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Christina Souther Date

Characterization of Hazardous Substance Emergency Events During Which Responders Became Victims

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

Characterization of Hazardous Substance Emergency Events During Which Responders Became Victims

By Christina Souther

Background: Hazardous substance emergency events, defined by the Agency for Toxic Substances and Disease Registry (ATSDR) as "uncontrolled or illegal releases or threatened releases of hazardous substances or the hazardous by-products of substances,"[5] occur frequently in the United States[9] and can be difficult to plan for due to their unexpected nature. The objective of this analysis is to determine which types of hazardous substance events more frequently affect responders in order to locate possible weaknesses in procedures and inform future training.

Methods: Hazardous substance emergency event surveillance data from 15 states during the years of 2002 through 2011 were used. Six of the 15 states consistently reported events throughout the study time period while the other states reported during intermittent years. Descriptive statistics were obtained for the six consistent states to characterize the types of events. Events from all states were analyzed using multivariate regression to identify associations between event characteristics and victims.

Results: Event type, day of the event, weather at the time of the event, cause of the event, land use in the surrounding area and the type of release were significantly associated with one or more victims resulting from an event. Cause of release, land use, and type of release were significantly associated with responder victims resulting from an event. The two most common types of events had fewer total victims as well as fewer responder victims per event than the average event.

Conclusions: The outcome of responder victims and the number of responder victims are related to the land use of the site of release, the cause of the release and the type of release. Situations that can be anticipated, such as the most common events, and more quickly controlled, such as those occurring in industrial areas, led to fewer victims. The events caused by fire and explosion had the strongest measure of association with responder victim outcomes. These events are inherently dangerous; it may be worth focusing more training and preparation efforts on this type of release to mitigate some of the threat to the responders.

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Table of Contents

Characterization of Hazardous Substance Emergency Events During Which Responders Became Victims

Introduction

Hazardous substance emergency events occur frequently in the United States[9] and can lead to health problems ranging from mild respiratory irritation to severe trauma and death.[1,2,3,4,8,10,14,15,16] Due to their unexpected nature, it can be difficult to prepare for these events and prevent injury during the response. First responders of all designations with differing levels of training can be involved in the early stages of event management and may be at increased risk of injury or disease depending on the type of hazardous substance emergency event, the training and experience of the individual responder, and the specific hazardous substances released.

The Agency for Toxic Substances and Disease Registry (ATSDR) defines hazardous substance emergency events as "uncontrolled or illegal releases or threatened releases of hazardous substances or the hazardous by-products of substances."[5] Surveillance data regarding hazardous substance events from 1990 to 2009 have been collected by state health departments and assembled by the Hazardous Substances Emergency Events Surveillance (HSEES) system under the leadership of ATSDR.[6] Similar data are currently collected by the National Toxic Substance Incidents Program (NTSIP), which became the primary toxic incident surveillance program in 2009.[6] NTSIP, also managed by ATSDR, is similar to HSEES but includes the collection of more detailed information and the opportunity for more outreach.[6] A major goal of the new NTSIP system is to decrease the morbidity resulting from future events.[6] Nineteen states participated in HSEES at some point during its operation and 7 states currently participate in NTSIP data collection.[6]

The surveillance data collected through HSEES and NTSIP and other similar databases have been used to characterize the recent history of hazardous substance events in certain states,[15] event outcomes in specific types of locations, e.g. schools,[1] or among certain victim populations, e.g. children.[14] Although first responders play a major role in the management and resolution of hazardous substance release events, the analysis of the impact of these events on the first responders themselves has been limited in the past.[2,3,7,8,11,13] A comprehensive look at events resulting in first responder victims from 1996 through 1998 was completed using HSEES data[16] but most of the other related studies described either a specific event or a more general overview of the mental health outcomes involved in response.[2,3,7,8,11,13]

A study focusing on hazardous substance release events in schools from 1993 to 1998 found that a higher proportion of school-related incidents resulted in victims than events in other types of locations (RR 3.94).[1] These school-related events also resulted in evacuation more frequently than events in other location types (RR 5.76).[1] The most common causes of the events in schools were chemical spills leading to the release of noxious gases which resulted in respiratory symptoms among the victims.[1] These were generally due to operator error, equipment failure, improper mixing and, in some cases, deliberate releases of hazardous substances.[1] A study focusing only on children as victims found that most of these events took place in schools, at home or in recreational centers.[14]

In New York from 1993 through 2002, 12% of the victims of hazardous substance events were responders to the incidents, while the general public made up 29% of the victims and employees at the location of the release comprised 37% of the victim population.[15] The incidents recorded in New York were predominantly caused by equipment failure and human error.[15] The majority involved volatile organic compounds (VOCs), solvents or acids and led mostly to respiratory symptoms, headaches and nausea/vomiting.[15]

A specific analysis of pesticide exposure among first responders was completed using HSEES data along with several other datasets containing information collected from 21 states from 1993 to 2002.[2] Out of the 291 responders who were victims of pesticide exposure, 38% were firefighters, 36% were law enforcement personnel and 14% were other unspecified emergency responders.[2] A separate study of HAZMAT events in the early 1990s found that firefighters and police officers were injured in 9% of HAZMAT events while civilians were injured in 21%.[8] However, the trained HAZMAT team members were only injured in 1% of the events analyzed.[8] The major injuries to first responders in these HAZMAT events were caused by burns.[8] Hydrocarbons and corrosive materials were the most common substances released.[8]

