather to discuss its public health consequences from acute releases. To assess these public health consequences specific to chlorine, the analysis was restricted to events where only one substance (chlorine) was released. The objectives of the analysis were to 1) describe the distribution and characteristics of chlorine only emergency events (hereafter referred to as chlorine events) and the acute public health consequences associated (i.e., morbidity, mortality, and evacuations), 2) compare the risk of events with victims for chlorine events with non-chlorine events involving one substance (hereafter referred to as non-chlorine events) 3) present examples of chlorine events, and 4) identify strategies that might help prevent or reduce future chlorine events and associated injuries.

Methods

Since 1990, ATSDR has maintained the active, state-based HSEES system to help reduce the morbidity and mortality associated with hazardous substance releases. During the period of 1993 to 2000, 10 state health departments participated in HSEES for the entire time period: Alabama, Colorado, Iowa, New York, North Carolina, Oregon, Rhode Island, Texas, Washington, and Wisconsin. Six state health departments participated during portions of this period: New Hampshire (from 1993 to 1996 only), Missouri (1994 to 2000), Minnesota (1995 to 2000), Mississippi (1995 to

2000), Utah (2000), and New Jersey (2000).

Data collected from 1993 to 2000 were used for this analysis because a) the initial years of data (1990-1992) are considered pilot data and b) 2000 data were the most recent data available at the time of analysis. States used multiple data sources available to capture complete event information. These sources included, but were not limited to, state environmental protection agencies, police and fire departments, poison control centers, hospitals, and local media. Information collected (i.e., substance[s] released, victims, injuries, and evacuations) was recorded on standardized data forms and entered into a computerized database. This information was then sent quarterly by the states to ATSDR where it was uploaded into the central HSEES database for analysis. Beginning in 2000, ATSDR ceased using the quarterly data submission system and deployed a real-time, web-based surveillance system. Statistical analyses were conducted using SAS and EpiInfo software (*11, 12*).

Hazardous substance emergency events were defined as actual, uncontrolled, or illegal releases of a hazardous substance(s), or the hazardous by-products of a substance that had to be removed, cleaned up, or neutralized according to federal, state, or local law (*10*). HSEES defines a hazardous substance as any substance that can cause an adverse health effect. For this analysis, the HSEES database was queried for all events that were grouped in the hazardous substance category *chlorine*. The individual substances that were mapped to this *chlorine* category included only "chlorine" and "chlorine not otherwise specified (NOS)." Hypochlorites and other chlorine-based compounds (i.e., sodium, potassium, and calcium hypochlorites; sodium hydroxide, hydrogen chloride, potassium hydroxide) are not included in the *chlorine* category. These substances are mapped to other substance categories respectively; *other inorganic substances, volatile organic compounds (VOCs), other inorganic substances, bases, acids,* and *bases*.

For analyses comparing chlorine events with other substance categories, substances were grouped into 11 categories: *chlorine, ammonia, acids, pesticides, bases, other, mixtures across categories, other inorganic substances, paints and dyes, VOCs, and polychlorinated biphenyls (PCBs).* The category *other inorganic substances* is comprised of all inorganic substances, except for acids, bases, ammonia, and chlorine. *Mixtures across categories* consists of substances that were mixed prior to the release. The *other* category consists of substances that could not be placed in one of the other ten substance categories above. Additionally, census codes were used to identify the major industry categories that manufacture and/or use hazardous substances (*13*). From these major industry categories, industry sub-categories were examined to establish greater event specificity.

HSEES victims were defined as persons sustaining at least one injury or symptom (i.e., respiratory irritation) or died as a result of the event. First responders included police officers, professional firefighters, volunteer firefighters, hospital personnel (i.e., emergency department [ED] physicians and nurses), emergency medical technicians (EMTs), and responders of unknown type. Evacuations were defined as events in which people left their home or place of work because of the release. Decontamination was defined as any cleaning procedure that was not considered routine (i.e., washing hands).

