Deaths, Injuries, and Evacuations from Acute Hazardous Materials Releases

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Abstract: We examined reports from three surveillance systems of 587 acute releases of hazardous materials in 1986. These releases resulted in at least 115 deaths, 2,254 injuries, and 111 evacuations. Only eight (1 percent) of the 587 events were common to all three systems. Estimates of the public health consequences of hazardous materials releases could be improved by enforcing existing laws, modifying report forms, and validating collected information. (*Am J Public Health* 1989; 79:1042–1044.)

Introduction

The Superfund Amendments and Reauthorization Act of 1986 contains extensive provisions about emergency planning and the community's right-to-know about toxic chemical releases. A 1987 survey showed that information about public health consequences of such releases was generally not available at the state and regional levels (Sue Binder, unpublished data). Accordingly, we evaluated the three largest national sources of data that record deaths and injuries from acute chemical releases—the National Response Center (NRC), the Department of Transportation (DOT) Hazardous Materials Information System (HMIS), and the Acute Hazardous Events (AHE) data base. Our goal was to determine if these data bases could yield useful public health information. Characteristics of these data sources are discussed in the Appendix.

Methods

This assessment focused on incidents occurring in 1986, the last year for which complete data were available. All 1986 events coded in AHE and HMIS as having resulted in death, injury, or evacuation were obtained. Since NRC did not code evacuations in 1986, only events resulting in death or injury from hazardous materials releases were included. Events were coded as transportation-related if they appear in HMIS, were stated explicitly in NRC to involve a vehicle carrying a toxic chemical or to involve loading or unloading of a vehicle, or were coded in AHE either as occurring in transit or as occurring during loading or unloading and as involving a vehicle not in transit.

The data were converted to a Statistical Analysis System (SAS) format.[1] Events appearing in more than one system were identified and collapsed into one report, and then all reports were merged to form the Public Health Consequences data base. Descriptive analyses were conducted using SAS procedures.[1]

Results

The Public Health Consequences data base included 587 releases resulting in deaths, injuries, or evacuations (Figure 1). Only eight (1 percent) events appeared in all three data bases. These eight events all involved transportation (by definition, since they appear in HMIS) but were otherwise unclustered by type of chemical or in the numbers of people injured or killed.

Fifty-eight events resulted in a total of 115 reported deaths. Thirty-six of these events resulted in a single death each; the largest number of deaths in a single event was 14. Four hundred ninety-six events resulted in a total of 2,254 injuries. Three events resulted in over 100 injured persons each. Although 111 evacuations were identified from HMIS and AHE, the numbers of persons evacuated were missing for 75 percent of evacuations.

The chemicals involved in these incidents were unknown in 23 (4 percent) of the 587 events. For many events, only the class of chemical involved (e.g., corrosive liquid) was specified. Table 1 lists all chemical entries appearing more than five times in a data base.

Three hundred twenty-eight events, 56 percent of the events in the Public Health Consequences data base, involved an in-transit vehicle or an activity related to transportation (e.g., loading or unloading a vehicle). One hundred nine events represented crashes, derailments, and vehicular overturns—events that might occur in areas unprepared to deal with hazardous materials spills.

Discussion

The merged reports from the three systems indicate that there are an average of 1.6 hazardous materials incidents a day in the United States that result in either death, injury, or evacuation; almost once every three days, there is a release from a crash, derailment, or overturned vehicle that results in a similar outcome.

According to the Public Health Consequences data base, the number of people killed from hazardous materials releases in 1986 was 115 and the number injured was 2,254. Although these estimates are probably the most accurate so far, they represent the minimum number of persons killed and injured. A major reason is the mandated limits in scope of the

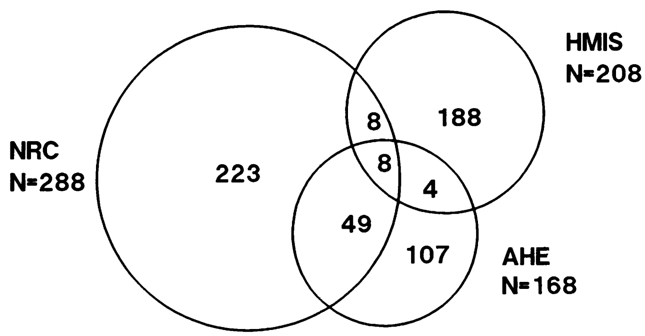

FIGURE 1—Reporting of 587 Hazardous Materials Releases Resulting in Deaths, Injuries, or Evacuations by Data Base, USA, 1986
NRC = National Response Center Data Base
HMIS = Hazardous Materials Information System
AHE = Acute Hazardous Events Data Base

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TABLE 1—Chemicals and Chemical Groups Associated with Releases Resulting in Deaths, Injuries, or Evacuations, by Data Base, 1986*

