Public Health Risks of Railroad Hazardous Substance Emergency Events

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Synopsis/Abstract

The number of railroad events reported to the Agency for Toxic Substances and Disease Registry's Hazardous Substances Emergency Events Surveillance system increased from 84 in 1993 to 177 in 1998. Comparisons of data on railroad and nonrailroad events were made. Overall results indicate a greater potential public health impact of railroad events. A median number of 2,039 persons were living within a 1-mile radius of railroad events versus 982 for nonrailroad events. The percentage of events during times when people are more likely to be home was also greater for railroad events. Railroad event victims were more likely to need hospital treatment than nonrailroad event victims, suggesting the need for better community planning, a reevaluation of current federal regulations and priorities for railroad hazardous material transport, and enhanced railroad industry commitment to safety.

Introduction

To better understand the public health risks associated with transporting hazardous materials by railroad, the Hazardous Substances Emergency Events Surveillance (HSEES) database, which is maintained by the Agency for Toxic Substances and Disease Registry (ATSDR), was examined for the 1993–1998 period. The objective of the analysis was to (1) ascertain whether railroad events

pose a greater risk to public health, i.e., whether they are more hazardous to railroad employees, emergency response personnel, and the general public than other types of hazardous substance events, and (2) to discuss what could be done to lessen this risk.

HSEES collects data on hazardous substance releases and threatened releases (releases that were anticipated and led to an action, e.g., evacuation, but the release did not occur). The purpose of HSEES is to reduce morbidity (injury) and mortality (death) associated with hazardous substance emergency releases.[1] Information on hazardous substance releases during railroad transportation, as well as related data on the public health impact, are available from other federal databases, such as the Hazardous Materials Incident Reporting System (HMIRS) maintained by the U.S. Department of Transportation (DOT), the Emergency Response Notification System (ERNS) of the U.S. Environmental Protection Agency (EPA), the National Response Center (NRC) database, and the accident/incident database of the Federal Railroad Administration (FRA). However, HSEES is the only federal hazardous substances release database designed specifically to assess and record the public health effects of hazardous substance emergency events. The other databases are designed mainly for emergency response or regulation and do not actively seek out and verify information on all injuries.[2] For the 14 states participating in HSEES during the

1993–1998 time period, there were more injuries from railroad hazardous-substance-related events recorded by HSEES than the other federal databases. The comprehensive nature of the public health consequence data in the HSEES database made it the preferred source of information for this analysis.

Methods

HSEES is an active, state-based surveillance system to collect and analyze information on hazardous substance emergency events. Its goals are to

- Describe the distribution and characteristics of hazardous substances emergencies,
- Describe the morbidity and mortality experienced by employees, emergency responders, and the general public as a result of hazardous substance releases,
- Identify risk factors associated with the morbidity and mortality, and
- Identify strategies that might reduce future morbidity and mortality resulting from the release of hazardous substances.[1]

In 1990, HSEES began collecting data in five states. The 1993–1998 time period was selected for analysis because (1) a new case definition that expanded the number of hazardous substances included in the system was introduced in

1993, therefore data prior to 1993 is considered pilot, and (2) the most recent year for which data are available is 1998.

HSEES defines "hazardous-substance emergency events" as "sudden, uncontrolled, or illegal releases or threatened releases of at least one hazardous substance, or the hazardous by-product of a substance, exclusive of petroleum products."[1] A substance is considered hazardous if it reasonably could be expected to cause adverse human health outcomes. At least one of the following criteria must be met for an event to be recorded by HSEES: (1) a release of at least one hazardous substance in an amount requiring removal, cleanup, or neutralization under federal, state, or local laws; or (2) a threatened release (anticipated but not actual release) of at least one hazardous substance, in an amount that would have required removal, cleanup, or neutralization under federal, state, or local law *and* the threat led to an action (e.g., an evacuation) that could have adversely affected the health of employees, emergency response personnel, or the general public.[1]

Ten states participated in HSEES for the entire time period analyzed (Alabama, Colorado, Iowa, New York, North Carolina, Oregon, Rhode Island, Texas, Washington, and Wisconsin). Additionally, four states participated during portions of the period considered: Minnesota (1995–1998), Missouri (1994–1998), Mississippi (1995–1998), and New Hampshire (1993–1996).