A larger focus has been placed on the psychiatric morbidity afflicting first responders.[7,13] Post-traumatic stress disorder has been seen in military first responders,[13] but among civilian first responders the evidence collected has not been sufficient to make any significant changes in the management of event response and follow-up of responder health.[7] In some cases, the focus has been on the legal issues involved with mental illness in first responders but does not include detail regarding the types of events and how these outcomes could be prevented.[11]

A comprehensive view of the first responders involved in hazardous substance releases during the years of 1996 through 1998 was completed using some of the earlier HSEES data.[16] During that time span 0.7% of the incidents recorded resulted in first responders becoming victims.[16] They were most likely to report to a hospital for medical attention if they experienced respiratory irritation, headaches, nausea or dizziness.[16] Despite their previous training and access to personal protective equipment (PPE), police officers and firefighters were the most likely out of all first responders to sustain injuries.[16] The authors suggested that a false sense of security due to the access to PPE and training may account for this higher number of injuries.[16] The first responders

were affected primarily by respiratory injury which was also the primary complaint reported by the other types of victims.[16] However, the first responders had no recorded traumas in transportation-related events as opposed to the other types of victims among whom 27% of injuries were classified as trauma.[16]

Many studies have been conducted using the surveillance data gathered by HSEES and NTSIP, and several have focused on certain groups of victims, such as students and school employees,[1,4] or children in general.[14] A small number of studies have focused on responders as victims of specific types of events, such as pesticide exposure[2] and methamphetamine laboratory event exposure.[3] Twelve percent of the hazardous substance event-related injuries in New York from 1993 to 2002 occurred in responders,[15] which was a higher proportion than the 9.2% of victims identifying as responders in 14 states from 1993 to 1997.[10] Less work has been done to characterize the types of hazardous events most frequently affecting responders. An analysis of available HSEES and NTSIP data focused on responders as victims can highlight certain categories of events that cause more injuries to responders and the conclusions can be used to inform responder training.

The objective of this analysis is to determine which types of hazardous substance events more frequently affect responders in order to locate possible weaknesses in responder procedures and inform responder safety training. This will be accomplished by identifying hazardous substance emergency events during which first responders became victims, describing the characteristics of these events and determining whether certain types of hazardous events are associated with responders becoming victims.

Methods

Data

HSEES and NTSIP surveillance data from 15 states, during the period from 1999 through 2011, were used. These states submitted information regarding all hazardous substance events within the state during that time period. The ATSDR definition for a hazardous substance emergency event was used to determine which events would be included in each state's report.[5] This hazardous substance event definition, which has been used consistently throughout the study period, excludes petroleum product-related events unless direct contact with the petroleum-product caused an adverse health effect.[5] For each hazardous substance event recorded, data were collected regarding the timing and location of event, the extent of hazardous substance release, contributing factors (including weather, equipment failure, human error, illegal acts), description of the substance released, victim demographics, types of morbidity and causes of mortality related to the event, and details regarding the response to the event . The specific subset of this surveillance dataset will include events in which responders were recorded as victims. The victim categories analyzed in this subset include responder (not specified), career firefighter, volunteer firefighter, firefighter (unspecified), police officer, and EMT personnel.

All of the data regarding victims are collected by HSEES without any identifying characteristics. Therefore, this analysis is considered non-human subjects research and IRB approval was not required.

Analysis

The data were analyzed using SAS software (version 9) to run multivariate Poisson regression with robust variances and estimate relative risk.[12] Analysis was restricted to data files marked as complete. The independent variables used for the primary analysis are described in Table 1. The dependent variables analyzed included two binary variables - at least one victim (Y,N) and at

least one responder victim (Y,N) - and two continuous variables - one for the number of victims and another for the number of responder victims.

A combined event variable was created to include the independent variables shown to have significant associations with events leading to victims and the number of victims. This combined variable was used to identify the most common combination of event characteristics. Descriptive statistics were then obtained for the three most common events during the study period.

Results

Descriptive Statistics

The dataset analyzed includes 68,426 hazardous substance emergency events which took place during 2002 through 2011 (Figure 1). 18,395 victims were reported to have resulted from 6,756 of events. 739 of the victims were labeled as first responders. Six states (LA, NC, NY, OR, UT, and WI) consistently reported their hazardous substance emergency events throughout the complete time period while other states reported events intermittently (Figure 2). The following descriptive statistics describe events only in the six states listed above. During this time period there was a mean of 0.29 total victims per event and a mean of 0.03 victims classified as responders per event. The mean number of victims ranged from 0.22 to 0.41 with the peak occurring in 2010 (Figure 3, Table 2). The mean number of responder victims ranged from 0.02 to 0.06 with the highest mean occurring in 2011 (Figure 3, Table 2).

The majority of events took place at fixed facilities (22,141 events) with less than one third of events occurring in a transportation system (9,698 events) (Figure 4). Approximately 16% of the events took place on a weekend (5011 events). Most events took place on clear days (84.4%) with precipitation being the second most common weather condition during an event (7.8%) (Figure 5). Equipment failure (47.0%) and human error (39.0%) were the two most common

causes listed (Figure 6). The events occurred mainly in areas classified primarily as industrial (37.3%) or as "other land use," which includes residential, recreational, military and other types of land use (54.5%). Only 7.5% of events occurred in undeveloped areas (Figure 7). The releases were predominantly in the form of a spill (53.9%) or volatilization (34.8%) and in few cases, a combination of the two (3.5%). Fire and/or an explosion were involved in 3.5% of releases while 4.1% were only threatened releases (Figure 8).

Multivariate Analysis

The multivariate analyses described below included events reported from all states.

