

Acute Pesticide-Related Illness Among Emergency Responders, 1993–2002

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Background Emergency responders are among the first to arrive at a pesticide-related release event. Magnitude, severity, and risk factor information on acute pesticide poisoning among those workers is needed.

Methods Survey data collected from the SENSOR-Pesticides, CDPR and HSEES programs between 1993 and 2002 from 21 states were reviewed. Acute occupational pesticide-related illness incidence rates for each category of emergency responder were calculated, as were incidence rate ratios (IRR) among emergency responders compared to all other workers employed in non-agricultural industries.

Results A total of 291 cases were identified. Firefighters accounted for 111 cases (38%), law enforcement officers for 104 cases (36%), emergency medical technicians for 34 cases (12%), and 42 cases (14%) were unspecified emergency responders. Among the 200 cases with information on activity responsible for exposure, most were exposed while performing activities related to a pesticide release event (84%) and not involving patient care, while the remainder involved exposure to pesticide-contaminated patients. A majority of cases were exposed to insecticides (51%). Most had low severity illnesses (90%). The incidence rate was highest for firefighters (39.1/million) and law enforcement officers (26.6/million). The IRRs were also elevated for these professions (firefighters, $IRR = 2.67$; law enforcement officers, $IRR = 1.69$).

Conclusions The findings suggest the need for greater efforts to prevent acute occupational pesticide-related illness among emergency responders. Am. J. Ind. Med. 49:383–393, 2006. Published 2006 Wiley-Liss, Inc.†

KEY WORDS: pesticides; poisoning; police; fire; emergency medical technicians

INTRODUCTION

Pesticides are ubiquitous in our society. Given their pervasiveness, events involving an uncontrolled release of

pesticides will arise through fires involving warehouses where pesticides are stored, highway spills during transport, unintentional drift of pesticides from farm fields, and intentional contamination of an individual during a suicide

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attempt. Emergency responders, such as firefighters, police officers, and emergency medical technicians, are among the first to arrive to the scene of a pesticide-related emergency event. Anecdotal information indicates that these exposures have sometimes led to illness among emergency responders [Merritt and Anderson, 1989], suggesting a risk of acute illness when responding to hazardous events.

Recently, large amounts of public health resources have been used to prevent and to be prepared to respond to chemical and biological terrorism events. Pesticides are among the chemical agents that might be used by terrorists [CDC, 2005a].

An assessment of the magnitude and incidence of acute pesticide poisoning among emergency responders can provide information on the preparedness of these important public servants, and can highlight areas in need of preventive action. To our knowledge this study is the first to provide information on the magnitude and incidence of acute pesticide poisoning among those responding to pesticide-related emergency events.

METHODS

Data were obtained on individuals age 15 through 64 years who developed an acute pesticide-related illness or injury from pesticide exposures incurred while engaged in emergency response and/or from exposure to a pesticide-contaminated patient between 1993 and 2002. The occupational categories of interest were firefighters (1990 Bureau of the Census [BOC] occupation codes = 416, 417) [US BOC, 1992], law enforcement officers (BOC occupation codes 418, 423), and emergency medical technicians (BOC occupation codes 089, 208, or 446 and BOC industry codes = 401, 831, or 910). Both volunteer and career firefighters were included. Throughout this report, these eligible workers will be collectively referred to as "emergency responders." This report excludes cases involving non-working bystanders. Exposures occurring in non-emergency situations were also excluded (e.g., firefighters exposed to pesticides used for routine pest control at their workplace, or law enforcement officers who are exposed to off-target drift of an aerially applied pesticide).

