Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH Technical Assistance Report: Assessment of Emergency Responders Following Vinyl Chloride Release from a Train Derailment—New Jersey, 2012

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Introduction

Over 2.5 million emergency responders in the United States face hazardous exposures while on duty [NIOSH 2013a], and this population has been identified as having the greatest risk of exposure during a disaster [Pak et al. 2008]. Responders to a chemical release following a train derailment must immediately assess the risks by gathering information about the situation, analyzing available options, and taking action to implement decisions to protect themselves, the public, other responders, and the environment [NIOSH 2004]. This report describes the events of a 2012 vinyl chloride release, defines its impact on local emergency responders, and offers recommendations for responder safety and health in similar incidents.

On November 30, 2012, around 7:00 a.m., a railway bridge collapsed, derailing a train in Paulsboro, New Jersey. Four tank cars, including a breached tank car carrying vinyl chloride, landed in a tidal creek. Crews responded from city, township, county, state, and federal agencies. A Unified Command (UC) was established to manage the incident, which included the United States Coast Guard, New Jersey Department of Environmental Protection, New Jersey Office of Emergency Management, Paulsboro Fire Department, and Conrail [Conrail 2012].

Shortly after responders arrived on scene, they reported seeing a “cloud of fog” that hovered over the area. Initially, after identifying the “fog” as vinyl chloride, a shelter-in-place order was implemented for residents within a half mile of the incident. Vinyl chloride is peroxidizable, and forms explosive polymeric peroxides in the air [Bretherick 1979], which caused concern that residents starting their vehicles might ignite the vinyl chloride. Around 4:00 p.m. on November 30, UC reported an acute increase in ambient air vinyl chloride levels, thought to be related to changing weather conditions. An evacuation of residents in the immediate area was ordered.

Vinyl chloride is a colorless gas with a mild, sweet odor that is used to make polyvinyl chloride for production of plastic goods. Vinyl chloride is an acute respiratory irritant and neurotoxin. Neurological symptoms associated with vinyl chloride exposure include headache, drowsiness, and dizziness. Although studies have revealed that chronic occupational exposures can result in liver damage, accumulation of fat in the liver, tumors (including angiosarcoma of the liver), and death of liver cells [ATSDR 2006], acute exposures have not been well studied.

On December 7, 2012, the New Jersey Department of Health (NJ DOH) requested assistance from the Centers for Disease Control and Prevention (CDC), including the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH). A team from these agencies deployed to New Jersey to assist the NJ DOH with the investigation on December 11. Objectives of the investigation were to (1) characterize exposure to vinyl chloride and resulting health effects; (2) assess the occupational health and safety of emergency personnel who responded to the incident; and (3) describe the response to the incident and develop recommendations for public health preparedness and response to chemical releases with mass casualty potential. This report focuses on the second objective.

Methods

A cross-sectional survey was created with a questionnaire adapted from the ATSDR Assessment of Chemical Exposures (ACE) toolkit [ATSDR 2013] to assess communication during the emergency response, occupational health factors, and acute health effects for the emergency responders who worked in the evacuation zone between November 30 and December 7, 2012. Meetings were held with UC, emergency response leaders, and local responders. Emergency responders completed the surveys during these meetings, and those who did not attend had the option of mailing in a survey.

The survey included questions addressing demographics and emergency response roles, activities, and experiences. Responders were categorized by profession, including Emergency Medical Services (EMS), firefighters, police officers, and hazardous material (HAZMAT) technicians. Because a typical work shift lasts 12 hours, participants were categorized by duration of exposure: those who worked a total of ≤12 hours and those who worked >12 hours in the evacuation zone throughout the entire eight-day period.

Symptoms were grouped according to clinical presentation. Neurological symptoms included dizziness, weakness, and loss of balance. Upper respiratory symptoms included runny nose, burning nose or throat, and hoarseness, whereas lower respiratory symptoms included shortness of breath, chest tightness, wheezing, and burning lungs. Coughing, increased congestion, and increased phlegm are presented separately from other respiratory indicators because their cause could be upper or lower respiratory in nature. Headache; nausea and vomiting; irritation, pain, or burning of the eyes and skin; and diarrhea were also reported.

Utilization of medical care and personal protective equipment (PPE), including respiratory protection, was assessed. In addition, respondents were asked questions to evaluate preparedness training and their perceptions of the response. Questions pertaining to medical history prior to the event and mental health status after the response were examined as well. Finally, the emergency responders' perceptions of the response and interagency communication were assessed.