Results

A total of 44,164 events was reported to the HSEES system from January 1, 1993 through December 31, 2000. Of these events, 952 (2.2%) were chlorine-related; 865 involved actual releases of chlorine only. During the period analyzed, the yearly number of these 865 chlorine events decreased; conversely, the number of non-chlorine HSEES events involving one substance (n=40,606) increased (Table 1). Almost half of the chlorine events, (n=411, 47.5%), occurred during the months of May through August. Of events when the time and day of occurrence were recorded (n=843, 97.5% and n=865, 100.0%, respectively), 73.3% (n=618) occurred during the hours of 6:01am and 6:00pm, and 82.4% (n=713) occurred during a weekday. The quantity of chlorine released during events ranged from one ounce to six tons. Of the 638 events for which the quantity of release was known, 564 (88.4%) were reported in pounds; of which 511 (90.6%) involved 250 pounds or less. Most of the events involved air emissions (n=592, 68.4%) and spills (n=134, 15.5%).

Of these 865 chlorine events, the two states accounting for the most events were Texas, (n=139, 16.1%), and Washington, (n=131, 15.1%). Of the events where location area was known (n=862, 99.6%), events were more likely to occur in industrial areas (n= 238, 27.6%), followed by commercial/residential areas (n=110, 12.8%). Most of the chlorine events (n=841, 97.2%) occurred at fixed facilities and 24 (2.8%) were transportation-related. Of the fixed-facility events where the area of occurrence was known (n=824, 98.0%), more than half occurred in three primary areas: 193 (23.4%) occurred from an above ground storage container; 173 (21.0%) occurred in piping, and 172 (20.9%) occurred from a process vessel. Of the 24 transportation-related events, 13 (54.2%) involved ground transport (i.e., truck, van, tractor) and 11 (45.8%) involved rail transport.

Most of the chlorine events were involved with the major industrial classification categories of *manufacturing*, (n=387, 44.7%), and *transportation, communications, and other public utilities*, (n=255, 29.5%) (Table 2). Of the *manufacturing* categorized events, 159 (41.1%) were classified under the sub-category *industrial and miscellaneous chemicals*, while 80 (20.7%) were classified under the sub-category *pulp, paper, and paperboard mills*. Of the *transportation, communications, and other public utilities* categorized events, 105 (41.2%) were classified under the sub-category *water supply and irrigation*, while 98 (38.4%) were under the sub-category *sanitary services*. Causal factors contributing to releases were known for 537 (62.1%) of the 865 chlorine events. The most frequent primary factors leading to events included equipment failure (n=364, 67.8%) and human error (n=99, 18.4%).

Victims, injuries, and personal protective equipment (PPE) usage

When compared with non-chlorine events, chlorine events exhibited the greatest significant risk of having events with victims (relative risk [RR] 4.5, 95% confidence interval [CI] 4.1 - 5.0) (Table 3). In the 865 chlorine events, 275 (31.8%) involved 1,071 victims. Of the 275 events with victims, 108 (39.3%) involved one victim and 167 (60.7%) had two or more victims. The number of victims per event ranged from one to 32. Of the victims where age and sex were recorded (n=691, 64.5% and n=883, 82.4%, respectively), the age range was one to 84 years old (median = 33.0) and 660 (74.7%) were male.

The population groups injured most frequently were employees (n=759, 70.9%) and the general public (n=235, 21.9%) (Table 4). Of all victims injured (n=1,071), there was a total of 1,654 injuries sustained (Table 5). Overall, the single most commonly reported injuries were respiratory irritation (n=930, 56.2%) and eye irritation (n=260, 15.7%). A large proportion of victims sustained more than one injury (n=354, 33.0%), with the number of injuries per victim ranging from one to seven. Most of the victims, (n=1,058, 98.8%), were injured in fixed-facility events. While the known health status of most chlorine victims was not severe (i.e., victims were treated on scene or treated at a hospital, but not admitted) (Table 6), chlorine victims had a greater likelihood of being admitted to a hospital when compared with non-chlorine victims (RR 1.6, CI 1.3 - 1.9). No deaths from chlorine events were reported.

The greatest number of victims were injured in the major industrial categories of *manufacturing* (n=397, 37.1%) and *entertainment and recreation services* (n=190, 17.7%) (Table 2). Of the victims injured in the *manufacturing* category,109 (27.5%) were sub-categorized as occurring in *pulp, paper, and paperboard mills,* and 109 (27.5%) injured victims were sub-categorized as occurring in *industrial and miscellaneous chemicals*. Of the victims injured in the *entertainment and recreation services* category, all 190 (100.0%) were sub-categorized as *miscellaneous entertainment and recreation services* injuries. It should be noted that the *elementary and secondary schools* sub-category—from the major industrial category *professional and related services*—was among the sub-categories with the highest number of events with victims (n=10 events, n=67 victims); most of these victims (n=39, 58.2%) were school employees (i.e., janitorial and maintenance staff).

