

## Risk Factors for Hazardous Substance Releases That Result in Injuries and Evacuations: Data from 9 States

### ABSTRACT

This study was undertaken to determine risk factors associated with hazardous substance releases (at fixed facilities or during transport) that have public health consequences. Data from nine states with surveillance systems for such releases and their consequences were analyzed. Risk factors were determined for releases resulting in (1) injuries or (2) evacuations. Both outcomes were more likely to occur as a result of facility releases (odds ratio [OR] = 1.89, 95% confidence interval [CI] = 1.44, 2.47, for injuries; OR = 3.29, 95% CI = 2.28, 4.74, for evacuations). Releases of ammonia, chlorine, and acids resulted in injuries and evacuations more frequently than releases of other substances. (*Am J Public Health*. 1996;86:855-857)

H. Irene Hall, PhD, Gilbert S. Haugh, MS, Patricia A. Price-Green, MSPH, V. Ramana Dhara, MD, and Wendy E. Kaye, PhD

### Introduction

Releases of hazardous substances are a major public health concern since they can potentially cause widespread morbidity and mortality as well as evacuations. Major unplanned releases—such as those in Bhopal, India; Seveso, Italy; and Chernobyl, Ukraine—have received worldwide attention. There are, however, many smaller and less publicized unplanned hazardous substance releases, an estimated 15% of which result in morbidity and mortality. In about 13% of all releases, people are evacuated.<sup>1</sup>

Many anecdotal accounts of hazardous substance releases are found in the literature,<sup>2-4</sup> as well as commentaries regarding the incidents and medical preventions, preparedness, and responses.<sup>3,5-11</sup> Few systematic studies have been conducted with representative samples to describe the number of events occurring in a defined geographic area and their characteristics. No study has been reported that assessed the risk factors for hazardous substance releases that result in public health consequences.

Potential risk factors for hazardous substance releases resulting in injuries and evacuations might include the location, the substances released, and the time of the releases. Most releases of hazardous substances occur at fixed facilities rather than during transportation. The most commonly released substances are ammonia, pesticides, volatile organic compounds, acids, and petroleum products.<sup>1,5,12,13</sup> On the basis of anecdotal evidence of major chemical accidents, it has been hypothesized that releases most likely occur on weekends.<sup>4</sup> A seasonal variation in the number of releases has also been reported, with a peak incidence in June.<sup>12</sup>

To determine whether these factors are associated with hazardous substance releases resulting in public health consequences, we analyzed data from a surveillance system of such releases.

### Materials and Methods

The Agency for Toxic Substances and Disease Registry has maintained the Hazardous Substances Emergency Events Surveillance system since January 1, 1990. This active, state-based system was implemented because no other reporting system collected adequate information to determine the public health consequences associated with hazardous substance releases.<sup>14-16</sup> During the first 2 years, five state health departments participated in the surveillance. The number of participating states increased to nine in 1992 (Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin).

State health departments apply for funds and are funded through cooperative agreements. At least one full-time staff person per state actively investigates all hazardous substance releases occurring in the state. Sources of information include the personnel and records of state environmental agencies, local emergency planning committees, fire and police depart-

H. Irene Hall, Patricia A. Price-Green, V. Ramana Dhara, and Wendy E. Kaye are with the Agency for Toxic Substances and Disease Registry, Public Health Service, Atlanta, Ga. Gilbert S. Haugh is with The Orkand Corp, Atlanta.

Requests for reprints should be sent to H. Irene Hall, PhD, Centers for Disease Control and Prevention, NCCDPHP, DCPC, K-55, 4770 Buford Hwy NE, Atlanta, GA 30341.