A bivariate analysis was conducted with SAS software version 9.3 (SAS Institute, Cary, NC) and OpenEpi software (CDC, Atlanta). Prevalence odds ratios (PORs) and 95% confidence intervals (CIs) of associated symptoms were computed with use of Fisher's exact test.

Results

Demographics

A total of 93 surveys were completed. Ninety-six percent of respondents were male and Caucasian. The median age of respondents was 42 years (range, 19–78 years), and the majority of respondents were between the ages of 25 and 54 years (Table 1). Respondents' level of education and role in the emergency response are shown in Table 1. Of 92 respondents who reported the number of hours worked in the evacuation zone, 44 (48%) spent >12 hours at the site, and 48 (52%) spent 1–12 hours at the site.

Table 1. Select characteristics of emergency responders

Characteristic	No. (%)
Age, years	n = 89
19–24	8 (9)
25–34	20 (22)
35–44	23 (26)
45–54	21 (24)
55–64	11 (12)
≥65	6 (7)
Education	n = 92
University/college graduate	16 (17)
Some college/technical school	59 (64)
High school graduate or equivalent	13 (14)
Some High School	4 (4)
Responder Role	n = 93
Firefighter	60 (65)
Police officer	17 (18)
Hazardous materials (HAZMAT) technician	13 (14)
Emergency medical services (EMS)	3 (3)

Symptoms

Figure 1 displays self-reported symptoms of emergency responders. The most frequent symptoms were headache (24), upper respiratory symptoms (24), and lower respiratory symptoms (20). Fifteen respondents reported coughing; 14, neurological symptoms; and 14, nausea and vomiting. Eleven each reported increased congestion or phlegm as well as irritation, pain, or burning of the eyes. Other reported symptoms include irritation, pain, or burning of the skin (2%) and diarrhea (1%).

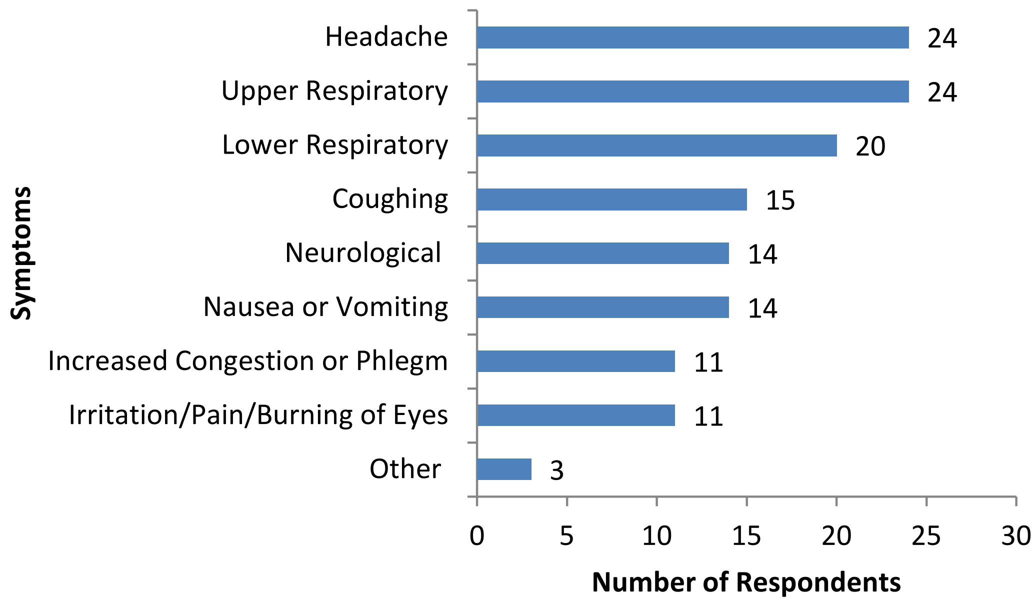

Figure 1. Self-reported symptoms of emergency responders (categories are not mutually exclusive)

Table 2 shows the prevalence odds ratios for symptoms. Lower and upper respiratory symptoms; irritation, pain, or burning of the eyes; and headache were significantly associated with an exposure >12 hours.