All Victims

In a multivariate Poisson regression analysis with robust variances, event type, day of the event, weather at the time of the event, cause of the event, land use in the surrounding area and the type of release were significantly associated with one or more victims resulting from an event (Table 3). Specifically, the risk of an event leading to any victims is 1.79 times higher among fixed facility events as compared to transportation events, 1.18 times higher in events occurring on weekends as compared to those occurring on weekdays, slightly lower during precipitation as compared to clear weather (RR 0.90), and 1.53 times higher during natural disasters when compared to clear weather. Releases caused by human error, "other causes", and intentional or illegal events all had a higher risk of leading to any victims than a release caused by equipment failure. However, releases caused by bad weather had a lower relative risk of leading to any victims.

All Responder Victims

Fewer variables were significantly associated with events leading to responder victims (Table 4). Human error, intentional or illegal causes, and bad weather were associated with an increased risk

of an event leading to responder victims. The magnitude of the relative risk of responder victims (5.86) from an intentional or illegal event was much higher than the relative risk of any victims (1.51). Events occurring in industrial areas had a much lower risk of leading to responder victims than events occurring in undeveloped areas (RR 0.30). Spills were not associated with the risk of an event leading to responder victims, but releases through volatilization, combined spill and volatilization and fire/explosion were at increased risk of leading to responder victims than threatened releases.

Number of Victims

The number of victims from a HSEES event was significantly associated with event type, weather, cause, land use, and release type (Table 5). Events occurring at fixed facilities had a higher risk of leading to more victims than transportation events (RR 1.91). Releases during weather conditions classified as "other" were at higher risk of victims when compared to those during clear weather conditions (RR 1.72). Human error and "other causes" were significantly associated with a higher risk of victims while intentional/illegal releases and those caused by bad weather were not significantly associated with higher victim counts compared to events caused by equipment failure. Events in "other land use" areas had a higher risk as compared to undeveloped areas. Spills were not significantly associated with the number of victims at each event, but all other release types had a higher risk of leading to victims than threatened releases.

Number of Responder Victims

The number of responder victims produced by each event was significantly associated with cause of release, land use of the event area, and the type of release (Table 6). Events caused by human error, intentional/illegal release and bad weather had a higher risk of leading to more responder victims when compared to events caused by equipment failure. Events occurring in industrial areas were at lower risk of creating responder victims compared to those occurring in

undeveloped areas. All causes of release aside from spill were significantly associated with the number of responder victims, all having higher relative risks when compared to threatened events. Releases through fire or explosion had the highest relative risk (19.52) of responder victims.

Any Victims vs. Number of Victims

In both categories of all victims and responder victims, more event characteristics were significantly associated with any victims than were associated with a higher number of victims. These variables included several weather, land use and cause of release variables for any victims and a land use variable for responder victims. The variables associated with risk of responder victims were more closely matched among any responder victims and higher numbers of responder victims than among all victims.

Common Events

The three most common event types were identified and descriptive statistics were obtained (Table 7). The most common event type was designated as common event A, which is characterized by fixed facility, clear weather, equipment failure, industrial land use area and volatilization. Common event A made up 15.70% of all events. Common event B took place 7.85% of the time and consists of a transportation event during clear weather caused by human error in an "other land use" area released through a spill. Common event C took place in 5.52% of cases and occurred at fixed facilities, in clear weather, with human error causing a spill in an "other land use" area. Common events A and B led to a lower number of total victims per event as well as responder victims per event than the overall mean among all events. However, common event C led to a higher mean of both total victims per event and responder victims per event.

Discussion

It is not surprising that most events occurred on weekdays since it is more likely for facilities to be operating during the work week. This also makes it more likely that potential victims will be in the vicinity of a release especially if it occurs in an industrial area. There was a slightly higher risk (RR 1.18) of events leading to any victims on weekends when compared to weekdays but a significant association was not present in any of the other victim categories tested. Although insignificant, the risk of an event leading to higher numbers of any victims was lower on weekends (0.93). It is possible that victims were more likely on weekends due to a lack of routine protocols and modes of operation different from the regular workday but perhaps fewer victims resulted from each event simply because fewer people were at the facilities where they would be exposed. The relative risks almost equal to 1 in most victim categories may also indicate that the day of the week was not important in determining the outcome of an event.

Events occurring at fixed facilities (as opposed to transportation event) were more likely to have victims resulting and were associated with a higher number of victims. The higher risk at fixed facility events may be due to the initial confinement of people in the vicinity of the release and possibly a higher concentration of the hazardous exposure if it is contained within the facility and unable to dissipate. This association was only seen with the whole victim population but was not significant among responder victims specifically.

Weather was also significantly associated only with total victims (both the risk of an event leading to any victims and the number of total victims). Precipitation seemed to have a protective effect which may be due to its assistance with decontamination or possible dilution of the hazardous substance. Natural disaster was unsurprisingly associated with an increased risk of an event leading to victims. Natural disasters create their own victims and the response during these

events is more complicated which could increase the time to decontamination and treatment after a release.

Most causes of release were associated with a higher risk of victims when compared to equipment failure. This may be explained by protocols for response within facilities using the equipment. If there is already a protocol in place to manage equipment problems, it is less likely that an event caused by equipment failure would be as unexpected as something caused by human error or an intentional release. If employees working with the equipment are familiar with possible problems, they may be able to deal with the release more rapidly and prevent exposure or initiate evacuation more effectively.

