Acute Illness and Injury from Swimming Pool Disinfectants and Other Chemicals — United States, 2002–2008

Swimming pools require disinfectants and other chemicals to maintain water quality and prevent swimmers from acquiring infections (*1*). When these chemicals are stored or used improperly or when they are handled or applied by persons not using appropriate personal protective equipment (PPE), illness or injury can result (*2*). To assess the frequency of illness and injury related to pool chemicals, CDC analyzed data for the period 2002–2008 from six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides surveillance program and from the National Electronic Injury Surveillance System (NEISS). This report describes the results of that analysis, which identified 584 cases of illness or injury associated with pool chemicals in the six SENSOR-Pesticides states and indicated an estimated national total of 28,071 cases (based on 688 NEISS cases) during that period. For the 77% of state cases and 49% of NEISS cases that had sufficient information to determine factors contributing to illness or injury, the most common contributing factors included mixing incompatible products, spills and splashes of chemicals, lack of appropriate PPE use, and dust clouds or fumes generated by opening a chemical container. Adhering to existing CDC recommendations can prevent some of the reported illnesses and injuries, but additional measures (e.g., improving package design to limit the release of dust clouds and fumes when a container is opened, making containers child-proof, and making product labels easier to understand) might reduce them further.

In the six SENSOR-Pesticides states (California, Iowa, Louisiana, Michigan, North Carolina, and Texas),* a case of poisoning associated with pool disinfectants was defined as two or more acute adverse health effects resulting from exposure to any pool disinfectant. Cases were categorized by certainty of exposure, reported health effects, and consistency of health effects with known toxicology of the chemical (*3*) (Table 1). State cases categorized as definite, probable, possible, and suspicious and California Department of Pesticide Regulation cases categorized as definite, probable, and possible were included in the analysis. NEISS cases† were those involving exposure to swimming pool chemicals (product code 938). State cases were excluded if the event occurred during crop farming activities. Neither state nor NEISS cases were included if the illness or injury was not directly caused by pool chemicals.§ Data were analyzed for demographic characteristics, event location, health effects, outcomes (e.g., hospitalization), and factors contributing to illness or injury. Data from the SENSOR-Pesticides states also were analyzed for reporting source, illness or injury severity,¶ chemical toxicity,** active ingredients, work-relatedness, and time lost from work.

For the period 2002–2008, a total of 584 cases were identified in the six SENSOR-Pesticides states (Table 2); most cases occurred in California (306 [52%]). Most cases reported by the states (65%) were identified through poison control centers, followed by cases indentified from workers' compensation claims (28%). The number of cases from NEISS for the period 2002–2008 was 688, which yields a weighted national estimate of 28,071 cases (Table 2). A substantial

* Currently, 12 states conduct surveillance of pesticide-related illness and injury, and these states comprise the SENSOR-Pesticides program. Of these states, only California, Louisiana, Michigan, and Texas collected data on illnesses and injuries related to disinfectants for the period 2002–2008. The North Carolina Department of Health and Human Services Division of Public Health began collecting data on illnesses and injuries related to disinfectants in 2008. The Iowa Department of Public Health has a collaborative relationship with the poison control centers in Iowa and was able to identify pesticide poisoning cases associated with swimming pool disinfectants for the period 2005–2008. The California Department of Public Health provided data for the period 2006–2008 (14 cases), and the California Department of Pesticide Regulation provided data for the period 2002–2008 (292 cases). The numbers of cases contributed by each state were as follows: California, 306; Louisiana, 138; Texas, 57; Michigan, 43; North Carolina, 25; and Iowa, 15.

† NEISS is a probability sample of emergency departments based on a sampling frame of 100 emergency departments in the United States and its territories. Each case is assigned a weight based on the sample design. The national estimate is the sum of weights.

§ NEISS cases that did not meet the case definition for inclusion in this analysis did not directly involve the pool chemical, did not have acute symptoms related to pool chemicals, or involved intentional exposure (e.g., drug use). Examples of cases that were excluded include a case in a person who injured his back while lifting a bucket of pool chlorine, a case in a person who sprained their ankle when they fell into the pool while adding pool chemicals to the pool water, cases in persons who had symptoms because they were drowning, cases in persons who lived in a home where chlorine, fertilizer, or muriatic acid was stored but did not have any symptoms, and cases in other persons whose illnesses or injuries did not directly involve pool chemicals or for whom no symptoms after exposure were reported. A total of 55 NEISS cases with product code 938 occurred during 2002–2008 that did not meet the case definition for this analysis. If these cases were included, the national estimate for illnesses and injuries associated with pool chemicals during that period would be 30,235 cases.