Table 2. Odds of reporting these selected symptoms, by hours worked (>12 versus $\leq$12) in evacuation zone

Symptoms	Prevalence Odds Ratio	95% Confidence Interval
Lower respiratory	14.1	3.0–135.0
Irritation, pain, or burning of eyes	5.8	1.1–58.6
Upper respiratory	3.9	1.3–13.9
Headache	3.6	1.2–11.8
Coughing	3.2	0.8–15.2
Neurological	3.2	0.8–15.2
Increased congestion or phlegm	2.8	0.6–18.0
Nausea or vomiting	2.2	0.6–9.1

Medical Care

Ninety-one respondents answered the following question: “Did you receive medical care or a medical evaluation because of the incident?” Of those, 21 (23%) reported seeking medical care. Table 3 lists the main reasons the other 70 respondents did not seek medical care. The most common reason was that they did not have symptoms (34%).

Table 3. Reasons respondents did not seek medical care (n = 70)

Reason	No. (%)
Did not have symptoms	24 (34)
Other reason*	18 (26)
Symptoms were not bad enough	12 (17)
None indicated	8 (11)
Unsure	5 (7)
Did not want to take time	2 (3)
Do not like to go to the doctor	1 (1)

*Other reason:

Not necessary, on the basis of information provided by administrators early on in response	6 (9)
Not offered or recommended	6 (9)
Urine test performed by third-party consultant	2 (3)
Not sure symptom was related to incident	1 (1)
Told by management not to document and to await administrative decisions	1 (1)
Emergency department would be crowded	1 (1)
Not provided with any information	1 (1)

Personal Protective Equipment

Ninety-two respondents marked an answer when asked to look at a list of PPE and identify what level they wore when responding to the incident. Twenty-one (23%) respondents reported wearing no PPE (Figure 2). Twenty-two percent of respondents used firefighter turn-out gear without respiratory protection, whereas 12% reported using firefighter turnout gear with respiratory protection. Many respondents (37%) indicated use of Level D protection, which consists of a work uniform [OSHA 1994]. Other respondents noted use of Level C (2%) and Level B (1%) protection. Level A, the highest level of protection, was not used. Table 4 displays PPE use by profession. Three respondents (3%) reported using other forms of PPE, including coveralls, gloves, safety glasses, composite-toed shoes, and hard hats.

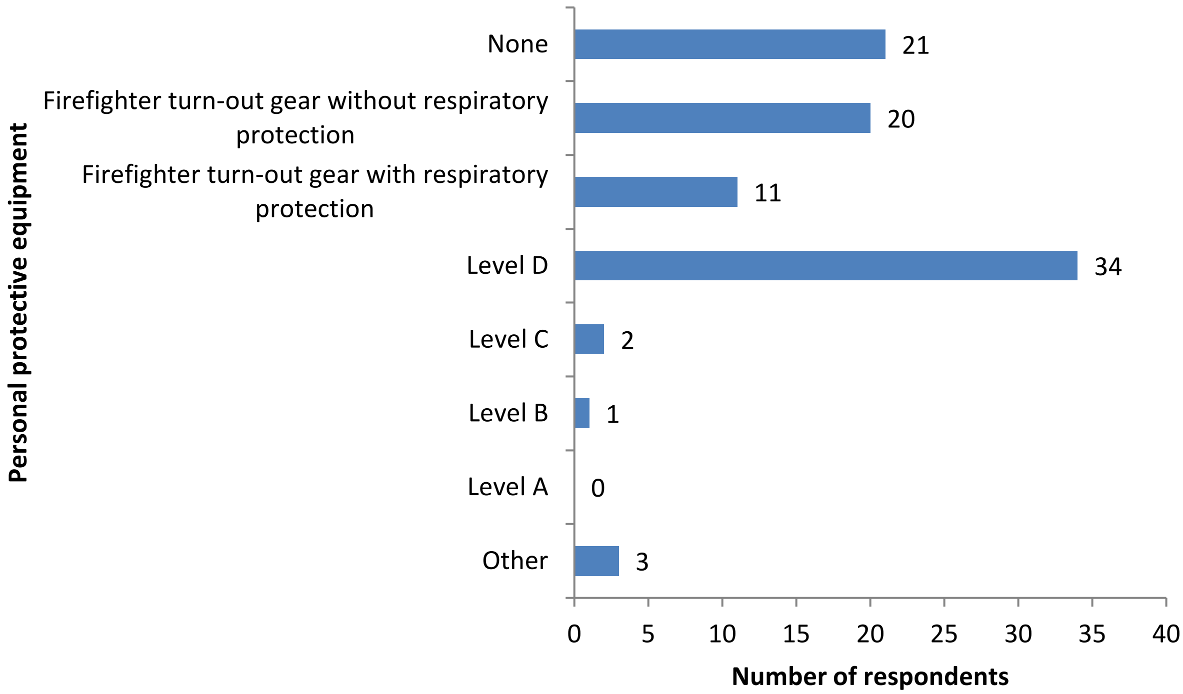

Figure 2. Personal protective equipment* use among respondents (n = 92)