Events occurring in industrial areas showed a significantly lower relative risk of leading to responder victims than events occurring in industrial areas. This protective effect may be due to response protocols within industrial facilities as well as knowledge of infrastructure and evacuation routes when initiating a response. Since industrial facilities working with hazardous materials have plans in place and have knowledge of the substances used within the area, it is more likely that the first responders would have some advance information about the event as opposed to a response in an undeveloped area where the substance is not known nor expected. The “other land use” category showed higher risk regarding the number of all victims than undeveloped areas. It would be expected that undeveloped areas would be less populated than the other land use types and would therefore have fewer potential victims present to be affected by a release.

As expected, all types of release, when compared to a threatened release, were associated with a higher risk of victims being produced by the event. However, spills were not significantly different from threatened releases with regards to the number of total victims, the number of

responder victims, and the outcome of any responder victims. The easier containment of spills (as opposed to volatilization or fire/explosion) may be the reason for the lower number of victims in these circumstances. Events caused by fire or explosion showed a much higher risk for more responder victims (RR 10.97 for any responder victims, RR 19.52 for the number of responder victims). The response to a fire or explosion itself is inherently more dangerous for the people involved and the addition of a hazardous substance would increase the threat of injury. It is also more likely to call for a larger number of responders to the scene of a fire or explosion, putting more people at risk of becoming victims.

More event characteristics were significantly associated with events resulting in any victims rather than a higher number of victims (both any victims and responder victims). This would suggest that the number of victims is not necessarily determined by the type of event but instead by other factors not measured in this study, possibly including the population density in the surrounding areas and the number of employees at each location. The occurrence of any victims (both responder and non-responder) seems to be determined in part by the variables analyzed. The risks for responder victims were more similar than the risks of all victims when comparing the outcomes of any responder victim to the outcome of higher numbers of responder victims. This may be due to a more uniform number of responders dispatched to a scene than the number of other people exposed at the scene. This may also result from the training and experience of the responders: if the event is severe enough to cause any responder victims despite their training, it may be likely to lead to a high number of responder victims as well.

The two most common events identified (Table 7), showed lower mean total victims per event and responder victims per event when compared to the mean victims of all events. Since these two events (A and B) are so common, potential victims working with hazardous substances may be better prepared to deal with a release and responders may have more experience with

managing these events. It is not surprising that the two most common events lead to fewer victims. However, common event C, which accounted for 5.52% of the total events, led to a higher number of total victims and even responder victims. The only difference between common events B and C is the event type. Common event C is a fixed facility event which has been shown to have a higher risk of victims than a transportation event. The transportation aspect of common event B may be protective bringing mean number of victims per event down when all of the other conditions are equal.

This study is limited by the lack of knowledge of the total number of potential victims (both responders and non-responders) exposed at each event. The collection of data describing exposed non-victims is difficult to implement since exposure areas can be large and people who may have been unknowingly exposed are unlikely to seek medical attention or identify themselves to state authorities if they are asymptomatic. Because of this limitation, the total victims and the responder victims were analyzed separately.

Many hazardous substance emergency event parameters are associated with the risk of an event leading to victims. The outcome of responder victims and the number of responder victims are related to the land use of the site of release, the cause of the release and the type of release. Situations that can be easily predicted, such as the most common events, and more quickly controlled, such as those occurring in industrial areas, lead to fewer victims. The events caused by fire and explosion had the strongest measure of association with responder victim outcomes. These events are inherently dangerous but it may be worth focusing more training and preparation efforts on this type of release to mitigate some of the threat to the responders.

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Tables and Figures

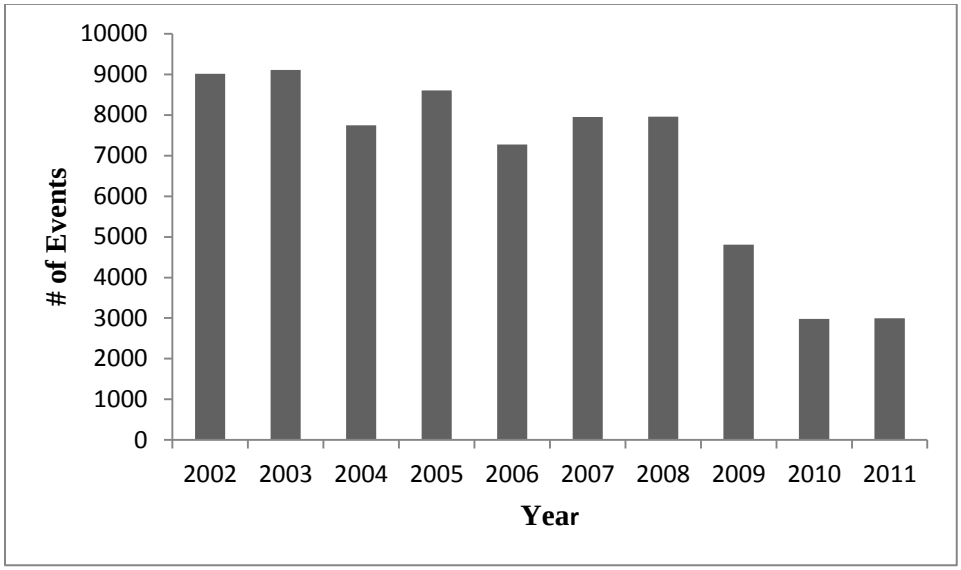

Figure 1. Hazardous Substance Emergency Events Reported by Year in All 15 States, 2002-2011.