Public Health Consequence Data Base	National Response Center Data Base	Hazardous Materials Information System	Acute Hazardous Events Data Base
1. Natural gas (88)	Natural gas (88)	Sulfuric acid (21)	Chlorine (35)
2. Chlorine (38)	Chlorine (18)	Gasoline (16)	Ammonia (16)
3. Gasoline (33)	Gasoline (17)	Hydrochloric acid (14)	Hydrochloric acid (11)
4. Sulfuric acid (30)	Diesel oil (12)	Sodium hydroxide (8)	Sulfuric acid (11)
5. Hydrochloric acid (25)	Ammonia (6)	Corrosive liquids (8)	
6. Ammonia (21)	Sulfuric acid (6)	Cleaning liquids (6)	
7. Sodium hydroxide (13)	Miscellaneous oils (5)	Phosphoric acid (6)	
8. Diesel oil (12)		Poisonous liquids (6)	
9. Corrosive liquids (8)		Ammonia (5)	
10. Nitric acid (7)			
11. Phosphoric acid (7)			
12. Cleaning liquids (6)			
13. Flammable liquids (6)			
14. Formaldehyde (6)			
15. Poisonous liquids (6)			
16. Sulfur dioxide (6)			
17. Toluene diisocyanate (6)			
18. Miscellaneous oils (5)			

*Number of appearances is in parentheses. Only those appearing in the data bases five or more times are listed.

contributing systems. For example, HMIS excludes incidents involving intrastate carriers. A second problem is that the data bases probably do not capture all events falling within their mandate.[2,3] The fact that only eight of 595 events (1 percent) appear in all three data bases probably results both from the different areas of emphasis and failure to report by responsible parties.

In addition to incompleteness, the three component data bases have other limitations for evaluating public health impacts. The accuracy of the death and injury information is unknown, particularly for NRC and AHE. Reporting biases may result because certain industries or companies are more likely to report than others. Responsible parties may wish to present themselves in the best possible light, and may therefore tailor their reports accordingly.

The described characteristics of events in the data bases should be interpreted with caution. In particular, the results in Table 1 should not be interpreted as indicating the frequency or even the relative frequency with which a chemical was associated with deaths, injuries, or evacuations, since compliance with reporting requirements and accuracy of identification varies with different chemicals. The chemicals listed in Table 1 also reflect differences in emphasis among reporting systems. Natural gas releases, many from pipeline ruptures or occurring within private residences, were common in NRC. The lack of events involving natural gas, gasoline, and oils in AHE reflects its exclusion of chemicals not covered in Superfund legislation.

Although collecting data on hazardous materials spills is difficult, costly, and time-consuming, it could be improved by enforcing laws on incident reporting; obtaining more specific information about deaths, injuries, and evacuations; and validating collected information. Accurate and complete data on deaths, injuries, and evacuations resulting from acute hazardous materials releases could be used in many ways. Linking these data with information about commodity flows and geographic distributions of chemicals would allow calculation of rates to identify industries, types of facilities, activities, and areas of the country with higher risks of having releases with public health consequences. These rates would make it possible to generate hypotheses about why these events are occurring and to intervene appropriately. The identification of high-risk chemicals, facilities, and activities would also be of use to persons planning emergency response activities and to concerned communities. Although the available data are useful for providing minimum estimates of some of the public health consequences of unintentional hazardous chemical releases, improved surveillance would be an important step toward understanding the problem and, ultimately, preventing it.

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APPENDIX

Description of Data Sources

The National Response Center (NRC), staffed and administered by the US Coast Guard on behalf of 15 participating federal agencies, has been collecting information on chemical releases and serving as a coordinating center for emergency response since 1974. The party responsible for the release is required to notify NRC about hazardous chemical and radiological releases exceeding certain quantities; hazardous materials releases from pipeline failures or cargo in transit resulting in specified outcomes, including death or serious injuries; and certain releases of toxic, corrosive or flammable gas, liquefied natural gas, or gas from a liquefied natural gas facility. By law, NRC must be notified by telephone within 24 hours for transportation-related events or as soon as practical for other events. Since this system is based on initial reports, the information is often incomplete. Much of the information is entered directly into a computer as long, uncoded fields of text. The data do not always indicate whether injuries or deaths resulted from the released chemical or from impact, as from a crash. Until recently, evacuations were uncoded. Data are generally neither verified nor updated.

The Hazardous Materials Information System (HMIS)—the main Department of Transportation (DOT) surveillance system for chemical releases since 1971—contains information about releases of hazardous materials in transit and during transportation-related loading, unloading, or temporary storage. By law, carriers must file written reports to HMIS within two weeks of a chemical release incident. These reports include information about the type of transport, cause of the incident, container structure and failure, and deaths and injuries resulting from the cargo. DOT attempts to validate death and injury data. Specifically excluded from reporting requirements are releases of small quantities of certain consumer commodities, and releases from motor carrier firms doing solely intrastate business and from certain water transporters. Automobiles striking storage tanks and certain transportation-related spills at fixed facilities are also excluded.