¶ Severity of illness or injury of cases was categorized into four groups using standardized criteria for state-based surveillance programs. In low-severity cases, illness or injury usually resolves without treatment and <3 days are lost from work. In moderate-severity cases, illness or injury is non–life-threatening but requires medical treatment and <6 days are lost from work. In high-severity cases, illness or injury is life-threatening and requires hospitalization and >5 days are lost from work. The category for fatal poisonings is death.

** The toxicity category of a pesticide is determined by the Environmental Protection Agency under guidance from Code of Federal Regulations Title 40 Part 156. Pesticides in category I have the greatest toxicity, and pesticides in category IV have the least toxicity.

TABLE 1. Case classification matrix for acute illnesses and injuries associated with pool disinfectants — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states, 2002–2008

Classification criteria†	Classification category*				
	Definite	Probable		Possible	Suspicious
Exposure	1	1	2	2	1 or 2
Health effects	1	2	1	2	1 or 2
Causal relationship	1	1	1	1	4

Source: CDC. Case definition for acute pesticide-related illness and injury cases reportable to the national public health surveillance system. Cincinnati, OH: US Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health; 2005. Available at http://www.cdc.gov/niosh/topics/pesticides/pdfs/casedef2003_revapr2005.pdf.

* Case classifications are slightly different between the SENSOR-Pesticides program and the California Department of Pesticide Regulation (CDPR) Pesticide Illness Surveillance system. CDPR classifies cases as definite, probable, and possible based on the relationship between exposure and health effects: definite = both physical (e.g., disinfectant residue on clothing) and medical evidence document exposure and consequent health effects; probable = limited or circumstantial evidence supports a relationship to pesticide exposure; and possible = evidence neither supports nor contradicts a relationship. Additional information available at http://www.cdpr.ca.gov/docs/whs/pisp/brochure.pdf.

† Cases are classified as definite, probable, possible, or suspicious based on scores for exposure, health effects, and causal relationship. Exposure score: 1 = laboratory, clinical, or environmental evidence for exposure; 2 = evidence of exposure based solely on written or oral report from the patient, a witness, or applicator. Health effects scores: 1 = two or more new postexposure signs or laboratory findings reported by a licensed health professional; 2 = two or more postexposure symptoms reported by the patient. Causal relationship scores: 1 = the observed health effects are consistent with the known toxicology of the disinfectant; 4 = insufficient toxicologic information available to determine the causal relationship.

What is already known on this topic?

Swimming pools require frequent application of disinfectants and other pool chemicals, and exposure to these chemicals can cause illness and injury.

What is added by this report?

During 2002–2008, an estimated 28,071 cases of illness or injury associated with pool disinfectants and other pool chemicals occurred nationally (an average of 4,010 cases per year). Most cases occurred at private residences. In the six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides surveillance program, 40% of cases were work-related, 9% of which involved loss of 1 or more days from work. The most frequently identified causes of illness or injury were mixing incompatible chemicals, spills and splashes of pool chemicals, lack of appropriate personal protective equipment (PPE) use, lack of proper training and supervision, and dust clouds or fumes generated by opening a pool chemical container.

What are the implications for public health practice?

Some of the identified illnesses and injuries resulted from failure to follow CDC recommendations to prevent illnesses and injuries associated with pool chemicals. Additional measures to reduce exposures to pool chemicals that are suggested by these findings include altering pool chemical container design and modifying labels to make them easier to understand, including using pictograms to depict appropriate PPE use.

proportion of cases were in children aged <15 years (25% of state cases and 34% of NEISS cases). Cases were most frequently poisonings at private residences (48% of state cases and 56% of NEISS cases) followed by nonmanufacturing facilities, which included hotels, health clubs, and other facilities (28% of state cases and 14% of NEISS cases). Symptoms most frequently reported were respiratory symptoms, such as cough, upper respiratory irritation, and dyspnea (65% of state cases and 24% of NEISS cases), eye injuries (33% of state cases and 42% of NEISS cases), and skin injuries (18% of state cases and 19% of NEISS cases). In the six SENSOR-Pesticides states, the active ingredients most frequently associated with acute illness or injury were sodium hypochlorite (31%), triazine compounds (22%), and calcium hypochlorite (16%). Most of the disinfectants were toxicity category I (87%). The majority of state cases (85%) involved low-severity illnesses or injuries. Forty percent of state cases were work-related, 9% of which involved loss of 1 or more days from work. A small proportion of cases involved hospitalization (2% of state cases and 4% of NEISS cases).