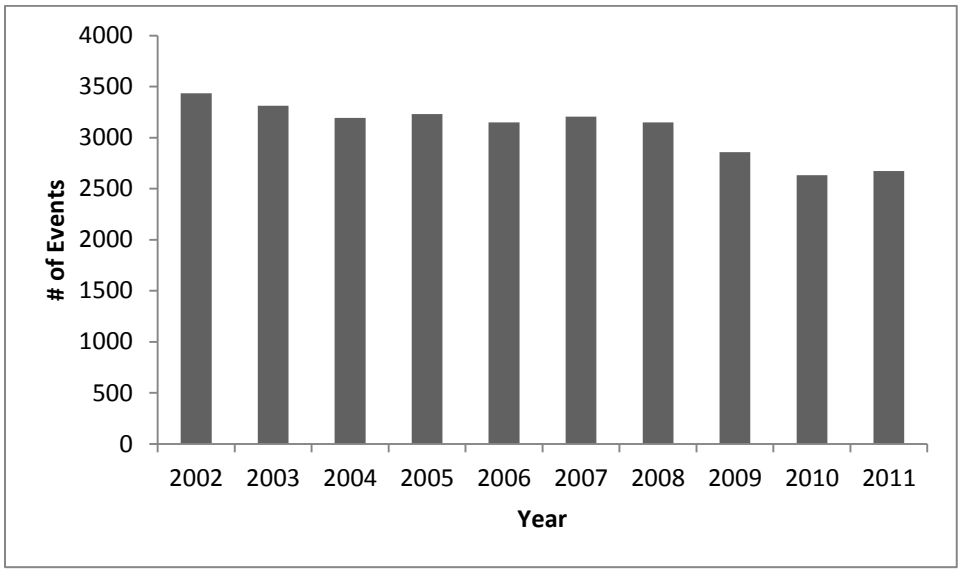

Figure 2. Hazardous Substance Emergency Events Reported by Year in Six States, 2002-2011.

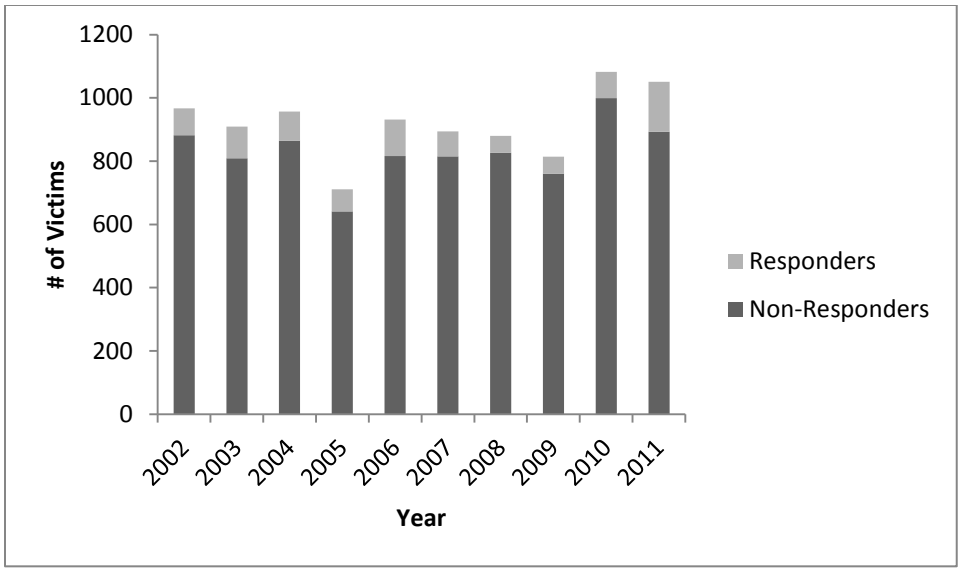

Figure 3. Victims of HSEES Events by Year and Responder Status in Six States.

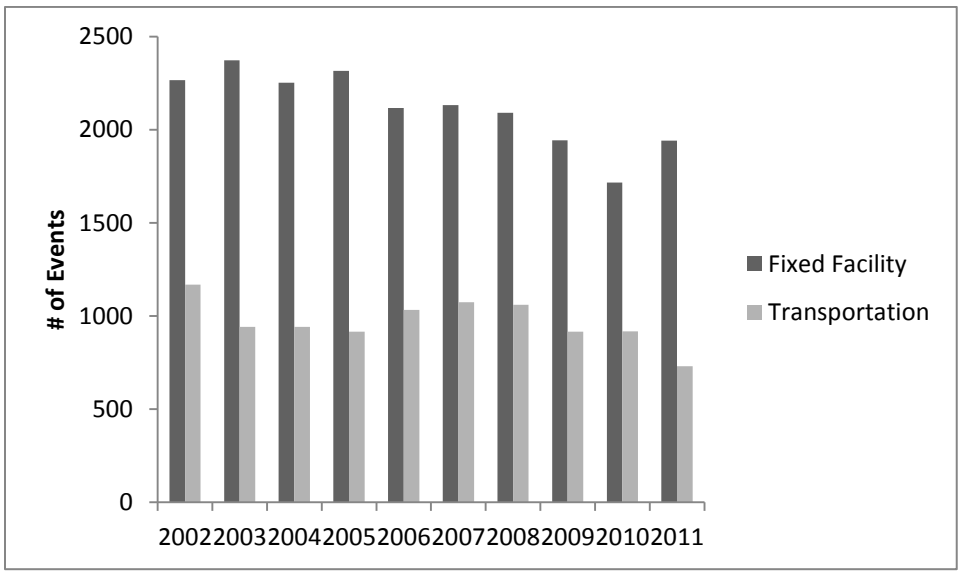

Figure 4. Number of Events by Type and Year in Six States.