PPE usage was analyzed for employees and first responders, which are groups who typically wear, or should at least have access to PPE. Of the 759 employees, PPE status at the time of injury was known for 662 employees (87.2%); 488 (73.7%) were not wearing PPE. Of the 174 employees wearing PPE, 31 (17.8%) were using eye protection and 25 (14.4%) were using a combination of gloves, eye protection, hard hat, and steel-toed shoes. Of all first responders where PPE status was known at the time of injury (n=72, 100.0%), 38 (52.8%) were not wearing PPE; these included mostly responders of unknown type (n=22) and police officers (n=10). Of all injured responders who were wearing PPE at the time of injury (n=34), the most frequently worn PPE was firefighter turn-out gear (n=24, 70.6%). Firefighter turn-out gear—which includes a self-contained breathing apparatus (SCBA), coat, pants, boots, and gloves— provides limited protection during fires only and is not effective in chemical spill situations (*7*).

Evacuations and decontaminations

Chlorine events were almost five times as likely to have involved evacuations of individuals when compared with non-chlorine events (RR 4.8, CI 4.3 - 5.3). Evacuation order status was known in 856 (99.0%) of the 865 chlorine events. Of the 856 events, 338 (39.5%) involved ordered evacuations, of which, 287 had a known number of evacuees. There were at least 20,469 known people evacuated, ranging from one to 1,840 people per event (median = 20.0). The events with the most individuals evacuated typically involved elementary and secondary schools. Evacuation duration was known in 272 (94.8%) of the 287 events with a known number of evacuees. The length of evacuations during these events ranged from one to 400 hours (median = 2.0).

Chlorine events were twice as likely to have involved decontamination of individuals when compared with non-chlorine events (RR 2.0, CI 1.7 - 2.4). Decontamination of potentially exposed individuals was necessary in 103 (11.9%) known events. A total of 517 individuals underwent decontamination; 298 (57.7%) were emergency responders, 175 (33.8%) were employees, and 44 (8.5%) were members of the general population. Most individuals (n=442, 85.5%) were decontaminated on the scene of the event.

Case vignettes

Pulp, paper, and paperboard mills event. In March 1993, a four inch joint pipeline gasket failed at a North Carolina paper/pulp mill allowing the release of 2,298 pounds of chlorine gas. Seventeen employees sustained respiratory irritation, eye irritation, and nausea. Fourteen of the employees were treated on-scene with first aid. Three employees were treated at a hospital, but were not admitted. All 17 employees were wearing gloves, eye protection, hard hats, and steel-toed shoes at the time of injury. Eighty employees were evacuated from the building for four hours while hazardous materials personnel responded.

Water supply and irrigation event. In August 1993, chlorine gas was released from a faulty hose as it was being transferred from a railcar to a Texas water treatment facility building. Twelve employees suffered respiratory irritation and went to a hospital for treatment; two of the 12 were admitted. None of the 12 employees was wearing PPE at the time of injury. Approximately 200 people were evacuated for two hours.

Miscellaneous entertainment and recreation services event. In May 1997, a malfunction in a chemical mixer for an indoor public swimming pool in Iowa caused a chlorine release in a room next to the pool. Six swimmers near the release, all teenagers or younger, sustained respiratory irritation and gastrointestinal problems (i.e., nausea, emesis) and were treated, but not admitted to a hospital. Forty-eight people in the pool building were evacuated for four hours.

Industrial and miscellaneous chemicals event. In January 1999, employees from a Missouri chemical repackaging plant were moving a one ton chlorine cylinder with a flatbed truck crane. The cylinder was accidentally dropped five feet to a snow and ice covered driveway, causing a six inch long breach in the container's seam. Twenty five people suffered respiratory and eye irritation, including two employees, one police officer, and 22 members of the general public. All 25 individuals were treated at a hospital, where one member of the general public was admitted. Approximately 150 employees and nearby residents were evacuated for seven hours. Eleven responders were decontaminated on the scene.

Elementary and secondary schools event. In January 2000, a Washington state high school maintenance worker discovered that a chlorine cylinder, used for the school swimming pool, was leaking inside a school building. The maintenance worker was able to stop the leak, but the air was already permeated with chlorine gas. Nine employees near the leak, including the maintenance worker and eight cafeteria workers, suffered a combination of respiratory irritation, eye irritation,

gastrointestinal problems, and dizziness or other central nervous system symptoms. More than 1,700 students were evacuated to the school parking lot for 45 minutes before being sent home.