Each state collects data from various sources, including, but not limited to, records and oral reports of state environmental protection agencies, police and fire departments, hospitals, corporations, and the media. Data collected on each event include time and place, the surrounding circumstances, the substances involved, and the persons affected. The information is recorded on a data collection form, entered into the state's data entry system, then transferred quarterly to ATSDR.

The purpose of this analysis was to compare railroad events involving hazardous substances with other types of emergency events recorded by the HSEES database to ascertain whether railroad events posed a greater potential health risk to employees, emergency response personnel, or the general public. Using Statistical Analysis Software (SAS) for Windows version (6.12),[3] descriptive analyses of all transportation-related events with mode of transportation indicated as "railroad" were compared to all other transportation events and all fixed-facility events combined indicated as "nonrailroad."

Based on the results of this analysis, recommendations to prevent morbidity and mortality from similar events in the future were considered.

Results

For the 1993–1998 time period, 30,346 hazardous substance emergency events were reported to the HSEES system. Approximately 20% (6,122) of these

were transportation-related. On average, railroad events made up 1.4% (828) of all types of events; across all 14 states examined, the percentage ranged from 0% to 4.9%. Overall, the number of railroad events reported increased from 84 in 1993 to 177 in 1998 (Table 1). The number of nonrailroad events reported also increased proportionately during this period.

Texas accounted for the greatest percentage of railroad events (35.5%), followed by Colorado (12.9%), Washington (12.0%), and Alabama (6.0%). New Hampshire and Rhode Island reported no railroad events. Texas also accounted for the greatest percentage of nonrailroad events (42.0%), followed by New York, (8.0%), Wisconsin (7.9%) and Washington (7.9%) (Table 1).

People Affected

Railroad events were more likely to occur in residential areas and during times when people were more likely to be at home. At least one residence was within a quarter-mile of 45.9% of the railroad events, compared with 37.1% of nonrailroad events. A greater percentage of railroad events (49.4%) occurred on weeknights between 6:01 PM and 6:00 AM, or on weekends. For nonrailroad events, the percentage occurring during these hours was 41.7%.

HSEES defines “victim” as a person suffering at least one symptom as a result of an event. Between 1993 and 1998, there were 179 victims of railroad

events and 10,967 victims of nonrailroad events. There were victims in 6.8% of railroad events and in 8.3% of nonrailroad events, and the median number of victims (N=1) was the same for both types of events. Of the 159 railroad victims whose sex was known, a larger percentage (81.8%) were male than nonrailroad victims (61.7%).

A greater percentage of members of the public and emergency response personnel were injured during railroad events compared to nonrailroad events. Of all railroad victims, 40.8% (N=73) were members of the general public, 40.2% (N=72) were employees or contractors of the railroad responsible for the event, and 19% (N=34) were emergency-response personnel. For nonrailroad events, the greatest percentage of victims were company employees or students (59.3%), followed by members of the public (32.0%), and emergency-response personnel. (8.6%). The victim category was unknown for 45 nonrailroad victims.

Based on the type of medical treatment received, the injuries of railroad victims were slightly more severe than nonrailroad victims. A larger percentage of nonrailroad victims (21.5%) compared to railroad victims (18.4%) did not require hospitalization, they either sought no medical treatment or were treated at the scene or in a physician's office. Whereas a greater percentage of railroad victims (79.9%) compared to non-railroad victims (77.2%) were treated or observed at a hospital, some eventually admitted to the hospital. Three railroad

(1.7%) and 144 (1.3%) non-railroad victims died from their injuries.