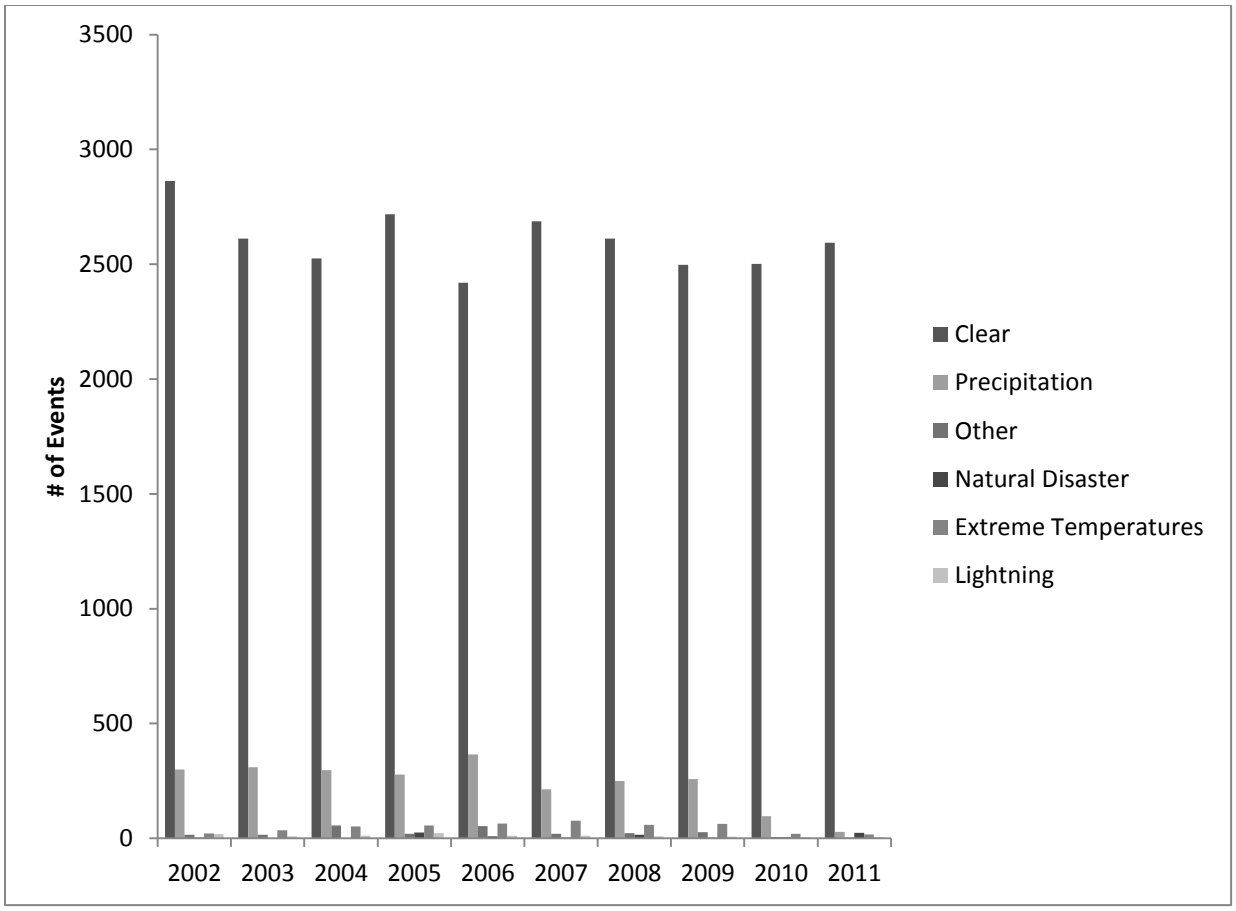

Figure 5. Number of HSEES Events by Primary Weather Condition by Year in Six States.

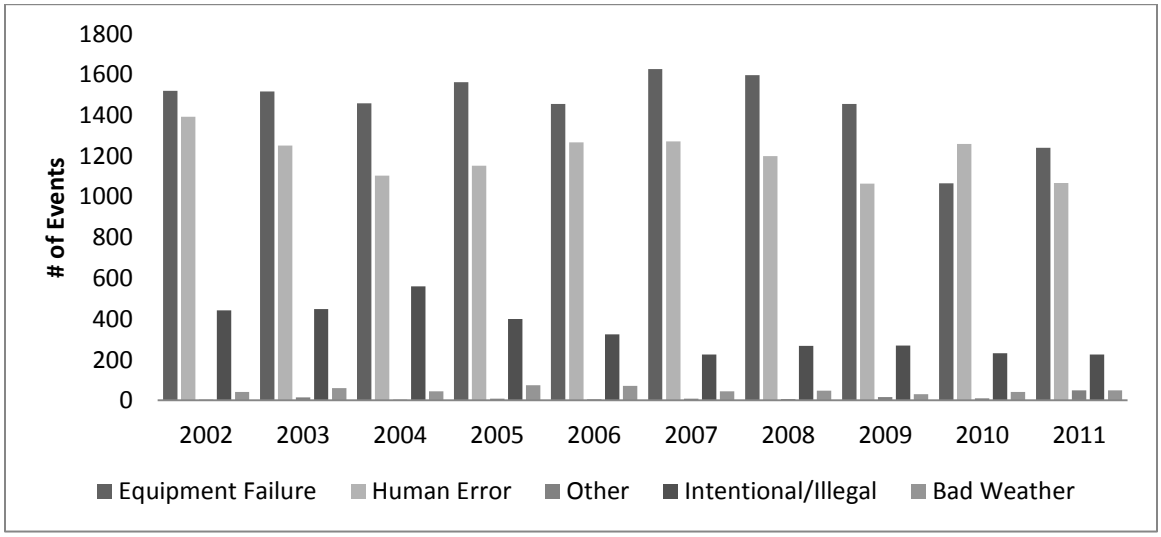

Figure 6. Number of Events by Release Cause by Year in Six States.