Discussion

In the HSEES database, chlorine has consistently been among the top individual substances reported as released (*8-10*). Yet, from 1993 to 2000, the number of chlorine events has decreased (Table 1). It is unclear why this downward trend has occurred, particularly when new HSEES states were added during the period analyzed. Intuitively, one would have expected the number of chlorine events to have increased (as did the total number of events) as the number of participating states increased. Likewise, one would have expected the number of chlorine events to have increased as the overall US production of chlorine increased during 1993 to 2000 (*14*). Most of the downward trend in chlorine events can be attributed to a decline in events in four of the top five industry sub-categories: *industrial and miscellaneous chemicals*; *sanitary services*; *pulp, paper and paperboard mills*; and *miscellaneous entertainment and recreation services*. Some possible reasons for the decrease in these events may have included the pulp industry and various water treatment facilities switching from chlorine to alternative substances (i.e., ozone, hydrogen peroxide), the adoption of pollution controls, technological upgrades, safety improvements by chlor-alkali industries, and/or the implementation of risk management plans (RMPs) by industry under the regulation of the US Environmental Protection Agency (EPA) (*15-19*).

While a downward annual trend appears to have occurred during the period analyzed, certain chlorine events appear to follow seasonal trends as well. Overall, the number of chlorine events during 1993 to 2000 was highest from May through August, with a peak occurring in June. This peak can possibly be explained because it coincides with the beginning of summer when chlorine demand is high for certain industrial sectors. For example, *miscellaneous entertainment and recreation services*, one of the industry sub-categories with the most events with victims, includes swimming pools. Generally, the summer months are when pools are frequently being chlorinated, and when chlorine events with victims tend to peak. *Water supply and irrigation*, the other top chlorine industry sub-category with the most events with victims also appears to have a seasonal trend. This sub-category comprises of facilities primarily engaged in operating water supply systems for municipalities (i.e., water treatment facilities). During the summer months, public demand for water increases, which results in more frequent injuries among water treatment employees (i.e., exposure from a leaking gasket or while changing a cylinder regulator).

Chlorine events constantly indicated a higher proportion of events with victims each year when compared with non-chlorine events (average of 31.8% versus 7.1%, respectively) (Table 1). This high proportion of chlorine events with victims remained stable and changed very little over time. Although the substance categories *ammonia*, *acids*, and *pesticides* did have a statistically significant increased risk of having events with victims, chlorine had the greatest risk of having events with victims (Table 3). In comparison, other substance categories (i.e., *other inorganic substances, paints and dyes, volatile organic compounds*, and *polychlorinated biphenyls*) had a statistically significant decreased risk of having events with victims. Additionally, when compared to the substance category *ammonia*—another common gas—chlorine events were still more likely to have events

with victims (RR 2.4, CI 2.1-2.8), even though ammonia had many more events. While there were no chlorine victim deaths, of the 145 victims who died in non-chlorine-related events, almost two-thirds of victims sustained trauma-related injuries (Table 6). These deaths typically occurred in transportation events and events with fires and explosions; therefore, the substance released was not necessarily the direct cause of death.

Most of the victims from chlorine events were injured occupationally (Table 4), of which a high percentage were not wearing PPE at the time of injury. Employees tended to be exposed to chlorine in industries where it was produced or used. For example, the *water supply and irrigation* sub-category, which includes industries that use large quantities of chlorine daily, had the highest number of events with injured employees. First responders tended to be injured when arriving at events during and/or immediately after releases. The 24 first responders who were wearing turn-out gear at the time of injury were most likely not wearing their SCBA. Possible reasons for why PPE may not have been worn by employees and first responders include discomfort or beliefs that the PPE was not needed before the event occurred (20). Had the employee and first responder victims worn the appropriate PPE (*6*, *7*), many injuries may have been averted.

