Hazardous Materials Events:: An Industrial Comparison

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Abstract Author Information Authors Article Outline Outline

Identifying industries at high risk for hazardous materials releases can facilitate prevention and preparation for such events. A retrospective review by Standard Industrial Classification (SIC) codes was conducted on non-petroleum hazardous materials emergency events from 1993 to 1995 and collected by the Washington State Department of Health in a program supported by the Agency for Toxic Substances and Disease Registry. Annual US Census data were used to determine the number of facilities and employees by SIC code in the state of Washington. SIC codes with the most total events and events per 10,000 employees were ranked and characterized by type of releases. In 3 years, 1269 events were recorded, with 294 involving human victims. Industries with the highest average annual number of events per 10,000 employees were agricultural chemical manufacturing (142); petroleum refining (122); industrial and miscellaneous chemical manufacturing (56); electric light and power (54); and pulp, paper, and paperboard mills (39). Industries with high rates of hazardous materials emergency events should continue to develop methods of preventing these releases.

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Emergency releases of hazardous materials are common events with the potential for significant impact on the environment and human health. There were over 5500 such events reported in 14 states in 1996, and 390 of these events resulted in human exposures for a total of 1620 exposure victims. [1] Industrial releases account for the majority of these events, yet there is limited published information on the relative frequency of hazardous materials events categorized by industry. This is particularly true of industries not commonly considered to contain significant quantities of hazardous materials.

Identification of industries at increased risk for releasing hazardous materials can provide tools for prevention and preparation for such events. These industries can identify high-risk processes and can institute process safety management programs to limit future releases. Emergency care facilities and first responders, including fire departments, are required to prepare for chemical releases. [2] Identifying industries at increased risk for chemical release can help health professionals and firefighters anticipate possible future releases. In addition, identification of frequently released chemicals within an industry may assist in planning appropriate fire department industrial inspections and disaster drills.

Methods

A retrospective review was conducted on hazardous materials events from 1993 through 1995. Data were collected by the Washington State Department of Health for the Hazardous Substances Emergency Events Surveillance (HSEES) system with support from the Agency for Toxic Substances and Disease Registry.

Hazardous materials events are defined by HSEES as "... uncontrolled or illegal releases or threatened releases of hazardous substances or the hazardous by-products of substances. Not included were events involving petroleum products exclusively. Events were included when the amount of substance that was released, or that might have been released, needed (or would have needed) to be removed, cleaned up, or neutralized according to federal, state, or local law; or when there was only a threatened release of a substance, but this threat led to an action (for example, evacuation) that could have affected the health of employees, responders, or the general public."[1] Information collected for each event includes location, substances(s) released, morbidity, mortality, potential population exposed, decontamination, evacuation, and in-place sheltering. Sources providing information include, but are not limited to, first responders, health care facilities, state agencies, and industry representatives.

HSEES industry codes were converted to Standard Industrial Classification (SIC) codes by using the 1990 Census of Population and Housing, Alphabetical Index of Industries and Occupations. [3] Frequencies of hazardous materials events for each SIC code were calculated and ranked for the 3-year period. Events without SIC codes or census information were excluded from analysis. SIC codes with only one reported event from 1993 to 1995 were not ranked.

Using the Washington State County Business Patterns reference pages, [4–6] numbers of establishments and employees in each SIC code were recorded by year, and an average for 1993 to 1995 was calculated. By dividing the number of events by the average number of establishments, events/facility were calculated for each SIC code. US Census population estimates were used to determine the number of households in the state by year. [7] The number of households was used in place of the number of establishments for the private households SIC. Events per 10,000 employees were calculated by dividing the number of events by the average number of employees for each SIC code and multiplying by 10,000. Yearly rates for events per

10,000 employees were calculated by using US Census annual employee data. [4–6] US Census population estimates were used to determine the number of persons in households. [7] The number of persons in households was used in place of the number of employees for the private households SIC.

Results

From 1993 through 1995, there were 1269 hazardous materials events in Washington State. The top 25 SIC codes ranked in descending order by frequency of total hazardous materials emergency events are listed in Table 1. Industries with the greatest number of reported events were trucking service; pulp, paper, and paperboard mills; sanitary services; electric light and power; and petroleum refining. Of all events, 284 (22%) occurred during transportation and 984 (78%) occurred at fixed facilities.