Factors most frequently associated with illness or injury included mixing incompatible products (21% of state cases and 6% of NEISS cases), spills and splashes of pool chemicals (18% of state cases and 33% of NEISS cases), and dust clouds or fumes generated by opening a chemical container (15% of state and NEISS cases) (Table 3). Factors that contributed to worker illness or injury included spills and splashes of liquid or dust (33%), lack of appropriate PPE use (24%), and equipment failure (19%). Among state and NEISS cases, 9% occurred when a child gained access to chemicals not securely stored, and 6% of state cases and 2% of NEISS cases involved other improper storage. Of cases that involved storage within reach of a child, 14% of state cases involved children aged 4–11 years who opened containers.

Five high-severity cases were identified by the six SENSOR-Pesticides states. One case occurred in a man aged 39 years in Louisiana with no pertinent medical history. He was in a public recreational swimming pool when chlorine was added to shock chlorinate it. He inhaled fumes and developed nausea, headache, cough, upper respiratory irritation, dyspnea, wheezing, hypoxia, and tachycardia. He was diagnosed with chlorine inhalation and ingestion, and was hospitalized for 4 days. The second case occurred in a boy aged 5 years in Louisiana who stuck his face in a bucket of pool shock treatment (65% calcium hypochlorite). Cyanosis and dyspnea were documented, and the boy was admitted to the critical-care unit, where he was hospitalized for 4 days. The third case involved a previously healthy woman aged 61

TABLE 2. Number and percentage of acute illnesses and injuries associated with pool chemicals, by selected characteristics — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states and the National Electronic Injury Surveillance System (NEISS), 2002–2008*

Characteristic	SENSOR states No.	SENSOR states (%)†	NEISS No.	NEISS U.S. estimate§	NEISS (%)†
Total cases	**584**	**(100)**	**688**	**28,071**	**—**
Year of exposure					
2002	103	(18)	95	3,753	(13)
2003	49	(8)	116	4,813	(17)
2004	42	(7)	64	3,111	(11)
2005	45	(8)	121	4,015	(14)
2006	97	(17)	79	3,507	(12)
2007	99	(17)	109	4,508	(16)
2008	149	(26)	104	4,364	(16)
Age group (yrs)					
0–5	43	(7)	109	3,619	(13)
6–14	106	(18)	186	5,960	(21)
15–24	121	(21)	89	3,580	(13)
25–44	175	(30)	171	8,389	(30)
≥45	125	(21)	133	6,523	(23)
Unknown	14	(2)	—	—	—
Sex					
Male	360	(62)	388	15,986	(57)
Female	218	(37)	300	12,086	(43)
Unknown	6	(1)	—	—	—
Status					
Definite	89	(15)	—	—	—
Probable	246	(42)	—	—	—
Possible	246	(42)	—	—	—
Suspicious	3	(1)	—	—	—
Work-related					
Yes	233	(40)	—	—	—
Lost time from work					
Yes	51	(9)	—	—	—
Reporting source					
Physician report	32	(5)	—	—	—
Poison control center	377	(65)	—	—	—
Workers' compensation	165	(28)	—	—	—
State health department	4	(1)	—	—	—
Other	6	(1)	—	—	—
Event location					
Agriculture¶	1	(<1)	—	—	—
Private residence	281	(48)	339	15,699	(56)
Institutions	29	(5)	3	115	(<1)
Manufacturing facility	2	(<1)	—	—	—
Nonmanufacturing facility	161	(28)	145	4,021	(14)
Other	68	(12)	—	—	—
Unknown/Missing	42	(7)	201	8,236	(29)
Toxicity**					
I-Danger	510	(87)	—	—	—
II-Warning	5	(1)	—	—	—
III-Caution	6	(1)	—	—	—
Missing/Unknown	63	(11)	—	—	—

TABLE 2. (*Continued*) Number and percentage of acute illnesses and injuries associated with pool chemicals, by selected characteristics — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states and the National Electronic Injury Surveillance System (NEISS), 2002–2008*