General use of PPE levels (not specific to vinyl chloride)
Level A: Recommended when greatest potential for exposure to skin and respiratory system exists
Level B: Recommended when highest level of respiratory protection is indicated but skin at a lesser level
Level C: Recommended when concentration/type of substance is known and criteria for respiratory use are met
Level D: Recommended when minimum protection is required
[EPA 2011]

Table 4. Personal protective equipment (PPE)* use, by profession (Total n = 92)

PPE Used	Number (%) of Responders			
	Firefighter n = 59	Police Officer n = 13	Emergency Medical Services (EMS) Technician n = 17	Hazardous Materials (HAZMAT) Technician n = 3
None	6 (10)	11 (85)	3 (18)	1 (33)
Level A	0 (0)	0 (0)	0 (0)	0 (0)
Level B	1 (2)	0 (0)	0 (0)	0 (0)
Level C	1 (2)	0 (0)	1 (6)	0 (0)
Level D	17 (29)	2 (15)	13 (76)	2 (67)
Firefighter gear with respiratory protection	11 (19)	0 (0)	0 (0)	0 (0)
Firefighter gear without respiratory protection	20 (34)	0 (0)	0 (0)	0 (0)

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[EPA 2011]

When respondents were asked a separate question about respirator types, 20 respondents (22%) indicated donning a self-contained breathing apparatus (SCBA) during the response, although it is unclear at what point they were used. Some respondents answered that they did use respiratory protection, but the respirator was donned later in the response and not upon initial arrival at the incident. Of these 20 respondents, 1 (5%) was an EMS worker, 1 (5%) was a police officer, 2 (10%) were HAZMAT technicians, and 16 (80%) were firefighters. Among the 16 firefighters, one reported using both an SCBA and a powered air-purifying respirator, and another reported using a full-face air-purifying respirator. One EMS responder also reported using an air-purifying respirator.

Of all respondents (n=72) who reported not wearing respiratory protection upon **initial** arrival at the evacuation zone, 35 (49%) stated that it wasn't required for their work (Figure 3). Because respondents were allowed to select more than one answer, the number of reasons reported is greater than the total number of respondents.