The general public tended to have been exposed to chlorine where it was used for recreational purposes (i.e., swimming pools). For example, the *miscellaneous entertainment and recreation services* sub-category had the highest number of events with general public victims. Typically, in these events, members of the general public were injured because of errors caused by an employee (i.e., improper mixing of chlorine for cleaning purposes) or because of equipment failure (i.e, malfunctioning swimming pool pump). In the two events that involved the four student victims (Table 4), one occurred at an elementary school and one at a high school. In the elementary school event, one student was injured while in close proximity to a release caused by janitorial staff. In the high school event, three students were injured when a chemistry teacher (also injured) opened an eight ounce bottle of chlorine gas while demonstrating physical properties.

The data presented in this analysis illustrates the usefulness of the HSEES system for capturing information about public health impacts from hazardous substances releases. However, there are some limitations to the system. First, while HSEES does capture more public health information on hazardous substances released than other federal databases (*21*), the reporting of events to participating HSEES states is not mandatory; therefore, participating states may not be informed about every event. Second, HSEES covers approximately one third of the US landmass and population and a has wide geographic distribution. However, the data for this report are from 16 states and may not adequately reflect the substances being released in non-participating states. Finally, each HSEES state has different minimum substance quantity reporting guidelines; therefore, small releases in some states may go unreported.

CONCLUSION

While the uses of chlorine are numerous, when mishandled, hazardous substances, such as chlorine, can have serious adverse public health consequences. Though the HSEES data indicate that the numbers of chlorine events are declining, chlorine events still cause a high percentage of events with

victims. Findings from this analysis suggest that certain public health actions can be taken by local government, industry, and first-responders to help reduce the number of chlorine-related injuries. For example, certain employee groups (i.e., employees in pulp/paper mill manufacturing and chemical manufacturing) and first responders were more likely to be exposed to chlorine. Personnel in these occupations could be targeted for proper hazmat training and appropriate PPE usage, where necessary. This analysis also found that equipment failure was the most frequent cause leading to an event. Therefore, thorough preventive maintenance on processing equipment that use chlorine and other hazardous substances should be routinely conducted. HSEES data also revealed that most events occurred within an industrial setting (i.e., manufacturing). This suggests that industries should attempt to utilize the latest technological advances for preventing and/or minimizing chlorine and other hazardous substances releases (i.e., electrochemical gas detectors, containment systems, treatment systems such as scrubbers and absorption tanks) (*22*). Additionally, industries should explore using alternatives to hazardous substances, where feasible. Finally, using information gathered from HSEES may help to pinpoint where potential releases of chlorine, and other hazardous materials, could occur in the future.

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Table 1

Distribution of chlorine events compared with non-chlorine HSEES events, by year. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Year	No. of participating states	Chlorine events*				Non-chlorine events†			
		Events	% of total	Events with victims	% of yearly events with victims§	Events	% of total	Events with victims	% of yearly events with victims§
1993	11	120	13.9	38	31.7	3365	8.3	368	10.9
1994	12	129	14.9	42	32.6	3654	9.0	316	8.6
1995	14	133	15.4	43	32.3	4809	11.8	302	6.3
1996	14	105	12.1	32	30.5	5120	12.6	302	5.9
1997	13	107	12.4	34	31.8	5142	12.7	284	5.5
1998	13	95	11.0	28	29.5	5620	13.8	301	5.4
1999	13	78	9.0	27	34.6	5933	14.6	408	6.9
2000	15	98	11.3	31	31.6	6963	17.1	591	8.5
Total	---	865	100.0	275	31.8	40,606	100.0	2872	7.1

* Includes events where only chlorine was involved.
† Includes non-chlorine events involving one substance only.
§ Number of events with victims ÷ number of events.

Table 2

Distribution of chlorine events and victims, by major industry category. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Major industry category	Events		Events with victims		No. of victims		Victims per event*
	No.	%	No.	%	No.	%	
Manufacturing	387	44.7	104	37.8	397	37.1	3.8
Transportation, communications, and other public utilities	255	29.5	59	21.5	124	11.6	2.1
Entertainment and recreation services	62	7.2	33	12.0	190	17.7	5.8
Professional and related services	31	3.6	15	5.5	91	8.5	6.1
Personal services	30	3.5	19	6.9	36	3.4	1.9
Wholesale trade	23	2.7	9	3.3	75	7.0	8.3
Retail trade	18	2.1	10	3.6	43	4.0	4.3
Public administration	18	2.1	9	3.3	49	4.6	5.4
Active duty military	9	1.0	1	0.4	26	2.4	26.0
Business and repair services	8	0.9	4	1.5	12	1.1	3.0
Construction	5	0.6	0	0.0	0	0.0	0.0
Finance, insurance, and real estate	4	0.5	3	1.1	9	0.8	3.0
Mining	2	0.2	1	0.4	1	0.1	1.0
Agriculture, forestry, and fisheries	1	0.1	1	0.4	6	0.6	6.0
Unknown industry	12	1.4	7	2.5	12	1.1	1.7
Total	865	100.0	275	100.0	1071	100.0	3.9

* Number of victims ÷ number of events with victims.