Characteristic	SENSOR states No.	SENSOR states (%)†	NEISS No.	NEISS U.S. estimate§	NEISS (%)†
Active ingredient†† §§					
Sodium hypochlorite	189	(31)	—	—	—
Triazines	133	(22)	—	—	—
Calcium hypochlorite	99	(16)	—	—	—
Chlorine	72	(12)	—	—	—
Other	111	(18)	—	—	—
Illness severity					
Fatal	—	—	—	—	—
High	5	(1)	—	—	—
Moderate	78	(13)	—	—	—
Low	499	(85)	—	—	—
Missing/Unknown	2	(<1)	—	—	—
Body part/System affected †† ¶¶					
Respiratory	379	(65)	193	6,846	(24)
Eye	194	(33)	271	11,813	(42)
Skin	103	(18)	125	5,216	(19)
Neurologic	94	(16)	24	732	(3)
Gastrointestinal	95	(16)	59	1,686	(6)
Cardiovascular	28	(5)	6	256	(1)
Other	18	(3)	6	333	(1)
Unknown	—	—	57	2,592	(9)
Hospitalization					
Yes	14	(2)	32	1,062	(4)

* Case classifications are slightly different between the SENSOR-Pesticides program and the California Department of Pesticide Regulation (CDPR) Pesticide Illness Surveillance system. CDPR classifies cases as definite, probable, and possible based on the relationship between exposure and health effects: definite = both physical (e.g., disinfectant residue on clothing) and medical evidence document exposure and consequent health effects; probable = limited or circumstantial evidence supports a relationship to pesticide exposure; and possible = evidence neither supports nor contradicts a relationship. Additional information available at http://www.cdpr.ca.gov/docs/whs/pisp/brochure.pdf.

† Percentages might not sum to 100 because of rounding.

§ Weighted national estimate.

¶ The injury occurred when a horse ranch maintenance worker applied chlorine to a pool for horses.

** Toxicity categories are classified by the Environmental Protection Agency based on established criteria, with I being the most toxic and IV the least.

†† The total might exceed the number of cases because multiple active ingredients or body parts/systems might have been involved in a single case.

§§ Information was not available to identify active ingredients in 19 cases in the six SENSOR-Pesticides states.

¶¶ Symptoms were derived from narratives of the illness or injury included in the NEISS dataset and were coded using SENSOR criteria. Narratives that lacked specific symptoms were coded as "Unknown."

TABLE 3. Number and percentage of acute illnesses and injuries associated with pool chemicals, by contributing factor — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states and the National Electronic Injury Surveillance System (NEISS), 2002–2008*

	SENSOR states						NEISS[§]		
	Total		Workers		Nonworkers				
Contributing factor[†]	No.[¶]	(%)	No.[¶]	(%)	No.[¶]	(%)	No.[¶]	U.S. estimate**	(%)
One or more contributing factors identified[††]	451	—	183	—	267	—	335	14,412	—
Mixing incompatible products	94	(21)	21	(11)	73	(27)	21	832	(6)
Spill or splash of liquid or dust	80	(18)	61	(33)	19	(7)	90	4,728	(33)
Required PPE not worn/PPE inadequate	75	(17)	44	(24)	31	(12)	—	—	—
Not properly trained or supervised	68	(15)	19	(10)	49	(18)	—	—	—
Application equipment failure	50	(11)	35	(19)	15	(6)	19	301	(2)
Dust cloud or fumes generated upon opening container	68	(15)	13	(7)	55	(21)	39	2,164	(15)
Stored within reach of child	42	(9)	—	—	42	(16)	41	1,359	(9)
Other improper storage	29	(6)	13	(7)	16	(6)	9	343	(2)
Exposure to fumes/dust during application	30	(7)	10	(5)	20	(7)	31	1,636	(11)
Illegal pesticide used/Illegal dumping	12	(3)	12	(7)	—	—	—	—	—
Inadequate ventilation	12	(3)	5	(3)	7	(3)	41	946	(7)
Decontamination not adequate or timely	8	(2)	7	(4)	1	(<1)	8	329	(2)
Early reentry	5	(1)	2	(1)	3	(1)	25	1,369	(10)
Persons in treated area	8	(2)	2	(1)	6	(2)	10	479	(3)
Excessive application	10	(2)	4	(2)	6	(2)	23	817	(6)
Label violation not otherwise specified	8	(2)	3	(2)	5	(2)	1	77	(1)
Person poisoned but no label violation identified	8	(2)	6	(3)	2	(1)	—	—	—

Abbreviation: PPE = personal protective equipment.

* Case classifications are slightly different between the SENSOR-Pesticides program and the California Department of Pesticide Regulation (CDPR) Pesticide Illness Surveillance system. CDPR classifies cases as definite, probable, and possible based on the relationship between exposure and health effects: definite = both physical (e.g., disinfectant residue on clothing) and medical evidence document exposure and consequent health effects; probable = limited or circumstantial evidence supports a relationship to pesticide exposure; and possible = evidence neither supports nor contradicts a relationship. Additional information available at http://www.cdpr.ca.gov/docs/whs/pisp/brochure.pdf.