Of the 179 victims of railroad events, 48 were from Texas, 45 from Colorado, 31 from Washington, 14 from Mississippi, 12 from North Carolina, 9 from Minnesota, 7 from New York, 4 from Iowa, 4 from Oregon, 3 from Missouri, and 2 from Alabama. The total number of railroad victims per year varied significantly: 1993 (N=27), 1994 (N=51), 1995 (N=10), 1996 (N=52), 1997 (N=15), and 1998 (N=24). Similarly, there was no discernable pattern for victims of nonrailroad events: 1993 (N=2,203), 1994 (N=2,127), 1995 (N=1,679), 1996 (N=1,568), 1997 (N=1,881), and 1998 (N=1,509).

Although only 49.4% of railroad events occurred on weeknights between 6:01 PM. and 6:00 AM or on weekends, 66.5% of railroad victims were injured then, which is considerably more than the 40.3% of nonrailroad victims injured during these typically “off-work” hours.

The most common symptoms reported in railroad events were respiratory irritation (n=110), eye irritation (n=38), nausea or vomiting (n=27), headache (n=20), and skin irritation (n=14). For nonrailroad victims, the distribution was similar, except for a greater number of reports of dizziness or other central-nervous-system symptoms.

Official evacuation orders were issued in a greater percentage of railroad events (11.8%) than nonrailroad events (10.6%). The median duration of railroad

evacuations was longer (4 hours, versus 2 hours for nonrailroad evacuations). The median number of people evacuated in railroad events was larger (N=39) than in nonrailroad events (N=20). An order to “take shelter in place” was issued in seven (1.1%) of the railroad events and in 183 (0.8%) of the nonrailroad events.

Most of the persons decontaminated at hospitals as a result of railroad events were members of the general public (55%, N=22). Railroad employees (37.5%, n=15) were next, followed by emergency-response personnel (7.5%, N=3). For nonrailroad events, the distribution of persons requiring decontamination at medical facilities was as follows: 39.6% (N=455) were employees, 35% (N=403) were members of the public, and 25.4% (N=292) were emergency-response personnel.

Table 2 compares all nonrailroad and railroad events on the median number of persons who had the potential to be affected within a specified distance (0.25–1 mile) of where the event occurred. Census figures are used to estimate the “Live within area” variable. These estimates are weighted according to the time of day and day of week in order to estimate the “At home within area” variable. States use available information, such as business directories, or make inquiries to estimate the “Number of people at work” variable. For areas of all sizes, the median number of people *working* in the vicinity of the event was higher for nonrailroad events than railroad events. The median number of people *living* in

the vicinity of the event was greater for railroad events than for nonrailroad events.

Actions to control or alleviate the release of hazardous substances were taken during a greater percentage of railroad events (95.5%) than nonrailroad events (91.2%). Emergency contingency plans were also followed during a greater percentage of railroad events (95.2%) than nonrailroad events (90.9%). The majority of contingency plans used during railroad events were either the Hazmat/emergency response team's standard operating procedures (42.4%) or an incident-specific, ad hoc plan (34.6%). A higher percentage of contingency plans for nonrailroad events were incident-specific, ad hoc (42.4%), and 31.0% used the Hazmat/emergency response team's standard operating procedures.

Employees Injured

Seventy-two railroad employees were injured in railroad events and 6,056 employees were injured in nonrailroad events. Approximately 97% of injured railroad employees were males, versus 67% of nonrailroad employees. According to the U.S. Department of Labor, Bureau of Labor Statistics, 88.2% of workers employed by railroads in 1998 were male, compared with 53.8% for all industries[4.] The median age of railroad-employee victims was higher (41 years) than nonrailroad-employee victims (35 years).