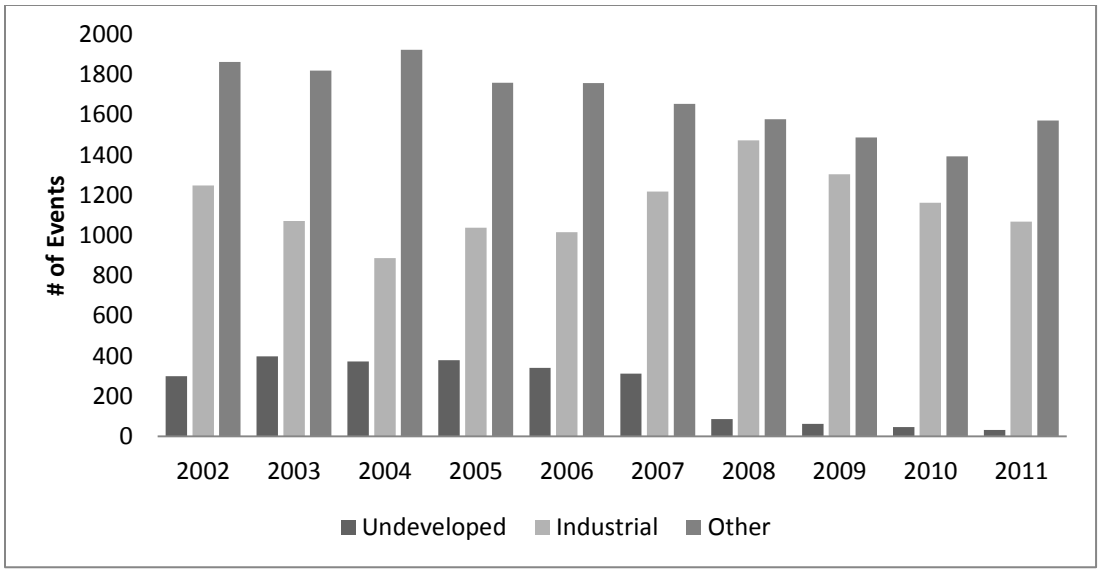

Figure 7. Number of Events by Land Use Classification by Year in Six States.

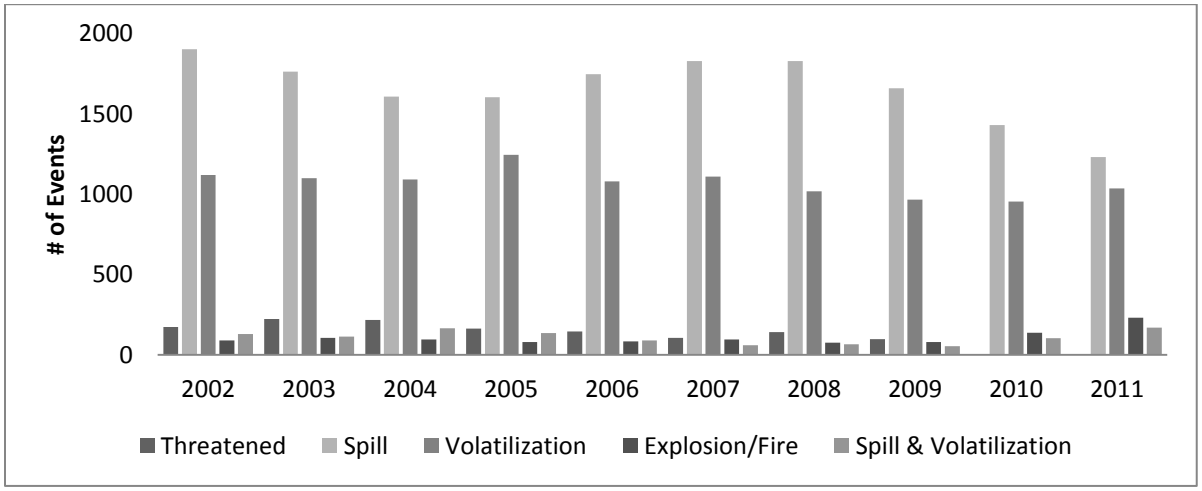

Figure 8. Number of Events by Type of Release by Year in Six States.

Table 1. HSEES Event Independent Variables Used in Multivariate Analysis	
Variable	**Categories**
Event Type	Fixed Facility Transportation
Day	Weekend Weekday
Weather	Clear Precipitation Natural Disaster Extreme Temperatures Lightning Other Weather
Land Use	Undeveloped Industrial Other Land Use
Cause	Equipment Failure Human Error Intentional/Illegal Bad Weather Other Cause
Release Type	Spill Volatilization Spill and Volatilization Fire or Explosion Threatened Release

Table 2. Victims of HSEES Events by Year in Six States			
Year	**# of Events**	**Mean Victims Per Event**	**Mean Responder Victims Per Event**
2002	3434	0.28	0.02
2003	3313	0.27	0.03
2004	3194	0.30	0.03
2005	3230	0.22	0.02
2006	3149	0.30	0.04
2007	3206	0.28	0.02
2008	3150	0.28	0.02
2009	2858	0.28	0.02
2010	2633	0.41	0.03
2011	2672	0.39	0.06
Total	30839	0.29	0.03