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**TABLE 1—Factors Associated with Hazardous Substance Releases Resulting in Injuries, in Selected States: Hazardous Substances Emergency Events Surveillance System, 1990 through 1992**

Substance Category	No. Events	% Involving Injuries	Crude Odds Ratio	Adjusted Odds Ratio <sup>a</sup>	95% Confidence Interval
Acid					
Yes	450	20.9	1.76	1.75	1.35, 2.26
No <sup>b</sup>	2439	13.1			
Ammonia					
Yes	424	22.6	1.98	1.93	1.49, 2.50
No <sup>b</sup>	2465	12.9			
Chlorine					
Yes	138	24.6	2.05	1.82	1.21, 2.73
No <sup>b</sup>	2751	13.8			
Acid, ammonia, or chlorine					
Yes	1012	22.1	2.54	2.45	1.98, 3.03
No <sup>b</sup>	1877	10.1			

Note. Releases involving substances from more than one substance category were not included. During 1990/91, participating states included Colorado, Iowa, Michigan, New Hampshire, and Wisconsin. During 1992, participating states included Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

<sup>a</sup>Adjusted for the type of event (fixed facility or transportation).

<sup>b</sup>Releases not involving the substance category listed.

**TABLE 2—Factors Associated with Hazardous Substance Releases Resulting in Evacuations, in Selected States: Hazardous Substances Emergency Events Surveillance, 1990 through 1992**

Substance Category	No. Events	% Involving Evacuations	Crude Odds Ratio	Adjusted Odds Ratio <sup>a</sup>	95% Confidence Interval
Ammonia					
Yes	297	34.3	3.68	3.64	2.77, 4.80
No <sup>b</sup>	2106	12.4			
Chlorine					
Yes	125	28.8	2.41	2.20	1.35, 3.04
No <sup>b</sup>	2278	14.4			
Ammonia or chlorine					
Yes	422	32.7	3.77	3.53	2.75, 4.52
No <sup>b</sup>	1981	11.4			

Note. Releases involving substances from more than one substance category were not included. During 1990/91, participating states included Colorado, Iowa, Michigan, New Hampshire, and Wisconsin. During 1992, participating states included Colorado, Iowa, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Washington, and Wisconsin.

<sup>a</sup>Adjusted for the type of event (fixed facility or transportation).

<sup>b</sup>Releases not involving the substance category listed.

this threat leads to an action such as an evacuation. About 2% of the reported releases are threatened releases.

Releases are defined as transportation related when they have occurred during surface, air, or water transport. Fixed-facility releases are defined as releases occurring at industrial sites, schools, farms, or any other permanent location. An evacuation is defined as an event in which an official, such as the incident commander, orders people to leave their homes or work.

Hazardous Substances Emergency Events Surveillance system data for the years 1990 through 1992 were analyzed. Chi-square analyses were conducted to test the associations between the factors of interest and the outcomes of (1) whether a hazardous substance release resulted in personal injury and (2) whether a release resulted in an evacuation. Crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to determine the magnitude of the associations.

The substances released were grouped into nine categories: acids, ammonia, bases, chlorine, other inorganic substances, pesticides, polychlorinated biphenyls, volatile organic compounds, and unclassified (substances that could not be grouped into the other eight categories). The potential risk factors assessed were the location of the release; the time, day, and month in which the release occurred; the type of substance released; and whether multiple substances were released.

## Results

A total of 3125 hazardous substance releases were reported to the Hazardous Substances Emergency Events Surveillance system from January 1, 1990, through December 31, 1992. During 467 (15%) of these releases, 1446 persons were injured. Of 2545 releases for which information was available, 400 (16%) resulted in evacuations.

Most releases, 2391 (77%), occurred at fixed facilities, and 723 (23%) were transportation related. The location was not known for 11 releases.

More than twice as many releases (an average of 538) occurred on weekdays as on weekend days (an average of 219), and most releases (75%) occurred during the daytime hours from 6 AM to 6 PM. The monthly number of releases peaked in May (461), and the lowest number of releases occurred in February (178).

ments, and hospitals. The data collection form and the dBASE<sup>17</sup> data entry program, designed by the Agency for Toxic Substances and Disease Registry, ensure uniform reporting. The data are sent to the agency quarterly, and their data quality control procedures and analyses are conducted.