Table 1

Of the 1269 hazardous materials events, 294 (23%) involved human victims. For 1993, 120 (26%) of 455 total events involved victims, as did 82 (22%) of 379 events in 1994 and 92 (21%) of 435 events in 1995. The top 19 SIC codes ranked in descending order by frequency of hazardous materials emergency events involving human victims are listed in Table 2. In comparison with the data in Table 1, elementary and secondary schools; private households; eating and drinking places; and the canned, frozen, and preserved fruits industry were ranked higher. For victim events, 35 (12%) occurred during transportation and 259 (88%) occurred at fixed facilities.

Table 2

The top 15 SIC codes ranked in descending order by total average annual events per 10,000 employees are listed in Table 3. Industries that ranked higher as compared with data in Table 1 were agricultural chemical manufacturing; guided missiles and space vehicles; dairy products; and paints, varnishes, and related products. Railroads and agricultural production of crops were excluded from Table 1 because annual facility and employee information was not available in the Washington State County Business Patterns guide.

Table 3

A more detailed yearly description of events for the five SIC codes ranked highest in average annual events per 10,000 employees are presented in Tables 4 through 8. An increase in events was noted for the agricultural chemical manufacturing industry but was not statistically significant, and the increase in trucking service events was determined to be the result of changes in incident reporting rather than an actual increase in incident rates.

Table 4

Table 5

Table 6

Table 7

Table 8

Within SIC codes, a limited number of chemicals often accounted for a majority of the releases. For example, ammonia, ammonia-containing compounds, nitric acid, and oxides of nitrogen were the most commonly released substances from agricultural chemical manufacturing plants in Washington State and comprised 88% of the total events. Similarly, sulfuric acid or sulfur dioxide was involved in 84% of petroleum refining and 52% of pulp and paper events, and chlorine or chlorine dioxide was involved in another 25% of the pulp and paper events. Polychlorinated biphenyls (PCBs) or PCB oil was released in 95% of electric light and power events. However, other SIC codes, such as industrial and chemical manufacturing and trucking service, had a larger number of different chemicals involved, with each accounting for only a small percentage of the total events.

Discussion

Although well-known chemical disasters such as in Bhopal, India, in 1984 have caused extensive mortality and morbidity, most industrial chemical releases in the United States do not involve direct human exposure. However, every new release has the potential to affect human health. Review of unplanned, industrial chemical releases can provide information for improving preparedness for and prevention of future events,

[8,9] and inclusion of both victim and non-victim events provides a larger sample size for analysis. Although not previously reported for hazardous materials releases, ranking by SIC codes has been used in studies of lead poisoning and silica exposure. [10,11] Once industrial releases are ranked by SIC, it is possible to examine more details that might correlate to the level of risk in each industry.

The top five SIC codes in Washington State by frequency of hazardous materials events include trucking service; pulp and paper; sanitary services; electric light and power; and petroleum refining. However, this ranking must be considered in terms of the relative size of each industry, including both the number of facilities in the state and the number of employees. Depending on which criteria are chosen, the order and type of industries change. Within an industry, preventive measures should focus on the most likely chemical releases. Although new Environmental Protection Agency mandated Risk Management Plans are limited to a specific set of substances, [12] it is prudent to consider the consequences of release of additional chemicals where they might pose a risk to the community.

Selection of industries for improved community planning will depend on the specific needs addressed. Environmental planning should focus on all events, whereas medical planning should focus on events involving human exposures. Locations where large numbers of people gather such as educational institutions and eating and drinking establishments, labor intensive industries such as canneries, and private residences should receive particular attention.

The results of this study are consistent with previous reports. In Massachusetts from 1990 to 1996, 157 events, including 46 (29%) involving injury, were reported. [13] Although SIC codes were not used, 31 events were reported during transportation, 19 at industrial facilities, 15 at commercial sites, 10 at health care institutions, 9 at residences, and 8 at schools. Of 24 hazardous materials incidents reported to the Washington Poison Center from 1994 to 1996 involving eight or more human victims, seven occurred at industrial facilities, five at schools, and three in hospitals or clinics. [14] Although they constitute a minority of events, hazardous materials exposures at hospitals and schools occur frequently and may affect large groups of people and/or individuals with preexisting medical problems.

Concentrating on SIC codes with high total counts of hazardous materials events and number of events per employee should provide the greatest opportunity to prevent future releases. Identification of frequently released chemicals within a SIC code could help industry focus on specific process safety management programs and help fire departments plan for these releases. For many of the SIC codes evaluated, concentrating on the limited number of chemicals accounting for the majority of the hazardous materials events may be the most effective means of reducing future releases.