Table 3. Any Victims Resulting from HSEES Events by Event Characteristics in All 15 States			
Variable	**Relative Risk**	**95% Confidence Interval**	
Event Type (Reference=Transportation)			
Fixed Facility	1.79	1.67	1.93
Timing (Reference=Weekday)			
Weekend	1.18	1.12	1.24
Weather (Reference= Clear)			
Precipitation	0.90	0.83	0.97
Natural Disaster	1.53	1.37	1.71
Extreme Temperatures	0.79	0.62	1.00
Lightning	0.41	0.10	1.62
Other Weather	1.17	0.95	1.45
Cause (Reference= Equipment Failure)			
Human Error	3.37	3.16	3.59
Intentional/Illegal	1.51	1.39	1.65
Bad Weather	0.71	0.53	0.93
Other Cause	2.51	2.02	3.13
Land Use (Reference= Undeveloped)			
Industrial	0.52	0.46	0.59
Other Land Use	2.13	1.88	2.42
Type of Release (Reference=Threatened)			
Spill	1.31	1.06	1.63
Volatilization	3.68	2.98	4.54
Spill and Volatilization	3.36	2.70	4.17
Fire or Explosion	5.45	4.40	6.768

Table 4. Any Responder Victims Resulting from HSEES Events by Event Characteristics in All 15 States			
Variable	**Relative Risk**	**95% Confidence Interval**	
Event Type (Reference=Transportation)			
Fixed Facility	1.015	0.79	1.30
Timing (Reference=Weekday)			
Weekend	1.04	0.86	1.27
Weather (Reference= Clear)			
Precipitation	0.78	0.58	1.04
Natural Disaster	0.60	0.19	1.84
Extreme Temperatures	0.27	0.07	1.11
Lightning	1.04	0.14	7.99
Other Weather	1.63	0.85	3.15
Cause (Reference= Equipment Failure)			
Human Error	3.15	2.45	4.06
Intentional/Illegal	5.86	4.56	7.53
Bad Weather	2.66	1.36	5.18
Other Cause	1.65	0.61	4.44
Land Use (Reference= Undeveloped)			
Industrial	0.30	0.19	0.46
Other Land Use	2.31	1.56	3.40
Type of Release (Reference=Threatened)			
Spill	0.82	0.45	1.49
Volatilization	6.97	3.97	12.23
Spill and Volatilization	4.62	2.58	8.28
Fire or Explosion	10.97	6.26	19.24

Table 5. Number of Victims Resulting from HSEES Events by Event Characteristics in All 15 States			
Variable	**Relative Risk**	**95% Confidence Interval**	
Event Type (Reference=Transportation)			
Fixed Facility	1.91	1.61	2.26
Timing (Reference=Weekday)			
Weekend	0.93	0.83	1.05
Weather (Reference= Clear)			
Precipitation	0.90	0.77	1.06
Natural Disaster	1.07	0.76	1.52
Extreme Temperatures	1.40	0.67	2.94
Lightning	0.34	0.08	1.42
Other Weather	1.72	1.09	2.71
Cause (Reference= Equipment Failure)			
Human Error	2.57	2.18	3.03
Intentional/Illegal	1.16	0.95	1.41
Bad Weather	0.79	0.44	1.40
Other Cause	1.97	1.23	3.16
Land Use (Reference= Undeveloped)			
Industrial	0.75	0.57	1.00
Other Land Use	3.38	2.57	4.45
Type of Release (Reference=Threatened)			
Spill	0.83	0.47	1.45
Volatilization	4.13	2.40	7.11
Spill and Volatilization	3.95	2.27	6.86
Fire or Explosion	5.42	3.14	9.35

Table 6. Number of Responder Victims Resulting from HSEES Events by Event Characteristics in All 15 States			
Variable	**Relative Risk**	**95% Confidence Interval**	
Event Type (Reference=Transportation)			
Fixed Facility	1.08	0.74	1.58
Timing (Reference=Weekday)			
Weekend	1.06	0.78	1.43
Weather (Reference= Clear)			
Precipitation	0.83	0.53	1.32
Natural Disaster	0.96	0.23	4.02
Extreme Temperatures	0.27	0.05	1.47
Lightning	0.83	0.10	6.90
Other Weather	1.65	0.68	4.02
Cause (Reference= Equipment Failure)			
Human Error	2.99	1.99	4.49
Intentional/Illegal	4.00	2.75	5.82
Bad Weather	3.76	1.53	9.25
Other Cause	1.71	0.52	5.60
Land Use (Reference= Undeveloped)			
Industrial	0.23	0.11	0.45
Other Land Use	1.50	0.77	2.91
Type of Release (Reference=Threatened)			
Spill	0.76	0.37	1.57
Volatilization	7.11	3.68	13.74
Spill and Volatilization	4.75	2.42	9.31
Fire or Explosion	19.52	10.05	37.93

Table 7. Common HSEES Events: Frequency and Number of Victims in All 15 States				
Event Type	**# of Events**	**% of Events**	**Mean Victims/Event**	**Mean Responder Victims/Event**
Common Event A	10744	15.70%	0.064	0.002
Common Event B	5370	7.85%	0.095	0.003
Common Event C	3780	5.52%	0.327	0.012
A= fixed facility, clear weather, equipment failure, industrial land use area, volatilization B= transportation, clear weather, human error, "other" land use area, spill C= fixed facility, clear weather, human error, "other" land use area, spill				