Hazardous substances emergency events are defined as uncontrolled or illegal releases or threatened releases of

substances or their hazardous by-products. The reportable substances are the 200 substances found to be the most hazardous at Superfund sites,<sup>18</sup> all pesticides, chlorine, sodium hydroxide, and hydrochloric, nitric, phosphoric, acrylic, and hydrofluoric acids. Releases are included when the amount released needs to be cleaned up according to federal, state, or local law. A threatened release of one of the substances is to be reported if

The substances most frequently involved in all releases and in releases with public health consequences were acids, ammonia, pesticides, and volatile organic compounds.

In 371 (12%) of the releases, more than one substance was released. Releases of multiple substances were more likely than releases of only one substance to result in personal injuries (OR = 1.53, 95% CI = 1.16, 2.01) and evacuations (OR = 1.84, 95% CI = 1.33, 2.55). However, in examinations of the risk factors for releases resulting in evacuations and injuries, only single substance releases or multiple substance releases from within the same substance category were included.

In 2889 releases, only substances from a single substance category were released, and complete data were available on all variables of interest for analyzing releases resulting in injuries. More people were injured in fixed-facility releases (OR = 1.89, 95% CI = 1.44, 2.47) than in transportation-related releases. Releases of acids, ammonia, and chlorine resulted in significantly higher proportions of releases involving injuries than all other releases (Table 1).

More releases involving personal injuries occurred in April and May than in any other month; however, no clear seasonal variation in the proportion of releases resulting in injuries was found. None of the other factors (such as time of day or day of week) were associated with releases resulting in personal injuries.

In 2403 releases, only substances from a single substance category were released, and complete data were available for all variables of interest for analyzing releases involving evacuations. Releases of ammonia and chlorine were more likely to result in evacuations than all other types of releases. Evacuations were more likely a result of fixed-facility releases (OR = 3.29, 95% CI = 2.28, 4.74) (Table 2). None of the other factors (such as time of day or day of week) were associated with releases resulting in evacuations.

## Discussion

The purpose of this study was to determine risk factors for hazardous substance releases resulting in public health consequences. Fixed-facility releases and releases of ammonia, chlorine, and acids were more likely to result in personal injuries and evacuations. Releases of

multiple substances were almost twice as likely as releases of single substances to result in evacuations.

The analyses were based on a comparison between one category of substances and all other substances. It was not possible to assess specific substances because so many different substances were released. Only ammonia and chlorine, which are more frequently released, could be individually assessed.

The Hazardous Substances Emergency Events Surveillance system records only acute health effects. However, there has been concern about the potential long-term health effects from hazardous substance releases.<sup>19</sup> Employees (67%) and first responders (14%) accounted for most of the victims. Assessing their long-term health effects would be difficult because these people might continue to have some occupational exposures to hazardous substances. Yet, short-term exposures to the most frequently released substances are not expected to result in chronic health effects unless exposure levels were very high. No information is available on the exposure levels or psychological impact of the releases and evacuations.

Prevention activities should focus on reducing the number of releases and their consequences. An analysis of hazardous substance releases in New York showed that 33% of the releases were due to equipment failure, 14% to human error, and 10% to deliberate dumping. Transportation releases were mostly due to vehicle crashes and failure of or damage to cargo containers.<sup>20</sup> Many of these mechanisms of releases are preventable (primary prevention). The preparedness for and response to hazardous substance emergency events have been discussed previously.<sup>3,5-11</sup> Yet, the relatively high number of employees and first responders who are injured in such events suggests that these individuals need additional training and protective equipment (secondary prevention).

The results from these analyses provide a basis for planning prevention activities and are based on population estimates for the states in the system. Confidence intervals were calculated to determine the stability of the results as risk estimates for prevention planning. However, the states included were not randomly selected and may not represent a true cross section of national demographics or industry. Future studies need to assess the reported releases in relation to industrial activities in the geographic

areas covered by the Hazardous Substances Emergency Events Surveillance system and the costs of response actions for cleanup and medical treatment of persons injured as a result of these releases. □

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