Between 1993 and 1998, railroad-employee victims of railroad events sustained 110 injuries. The most frequently reported symptoms among railroad employees were respiratory irritation (N=26), nausea and vomiting (N=18), trauma (N=17), and headache (N=15). For nonrailroad-employee victims, the most frequent symptoms were respiratory irritation (N=3,706), eye irritation (N=1,478), nausea or vomiting (N=1,253), and headache (N=1,196). Injuries suffered by railroad employees seemed more severe than those of nonrailroad employees (4.2% of injured railroad employees died, compared with 1.7% of nonrailroad employees). Almost 80% of injured railroad employees were taken to a hospital, whereas 75.2% of nonrailroad employee victims were taken to a hospital. Of railroad-employee victims, 56.9% wore no personal protective equipment (PPE) and 43.1% wore protection at Level D or below, which affords little or no respiratory or skin protection.[5] Of the nonrailroad-employee victims, 71.2% wore no PPE, but 6.8% wore protection at Levels A, B, or C, which affords various measures of respiratory and skin protection.

A greater percentage of railroad-employee victims (61.1%) than nonrailroad employee victims (29.0%) were injured on weeknights between 6:01 PM and 6:00 AM, or on weekends. The states with the greatest number of injured railroad employees were Texas (n=19), Washington (n=14), and Colorado (n=11). The states with the greatest number of injured nonrailroad employees were

Washington (n=1,871), Texas (n=1,043), and North Carolina (n=472).

Substance Released

When a rail car carrying hazardous substances is involved in a derailment, collision, or other incident, it may be difficult to determine at first whether a release has occurred. Damage to the rail car, as well as to any hazardous substance packagings inside, must be fully assessed. While emergency response, wrecking, and cleanup activities are being carried out, there may be a continued threat of release until the potential hazard has been controlled or removed from the site.

Of the 828 railroad events, 754 (91.1%) involved the actual release of hazardous substances into the environment, 38 (4.6%) involved a threatened release, and 36 (4.3%) were a combination of actual and threatened releases. There was a higher percentage of actual releases (97.1%) for nonrailroad events and a smaller percentage of threatened (1.2%) or actual and threatened releases combined (1.8%).

Almost 95% of all railroad and nonrailroad events involved only one hazardous substance. The number of substances involved in the railroad events analyzed ranged from 1 to 22; the number of substances involved in the nonrailroad events ranged from 1 to 99. HSEES classifies substances into 11

categories (acids, ammonia, bases, chlorine, other inorganics, paints and dyes, pesticides, polychlorinated biphenyls [PCBs], volatile organic compounds [VOCs], multi-category; and other). The “other” category includes mixtures of substances from different categories, and substances that cannot be classified in any of the other categories. For railroad events, the categories of hazardous substances most often released were other (23.9%), acids (19.2), volatile organic compounds (17.4%), and other inorganic substances (14.5%) (Table 3). For nonrailroad events, the categories of hazardous substances most often released were other inorganics (19.9%), other (19.6%), and volatile organic substances (17.5%). For railroad events, pesticides were most often associated with events involving evacuations and victims while for nonrailroad events, chlorine was most often associated with events involving evacuations and victims.

Discussion

People Affected

Railroad events are potentially more harmful to the health of the general public than other types of events for the following reasons:

- Railroad hazardous substance emergency events have occurred in or near areas that are more densely populated,
- A greater percentage of these events occur when nearby residents are more

likely to be at home,

- Victims of railroad events are more likely to be members of the general public,
- Victims of railroad events are more likely to require hospitalization or die,
- Members of the general public are more likely to require decontamination at a medical facility,
- Official orders to evacuate or "to take shelter in place" occur more frequently during railroad emergency events, and
- Evacuations following railroad events are more likely to affect a larger number of people for a longer period of time.

Members of the public living near fixed facilities where hazardous substances are used are often offered information about potential hazards and what to do in case of an accidental release. The Risk Management Program (RMP) Rule[6] is designed to focus accident prevention at the local level by making more information available to local emergency response agencies and the public about chemical hazards in fixed facilities, the potential effects of an accidental release, and facilities' emergency response programs.

Although transportation-related releases are not covered by the RMP Rule, this analysis found railroad events potentially more harmful to the health of the general public than other types of events. Because most members of the public

have not been offered information on how to respond to a transportation-related hazardous substance emergency event, they are less likely to know how to protect themselves in case of a railroad hazardous substance emergency event.