† For 133 cases (23%) in the six SENSOR-Pesticides states and 353 (51%) cases in NEISS, information was not available to determine contributing factors.

§ Because there was no product-identifying information available in NEISS, label information about directions for use and required PPE could not be determined.

¶ A case can have multiple contributing factors that resulted in illness or injury; thus, the sum of the categories exceed the total number of cases with sufficient information to determine contributing factors, and the total percentage exceeds 100%.

** Weighted national estimate.

†† The denominator for the proportions was the total cases that had sufficient information to determine contributing factors.

years in California who mixed two pool chemicals, calcium hypochlorite and cyanuric acid, in her kitchen sink. The chemicals reacted and created fumes in the poorly ventilated kitchen. She reported cough, upper respiratory irritation, and dyspnea, and was treated with oxygen. The next day, she was wheezing and was diagnosed with pulmonary edema and hospitalized for 6 days. The fourth case occurred in a woman aged 42 years in Iowa who had asthma. She inhaled dust while applying chlorinating granules, resulting in cough, dyspnea, and lower respiratory pain and irritation. She received a diagnosis of asthma exacerbation caused by chemical exposure and was admitted to an intensive-care unit, where she was hospitalized for 4 days. The fifth case occurred in a woman aged 54 years in Michigan who had allergies. She was exposed to chlorine fumes when an excessive amount of chlorine was added to a pool in which she was swimming. She had cough, dyspnea, wheezing, and vomiting. She received a diagnosis of chemical pneumonitis and was hospitalized for 7 days.

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Editorial Note

Chlorine-based disinfectants are the most commonly used disinfectants for treating swimming pool water. A total of 36 pool chemical–associated events were reported in New York during 1983–2007, of which 31 events were attributed to

chlorine gas exposure, which most often resulted from mixing sodium hypochlorite solutions (e.g., household chlorine bleach) with acid (*4*). In England and Wales, 13 events involving pool chemicals were reported during June–October 2007, of which 10 events involved sodium hypochlorite and nine events resulted from equipment failure or mixing incompatible chemicals (*5*). Several individual cases of illness or injury attributed to pool disinfectants have been reported and include respiratory illness and eye and skin injury (*6,7*).

The findings in this report are subject to at least five limitations. First, illnesses and injuries related to pool chemicals likely are underreported. Case identification by states relies on a passive surveillance system, so cases in persons experiencing minor symptoms who do not seek medical treatment or advice from poison control centers are not reported. Also, cases reported in NEISS only involve persons who sought treatment in a hospital emergency department. Second, cases might have been excluded because insufficient information was provided to meet the case definition. Third, symptoms for illness or injury associated with pool chemicals are nonspecific and not pathognomonic, so false-positives might have occurred. Fourth, some cases that were not work-related might have been missed in Iowa, Louisiana, Michigan, North Carolina, and Texas because CDC's National Institute for Occupational Safety and Health advises these states to prioritize work-related cases when staffing limitations preclude follow-up of all cases. Finally, the NEISS dataset had limited information, which for some cases precluded the identification of symptoms and contributing factors. Furthermore, no product-identifying information was available in NEISS. Thus, whether illnesses and injuries were caused by nondisinfectant pool chemicals or whether noncompliance with product labels contributed to the reported illnesses and injuries could not be determined. However, most NEISS cases are thought to be disinfectant-related, based on the pool chemical–associated events reported in New York and England and Wales (*4,5*). Pool disinfectant byproducts, such as chloramines, are responsible for many illnesses and injuries reported (*8–10*). No cases from the six SENSOR-Pesticides states were attributed to chloramines; however, chloramines might have contributed to some NEISS injuries, but their involvement could not be discerned given the limited product and event information.

Current CDC recommendations to reduce illness and injury from pool chemicals, including disinfectants, are available at http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html. These recommendations address contributing factors related to application equipment failure, storage within reach of a child and other improper storage, illegal dumping, and inadequate PPE used by workers. In addition to the existing CDC recommendations, the findings described in this report suggest that pool chemical manufacturers should design containers so that dust clouds or fumes are minimized when containers are opened and should make the containers child-proof. Label information on appropriate PPE usage should be easy to find and understand; the addition of pictograms depicting appropriate PPE might increase the likelihood of correct use. Instructions for consumers to point the container away from their face while opening might also reduce illness and injury from pool chemicals.

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