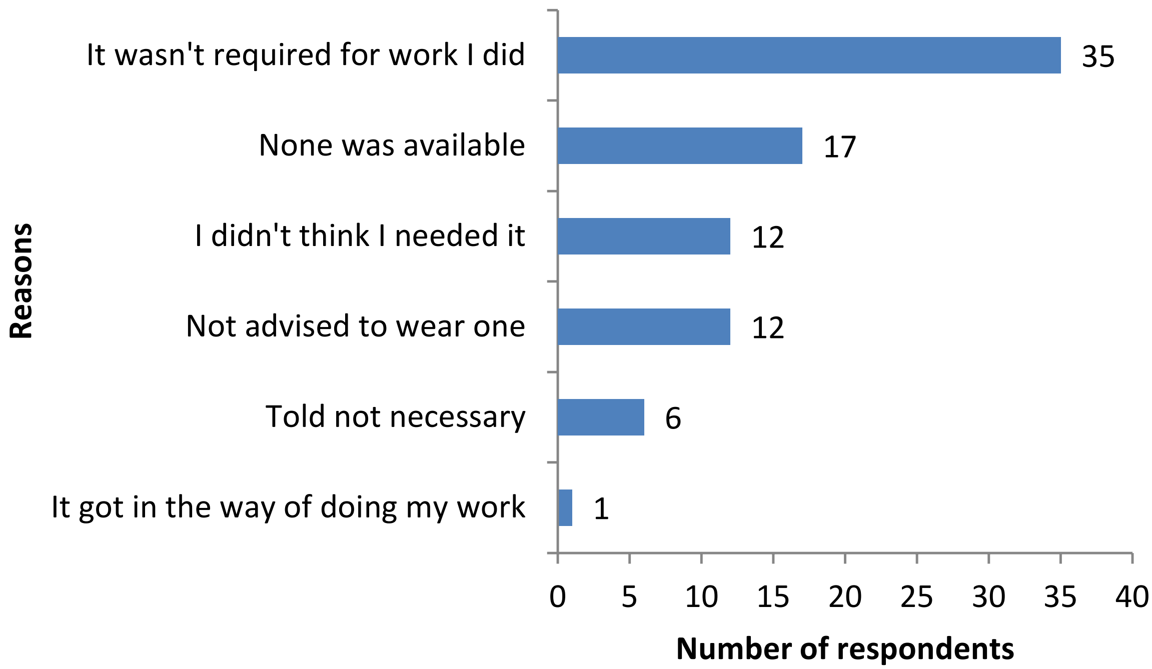

Figure 3. Reasons respondents did not wear a respirator (categories are not mutually exclusive)

Training

Eighty percent of respondents reported that they received training in first responder awareness, 52% in first responder operations, 27% in hazardous materials for technicians, and 27% in hazardous waste operations and emergency response (HAZWOPER). Table 5 shows the types of training by profession. A smaller proportion of respondents reported taking annual refresher coursework in those areas: first responder awareness (67%), first responder operations (38%), hazardous materials for technicians (17%), and HAZWOPER (19%).

Table 5.Training reported, by profession (n = 93)

Training	Number (%) of Respondents			
	Firefighter (n = 60)	Police officer (n = 13)	Emergency medical services (EMS) technician (n = 17)	Hazardous materials (HAZMAT) technician (n = 3)
First responder awareness	48 (80)	11 (85)	13 (76)	2 (67)
Refresher	41 (68)	8 (62)	11 (65)	2 (67)
First responder operations	34 (57)	4 (31)	8 (47)	2 (67)
Refresher	27 (45)	2 (15)	4 (24)	2 (67)
HAZMAT*	17 (28)	1 (8)	4 (24)	3 (100)
Refresher	9 (15)	2 (15)	3 (18)	2 (67)
HAZWOPER†	19 (32)	0 (0)	0 (0)	1 (33)
Refresher	13 (22)	0 (0)	0 (0)	1 (33)

*Hazardous materials technician training
†Hazardous waste operations and emergency response standard training

Emergency Response

Respondents were asked to evaluate the emergency response process on a 5-point Likert scale. The statement "There were no significant shortcuts or compromises taken when worker safety was at stake" yielded the following responses: 37 (40%), "Strongly agree" or "Agree"; 46 (50%), "Strongly disagree" or "Disagree"; and 9 (10%), "Don't know." The statement "I had the training I needed/need to perform my job safely and competently" yielded these responses: 76 (82%), "Strongly agree" or "Agree"; 15 (16%), "Strongly disagree" or "Disagree"; and 1 (1%), "Don't know." Table 6 includes additional questions and answers pertaining to emergency responder training and safety.

Table 6. Respondents' perceptions of emergency responder training and safety

Perception	No. (%) of Respondents				
	All of the time	Most of the time	Some of the time	A little of the time	None of the time
Safety issues are given a high priority in training programs (n = 91)	52 (57)	23 (25)	10 (11)	6 (7)	0 (0)
Workplace health and safety training covers the types of situations that employees encounter in their jobs (n = 91)	33 (36)	29 (32)	22 (24)	7 (8)	0 (0)
Employees receive comprehensive training in workplace health and safety issues (n = 90)	32 (36)	28 (31)	21 (23)	6 (7)	3 (3)
Employees have sufficient access to workplace health and safety training programs (n = 91)	52 (57)	35 (38)	3 (3)	1 (1)	0 (0)
I know how to perform my job in a safe manner (n = 91)	52 (57)	35 (38)	3 (3)	1 (1)	0 (0)
I know how to use safety equipment and standard work procedures (n = 92)	56 (61)	30 (33)	4 (4)	2 (2)	0 (0)
I know how to maintain or improve workplace health and safety (n = 91)	47 (52)	36 (40)	5 (5)	3 (3)	0 (0)

Respondents were asked, "How would you rate your current state of interagency communications with other first responders on a scale of 1–10," with 1 representing the lowest score and 10 representing the highest score? Firefighters and EMS workers each rated a median score of 7, with a range of 1–10; police officers rated a median score of 6, with a range of 3–8; and HAZMAT technicians rated a median score of 4, with a range of 3–5.