The Acute Hazardous Events (AHE) data base was begun in 1985 and uses the NRC as its main source of data. However, data are also included from selected state governments, the Environmental Protection Agency (EPA) Region 7, some newspapers and wire services, and other sources. Information collected includes cause of event, activity taking place during the event, and type of property damaged. Attempts are made to eliminate deaths and injuries not caused by hazardous materials. Because emphasis was placed upon events involving chemicals covered by Superfund legislation and air releases from fixed sites, many events which appear in the NRC data base are excluded. AHE is maintained and augmented by EPA and its contractors, primarily Industrial Economics, Incorporated, and has been updated through 1986.[4] If events appear in more than one source, they are checked for consistency; otherwise, data are not validated.

REFERENCES

1. SAS Institute Inc: SAS User's Guide: Basics. Version 5 Ed. Cary, NC: SAS Institute Inc, 1985.
2. US Congress, Office of Technology Assessment: Transportation of hazardous materials. Washington, DC: Govt Printing Office, 1986; 66–86.
3. Shaw GN, Windham GC, Leonard A, Neutra RN: Characteristics of hazardous material spills from reporting systems in California. Am J Public Health 1986; 76:540–543.
4. Industrial Economics, Inc; Management Technology and Data Systems, Inc; PEI Associates, Inc; ICF, Inc: Acute hazardous events data base. Springfield, VA: National Technical Information Service, 1985; EPA Contract No. 68-02-4055.

Formaldehyde Exposures from Tobacco Smoke: A Review

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Abstract: Reports of formaldehyde levels in mainstream, sidestream, and environmental tobacco smoke from nine studies are reviewed. Considerable disparity exists between formaldehyde production rates determined from mainstream-sidestream studies and those reporting levels in environmental tobacco smoke. Tobacco smoke does not appear to increase vapor-phase formaldehyde levels significantly in indoor environments, but formaldehyde exposure in mainstream smoke may pose a risk of upper respiratory system cancer and increase the risk of cancer in smokers. (*Am J Public Health* 1989; 79: 1044–1045.)

Introduction

Formaldehyde is a major oxidation by-product of combustion processes including tobacco smoking. It is produced in both the mainstream (MS), and sidestream smoke (SS), and has been reported in substantial levels in environmental tobacco smoke (ETS).

Formaldehyde levels in mainstream, sidestream, and environmental tobacco smoke reported by a number of investigators are summarized in Table 1. Reported studies vary in testing methodologies and expression of concentrations. Concentration units are those originally reported and those calculated and standardized by the author from original data, assuming a smoking rate of 35 ml/puff and 10 puffs/cigarette.

As seen in Table 1, formaldehyde concentrations in mainstream smoke[1–4] ranged from about 10 μg/cigarette to over 100 μg/cigarette. Differences in concentrations reflect differences in tobacco type and brand. Higher average concentrations reported by the Surgeon General in 1986[3] reflect those of regular non-filter cigarettes.

Sidestream vapor-phase formaldehyde concentrations also varied somewhat. Ayer and Yeager[5] reported 15–48 ppm. Hoffman's observations ranged from nondetectable to 34.2 μg/cigarette, with an average of 12.1 μg/cigarette for 16 different brands.[4]

Room or large chamber formaldehyde levels associated with environmental tobacco smoke[6–9] indicate that formaldehyde concentrations in such rooms are high. For example, in the studies of Howlett, *et al*,[8] one cigarette smoked in an environmental chamber caused the formaldehyde level to increase to 0.21 ppm within a half hour. Formaldehyde production rates calculated from ETS concentrations (Table 1) are substantially higher (one to two orders of magnitude) than those reported for MS, SS, and MS-SS combined.

The considerable disparity in formaldehyde production rates determined from MS-SS and ETS studies suggests differences due to methodologies employed in sampling and analysis. In the mainstream-sidestream smoke studies reported by the Surgeon General[2,3] and by Hoffman,[4] gas and particulate phase materials were separated by high-efficiency filtration. In studies by Weber, *et al*,[6] no attempt was made to remove particulate phase materials. Sundin[7] employed particulate phase filtration of unknown efficiency. Attempts to remove particulate phase materials in ETS samples were not reported by Howlett, *et al*,[8] and Klus, *et al*.[9]

In mainstream-sidestream smoke studies,[2–4] smoke samples were analyzed by the 2,4 dinitrophenylhydrazene-HPLC method which is specific for free formaldehyde. The chromatropic acid method[10] on the other hand was used in the studies of Weber, *et al*,[6] and Sundin[7]; it is likely to have been employed in the two other environmental tobacco smoke studies as well because it is the dominant method used to determine formaldehyde concentrations in air. In the chromatropic acid method, formaldehyde forms a stable addition product on sample collection in sodium bisulfite solution. On analysis, the addition product is destroyed yielding free formaldehyde. Any solution which contains free formaldehyde, a formaldehyde addition product, or organic compounds which produce formaldehyde on sulfuric acid destruction will test positive for formaldehyde.

On analysis with the chromatropic acid method, the particulate phase of tobacco smoke has been shown to contain appreciable quantities of formaldehyde.[5] This formaldehyde may be present as free formaldehyde dissolved in liquid water or it may be produced by the destruction of formaldehyde addition products and possibly other organic

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