When evaluating the rate of hazardous materials releases by SIC code, it is important to consider the limitations of our study. All hazardous material incident data came from the HSEES database. Although no single database includes all hazardous materials events, the HSEES system uses multiple reporting sources in an attempt to be as comprehensive as possible within their selection criteria. However, the actual number of exposures per SIC code still might not be fully represented, particularly smaller-scale releases not meeting reporting requirements. Furthermore, releases limited to petroleum products, although relatively common, are excluded from the HSEES database. In addition, our data come from just one state and may not be representative of the entire country.

Apparent longitudinal trends in hazardous materials releases by SIC code should also be evaluated carefully, because reporting to HSEES by public agencies and industries within Washington State changed from 1993 through 1995. For instance, there was an increase in reporting for SIC 421 and 423 (trucking services) from

1993 through 1994 because of increased access to transportation data. For both SIC 291 (petroleum refining) and SIC 287 (agricultural chemical manufacturing), most of the reporting was done by one company in each SIC code, so generalizing the results to all companies within the SIC code may be inappropriate.

Despite these limitations, the HSEES system provides an excellent source of information for both emergency planners and industry. HSEES data are available for 13 states, and contact information for individual states can be obtained through the Agency for Toxic Substances and Disease Registry in Atlanta. In addition, hazardous release information is available for larger industries through the US Environmental Protection Agency Emergency Planning and Community Right-to-Know regulations, including Toxic Release Inventory lists. [15]

Prevention of future events requires identification of variables that place certain industries at higher risk for releases and/or injuries. Factors associated with increased accident risk levels, not limited to hazardous materials events, include work environment, individual employee characteristics, and the interaction between worker and environment. [16,17] Estimating the risk of accidents in a workplace should therefore include the worker, the workplace environment, and industry design.

Probably our best understanding of worker contribution to accidents comes from accident investigations in aviation and trucking industries. In one review of 4 years of naval aviation mishaps, 58% were attributed to human error. [18] In the trucking industry, the length of a driver's journey and delivery schedules are noted as predictors of driving accidents, suggesting that driver fatigue contributes to accidents. [19] Many drivers are noted to be in violation of the interstate trucking hours of service, which limit drivers to 10 hours following an 8-hour rest. [20] In addition, medical conditions may affect worker performance and may contribute to accidents or unsafe conditions. For example, sleep apnea decreases daytime alertness and increases driving accidents. [21–23]

Aside from worker risk factors, the workplace itself might increase the risk of accidents. In the workplace environment, freely available alcohol, excessively loud work areas (over 82 dB), and untrained coworkers may create a dangerous work atmosphere. [24,25] Combinations of these factors may further increase the risk level. Working with fatigued coworkers and using drugs or narcotics during work hours are examples of interactions between environment and workers that may create hazardous conditions. [24]

The overall design of an industry or company can also affect the risk of disaster. As the technology of an industry evolves, the environment must be updated to account for the changes. [24] Change in industry location, especially on an international scale, requires appropriate policies and recommendations for safety and continued evaluation. [9] Third World countries are at an increased risk for chemical disasters because zoning regulations may be inadequate or not enforced.

Certain industries have developed process management tools to help prevent hazardous materials releases. For instance, the American Petroleum Institute has published process hazard management recommended practice guidelines. [26] Federal regulations for process safety management of highly hazardous chemicals and explosives have also been published in an attempt to limit accidents. [27] Many of the general steps involved in these process management protocols could be applied to other industries and chemicals as well to help limit future releases of hazardous materials. One author suggests a "sentinel marker" system in which evaluations of industries and companies focus special attention on the review of safety protocols, past events, low-level or near-miss exposures, and real-time drills. Routine walk-through evaluations and, eventually, controlled studies that compare hazard points with events could increase prevention of industrial disasters. [24]

Medical and community awareness of the potential for industrial hazardous materials release should also be encouraged. Industrial accidents can affect both the workers and the general public. [8] Worker and community right-to-know acts require that the public be informed of potential hazards and appropriate responses. [9,24,28] The choice of actions such as evacuation versus in-place shelter, selection of personal protective equipment and antidotes, and appropriate drills can become clear as knowledge about potential hazards is circulated. Moreover, increasing awareness of information resources such as poison centers, and hospitals equipped for disaster management, may facilitate appropriate community and medical response. Reporting of hazardous materials releases to agencies such as poison centers will also serve to create real-time exposure information, which can be used for future analyses. [29,30] Increased exposure knowledge, risk communication, routine evaluations of employees and work environments, and continued research have the potential to decrease the number of industrial disasters and their impact.

In conclusion, identification of industries at increased risk for hazardous materials release can help companies anticipate potential future releases. To help prevent these releases, industries can institute process safety management programs. Public and industry fire departments, emergency care facilities, and state and local emergency planning committees can use this information to prepare for hazardous materials releases.

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