Discussion

This report is the first attempt to document health effects among emergency responders who were in the evacuation zone during the vinyl chloride release. To prepare for future incidents, the response agencies involved should consider implementing the Emergency Response Health Monitoring and Surveillance (ERHMS) system for future incidents [NIOSH 2013b]. ERHMS is a framework that includes recommendations and specific tools to protect emergency responders during all phases of a response, including pre-deployment, deployment, and post-deployment. The pre-deployment phase encompasses rostering and credentialing, health screening, and safety training for emergency responders prior to an event. When a disaster occurs, the deployment phase of ERHMS includes in-processing of responders, health monitoring and surveillance, exposure assessment, and documentation of results. Finally, in the post-deployment phase, responders are out-processed and the need for further health tracking is assessed. ERHMS may help workers maintain their ability to respond effectively and reduce their chances of being harmed during a response.

Acute symptoms of vinyl chloride exposure were common among emergency responders and were associated with a longer exposure period. The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for vinyl chloride is 1 part per million (ppm), based on an 8-hour time-weighted average [OSHA 2012].

NIOSH recommends reducing vinyl chloride exposures to the lowest feasible concentration, as it has been designated a potential occupational carcinogen. In an emergency response, appropriate respiratory protection is necessary because of not only potential health effects but also highly variable and unpredictable environmental concentrations at the disaster site. Consult the NIOSH Pocket Guide for additional information on vinyl chloride and respiratory protection recommendations [NIOSH 2005].

Unfortunately, no personal breathing zone measurements of responders' exposure to vinyl chloride were available to us. Therefore, it is difficult to directly correlate vinyl chloride exposure levels with symptoms. On the basis of the OSHA and NIOSH guidance referenced above, respiratory protection would likely have been required for many first responders, although proximity to the evacuation zone and assigned job task could be used as a proxy indicator for respirator use. According to OSHA regulations, "employees engaged in emergency response and exposed to hazardous substances presenting an inhalation hazard or potential inhalation hazard shall wear positive pressure [SCBA] while engaged in emergency response, until such time that the individual in charge of the incident command system determines through the use of air monitoring [that] a decreased level of respiratory protection will not result in hazardous exposures to employees" [29 CFR 1910.120]. The implementation of a respiratory protection program, including the use of exposure monitoring to determine when respirator use is required, may assist emergency responders in future events.

OSHA training requirements vary by responder role and are based on duties performed by each responder [29 CFR 1910.120]. First responder awareness training is intended for individuals who are likely to witness or discover a hazardous substance release and initiate notification of proper authorities. First responder operation training is for individuals who respond to releases and are responsible for protecting nearby persons, property, or the environment. HAZMAT and HAZWOPER trainings are for individuals who must have a direct and specific knowledge about hazardous substances. The determination of appropriate level of training, including annual refresher training, should be evaluated and documented.

Our assessment had several limitations. An accurate count of the number of emergency responders who worked in the evacuation zone and the time period over which work shifts occurred were unavailable. Selection bias is likely in that our sample consisted of emergency responders who attended the scheduled meetings and completed the survey there or who obtained surveys from emergency response leaders and mailed them in. The small number of participants prevents us from meaningfully analyzing the associations between respirator use and symptoms.

Our investigation had several strengths, however. First, it allowed us to describe the respondents who arrived at the evacuation zone after the release and later completed the survey. We were able to collect prevalence information about acute health effects, medical evaluations, and use of PPE. Finally, we were able to capture respondents' perceptions, attitudes, and beliefs about training and safety prior to, during, and after the response.

Conclusions

Acute symptoms of vinyl chloride exposure were common. The most frequently reported symptoms include headache, upper respiratory illness, and lower respiratory illness. Although symptoms of vinyl chloride exposure followed the release, only 23% of respondents sought medical care, indicating that in most cases the symptoms may have been transient. The majority of respondents did not use respiratory protection, but most respondents reported receiving some emergency responder training and felt they had sufficient instruction, indicating a possible gap in perception of risk.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the various departments to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation.

- Promptly implement ERHMS (http://www.cdc.gov/niosh/topics/erhms/).
- Use respiratory protection until engineering controls and work practices can be implemented that reduce employee exposure to below the appropriate occupational exposure limit (OSHA PEL or NIOSH recommended exposure limit). Implementation should follow the OSHA respiratory protection standard [29 CFR 1910.134]. An SCBA should be used when exposure levels are unknown or until they have been measured to be below the appropriate occupation exposure limit.
- Evaluate training needs for all emergency response roles.

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