Within DOT, the FRA is the primary source of assessment, rulemaking, and enforcement. Yet FRA's accident/incident and inspection system did not capture many of the events that the HSEES system captured. Because public health impact should be a major consideration in risk assessment of rail transportation of hazardous materials, the FRA should use HSEES data in its rulemaking.

Employees Injured

In the case of the railroad events analyzed, railroad employees were more likely to suffer trauma. Many of the trauma injuries reported were sustained during crashes and were not caused by chemical exposure.

Besides trauma, the most frequent injuries suffered by railroad employees were respiratory irritation, nausea, vomiting, and headache; this indicates that employees encountered the risk of inhaling or coming into contact with hazardous chemicals while at work. This analysis found that railroad-employee victims wore types of PPE which provided little or no protection from hazardous substances, or wore no PPE at all.

Releases from Tank Cars

DOT determines which hazardous substances must be shipped in tank cars that are best designed to withstand train crashes. To better ensure that hazardous materials posing the greatest risk are shipped in tank cars with the safest designs, the National Research Council's Transportation Research Board asked DOT in 1994 to develop more quantitative measures for assessing the safety performance of alternative tank car designs[7]. DOT can use incident data from HSEES to rate the safety performance of tank car designs.

Recommendations

For the states and the time period considered, analysis of the HSEES data showed (1) an increase in the number of railroad hazardous substance-emergency events, and (2) that railroad events were potentially more harmful to the health of the general public than other types of events. These findings indicate a need for: (1) better community planning for railroad hazardous material events, (2) reevaluating current federal regulations and priorities, and (3) improved railroad commitment to safety in joint effort with the unions. Following is a list of suggested recommendations.

Recommendations to State and Local Agencies (Emergency, Health, Environmental, Transportation) for Community Planning

- Examine closely the railroad hazardous material industry within your area (especially in states with a large number of railroad events or railroad events with victims, e.g., Texas, Colorado, Washington, Mississippi, and Alabama) and determine where the greatest risk to the public occurs and the best strategies to minimize that risk.
- In areas of high risk, develop a community-based public education campaign detailing proper evacuation, shelter-in-place, and decontamination procedures. Public warning systems (e.g., sirens), practice drills, and public shelters are very important to protecting the public's health in case of a hazardous substance release.
- Hospital emergency rooms in areas where there are railroad shipments of hazardous materials should have the proper training and facilities to decontaminate and treat large numbers of chemically contaminated patients.

Recommendations to Federal Agencies (FRA, DOT, OSHA)

- Re-evaluate current regulations for railroad tank car designs for substances frequently released (e.g., VOC's, acids, and other organics) or

substances frequently causing injuries (e.g. pesticides, chlorine, paints and dyes, and ammonia) in HSEES railroad-related events.

- **Make use of HSEES public health impact data, when possible, to set priorities or rules. For example, railroad personnel are being injured from exposure to hazardous substances. Improved emergency response procedures, including proper PPE, could be a priority area, helping to decrease morbidity and mortality from railroad events involving hazardous substances.**
- Look for increased opportunities to schedule railroad shipments of hazardous substances through highly populated areas during times of day when the least number of persons would be affected.

Recommendations to Railroads

- **Follow OSHA rules** for emergency response to hazardous materials releases consistently. These rules include the incident command system, emergency response plans and procedures, training, and personal protective equipment.
- Identify opportunities to schedule railroad shipments of hazardous substances through highly populated areas for times of day when the least number of persons would be affected.

- Inspect equipment regularly, do maintenance as scheduled, and keep up to date on current safety developments.
- In densely populated areas, support local emergency response planning committees in education activities for the community about the potential dangers and proper actions to take.

Although a statistically rare occurrence, the effects on public health from the release of hazardous substances during rail transportation are potentially catastrophic. Even small improvements in strategies for primary prevention of releases, and secondary prevention of adverse public health outcomes could have a large positive impact.