Table 3

Distribution of all events and a univariate analysis of events with victims, by substance category. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Hazardous substance category	Events		Events with victims				Proportion of events with victims
	No.	% of total	No.	% of total	Relative Risk*	95% Confidence Interval	
Chlorine	865	2.1	275	8.7	4.5	4.1 - 5.0§	31.8
Ammonia	2845	6.9	376	11.9	1.8	1.7 - 2.0§	13.2
Acids	3716	9.0	440	14.0	1.7	1.5 - 1.8§	11.8
Pesticides	1940	4.7	223	7.1	1.6	1.4 - 1.8§	11.5
Bases	1567	3.8	114	3.6	1.0	0.8 - 1.2	7.3
Other	8315	20.1	584	18.6	0.9	0.8 - 1.0	7.0
Mixtures across categories	3971	9.6	259	8.2	0.9	0.8 - 1.0	6.5
Other inorganic substances	8567	20.7	514	16.3	0.8	0.7 - 0.8§	6.0
Paints and dyes	1011	2.4	41	1.3	0.5	0.4 - 0.7§	4.1
Volatile organic compounds	7751	18.7	311	9.9	0.5	0.4 - 0.5§	4.0
Polychlorinated biphenyls	923	2.2	10	0.3	0.1	0.1 - 0.3§	1.1
Total	41,471¶	100.0	3147	100.0	---	---	7.6

* Comparison of substance category victim events with victim events in all other substance categories.
† Calculated by taking events with victims ÷ events.
§ Statistically significant at 0.05.
¶ Includes events where only one substance was involved (n=41,471/44,164, 93.9%).

Table 4

Distribution of chlorine event victims, by population group. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Population group	No.	%
Employee	759	70.9
General Public	235	21.9
Responder, unknown type*	47	4.4
Police officer	10	0.9
Professional firefighter	9	0.8
Hospital personnel	4	0.4
Student	4	0.4
EMT personnel	2	0.2
Unknown	1	0.1
Total	1071	100.0

* First responders were not categorized by responder type before 1995; therefore, responder victims from 1993-1994 were grouped in “Responder, unknown type.”

Table 5

Distribution of injuries sustained during chlorine events. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Injuries	No.	%
Respiratory irritation	930	56.2
Eye irritation	260	15.7
Gastrointestinal problems*	151	9.1
Dizziness/CNS† symptoms	96	5.8
Skin irritation	61	3.7
Headache	54	3.3
Shortness of breath	42	2.5
Chemical burns	21	1.3
Heart problems	10	0.6
Heat stress	4	0.2
Trauma§	4	0.2
Other¶	21	1.3
Total	1654‡	100.0

* i.e., nausea, vomiting.

† Central nervous system.

§ Trauma may have been caused by the sequence of events (i.e., motor vehicle accident) leading to the release of a hazardous substance, and not necessarily by exposure to the hazardous substance itself.

¶ Includes symptoms such as chest tightness, allergic reaction, bitter taste in mouth, etc.

‡ The number of injuries (n=1,654) exceeds the number of victims (n=1,071) because a victim can have multiple injuries.

Table 6

The health outcome of chlorine victims compared with non-chlorine victims. Hazardous Substances Emergency Events Surveillance, 1993–2000.

Severity	Chlorine victims		Non-chlorine victims	
	No.	%	No.	%
Treated at hospital, not admitted	677	63.2	7359	61.1
Treated on scene	166	15.5	2198	18.3
Treated at hospital, admitted	105	9.8	758	6.3
Transported to hospital for observations, no treatment	72	6.7	682	5.7
Seen by private physician within 24 hours of event	36	3.4	583	4.8
Injuries experienced within 24 hours of event and reported by an official*	10	0.9	300	2.5
Death	0	0.0	145	1.2
Unknown	5	0.5	16	0.1
Total	1071	100.0	12,041	100.0

* i.e., police officer, EMT, poison control center operator.