TABLE 1. Distribution of Railroad Events by Year and State Compared to Nonrailroad Events, Hazardous Substance Emergency Events Surveillance 1993–1998

State	Railroad Events by Year						Railroad Events		Nonrailroad Events	
	1993	1994	1995	1996	1997	1998	Total	%	Total	%
AL	6	11	8	2	5	18	50	6.0	1,016	3.4
CO	16	18	21	23	15	14	107	12.9	2,078	7.0
IA	7	4	6	9	10	5	41	5.0	1,761	6.0
MN			1	4	5	2	12	1.4	1,160	3.9
MO		9	8	10	12	9	48	5.8	1,006	3.4
MS			4	8	4	10	26	3.1	504	1.7
NC	7	4	3	6	3	12	35	4.2	1,203	4.1
NH	0	0	0	0			0	0.0	181	0.6
NY	6	14	6	9	6	7	48	5.8	2,367	8.0
OR	4	6	4	13	9	8	44	5.3	1,034	3.5
RI	0	0	0	0	0	0	0	0.0	265	0.9
TX	32	42	53	44	59	64	294	35.5	12,387	42.0

WA	5	13	19	22	20	20	99	12.0	2,319	7.9
WI	1	1	5	3	6	8	24	2.9	2,237	7.9
Total	**84**	**122**	**138**	**153**	**154**	**177**	**828**	**99.9**	**29,518**	**100.3**

TABLE 2. Median Number of Persons Living, Working, or at Home Within the Specified Area of Nonrailroad and Railroad Events, Hazardous Substances Emergency Events Surveillance, 1993–1998

Radius	Median Number					
	Living Within Area		Working Within Area *		At Home Within Area*	
	NR†	Railroad	NR	Railroad	NR	Railroad
¼ mile	2	67	100	10	0	20
½ mile	160	500	150	30	50	196
1 mile	982	2039	300	75	351	930

*Estimated based on time of day.

†Nonrailroad.

TABLE 3. Number of Railroad and Nonrailroad Events in Each Substance Category and the Number of Events with Evacuation and Victims for Each Category, Hazardous Substances Emergency Events Surveillance, 1993–1998

Substance Category	Railroad Events						Nonrailroad Events					
	Events	%	Evacuations	%	Victims	%	Events	%	Evacuations	%	Victims	%
Acids	159	19.2	11	6.9	10	6.3	2488	8.4	307	12.3	292	11.7
Ammonia	57	6.9	6	10.5	6	10.5	2054	7.0	507	24.7	252	12.3
Bases	55	6.6	3	5.5	5	9.1	1032	5.5	40	3.9	72	7.0
Chlorine	14	1.7	2	14.3	2	14.3	688	2.3	278	40.4	215	31.3
Other inorganics	120	14.5	12	10.0	11	9.2	5871	19.9	543	9.2	379	6.5
Paints & Dyes	8	1.0	0	0.0	1	12.5	683	2.3	34	5.0	28	4.1
Pesticides	6	0.7	1	16.7	1	16.7	1728	5.9	98	5.7	172	10.0
PCBs*	2	0.2	0	0.0	0	0.0	753	2.6	11	1.5	9	1.2
VOCs †	144	17.4	14	9.7	4	2.8	5172	17.5	365	7.1	196	3.8

Substance Category	Railroad Events						Nonrailroad Events					
	Events	%	Evacuations	%	Victims	%	Events	%	Evacuations	%	Victims	%
Other‡	198	23.9	22	11.1	10	5.1	5772	19.6	509	8.8	419	7.3
Multi-category§	65	7.9	27	41.5	6	9.2	3277	11.1	401	12.2	356	10.9
Total	**828**	**100.0**	**98**	**11.8**	**56**	**6.8**	**29,518**	**100.0**	**3,093**	**10.5**	**2,390**	**8.1**

*Polychlorinated biphenyls.

†Volatile organic compounds.

‡Hazardous substances that cannot be placed into one of the other categories. This category includes mixtures unless all of the components of the mixture were identified as the same category.

§Events with more than one hazardous substance involved but that do not belong to the same category.

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