Source of Cases

Cases were identified from the Sentinel Event Notification System for Occupational Risks-Pesticides (SENSOR-Pesticides) program, the California Department of Pesticide Regulation (CDPR) pesticide poisoning surveillance program, and the Hazardous Substances Emergency Events Surveillance (HSEES) System. The SENSOR-Pesticides program is funded by the National Institute for Occupational Safety and Health (NIOSH) and the US Environmental Protection Agency (EPA), and provides financial and/or

technical support to state agencies engaged in surveillance of acute occupational pesticide-related illness and injury [Calvert et al., 2004]. The SENSOR-Pesticides states that provided cases included the California Department of Health Services (CDHS), the Texas Department of State Health Services, the Washington State Department of Health, the Oregon Department of Human Services, the New York State Department of Health, and the Florida Department of Health. The Arizona Department of Health Services, the Louisiana Department of Health and Hospitals, and the Michigan Department of Community Health were queried but reported no relevant cases for the years under study. Each of these state agencies maintains its own surveillance system for acute pesticide-related illness and injury. The CDPR surveillance program is similar to SENSOR-Pesticides but uses a slightly different case definition and comparable but different standardized variables. Cases were also provided by HSEES under a data sharing agreement. HSEES is maintained by the Agency for Toxic Substances and Disease Registry/National Center for Environmental Health (ATSDR/NCEH). It collects reports from state health departments on events associated with sudden, uncontrolled, or illegal releases of hazardous substances [Horton et al., 2004]. A total of 17 states (AL, CO, IA, LA, MN, MO, MS, NC, NH, NJ, NY, OR, RI, TX, UT, WA, WI) participated in HSEES for at least 6 years during the study period. The data used in these analyses were surveillance data provided to the lead author without identifiers, and as such are exempt from consideration by the human subjects review board (45 CFR 46.101[b][4]).

The time periods for which acute pesticide-related illness data were available varied by agency. The SENSOR-Pesticides programs in California, New York, Oregon, Texas, and Washington State, as well as CDPR, provided data for the entire study period. As for the other SENSOR-Pesticides states, data were available for the following time periods: Arizona, 1993–2001; Florida, 1998–2002; Louisiana, 1999–2002, and Michigan, 2000–2002. With respect to HSEES, 10 states participated for the entire study period: Alabama, Colorado, Iowa, New York, North Carolina, Oregon, Rhode Island, Texas, Washington, and Wisconsin. The remaining HSEES states participated for the following time periods: Louisiana, 2001–2002; Minnesota and Mississippi, 1995–2002; Missouri, 1994–2002; New Hampshire, 1993–1996; and New Jersey and Utah, 2000–2002.

To avoid double counting the same case, cases provided by SENSOR/CDPR were compared to cases in HSEES. Cases that matched on year and month of exposure, state, age, gender, and pesticide active ingredient were assumed to be the same individual. These individuals were included in the SENSOR/CDPR totals only. Similarly, cases provided by CDPR and CDHS were compared and cases that matched were counted only once in the SENSOR/CDPR totals.

Information Available on Each Case

The information collected by the state agencies and HSEES includes date of illness, information on the case (gender, age, occupation, industry, health effects, illness severity), whether the illness occurred as a result of workplace exposures, activity being performed by the individual at the time they were exposed, whether personal protective equipment (PPE) was used, and the pesticide(s) that produced the illness. Length of hospitalization and information on time lost from work was collected by the state agencies but not by HSEES. For this analysis, PPE included eye protection (e.g., goggles or faceshield), hand protection (i.e., gloves), or respiratory protection (i.e., respirator).

The EPA acute toxicity category was sought for all pesticide products responsible for illness. The EPA classifies all pesticide products into one of four toxicity categories based on established criteria (40 CFR Part 156). Pesticides with the greatest toxicity are placed in Category I, and those with the least are in Category IV. In this analysis, the toxicity category for the pesticide product responsible for illness was often provided by state agencies participating in SENSOR/CDPR, but was not available for cases reported by HSEES. In events involving exposure to more than one product, the event was assigned a toxicity category corresponding to the product with the greatest toxicity category. When the toxicity category was not provided, it was retrieved from a US EPA dataset [US EPA, 2005] that provides information on pesticide products, including the assigned toxicity category. When the specific product was not identified, and only the active ingredient was available, we selected the toxicity category most commonly assigned to products that contain the active ingredient.

Severity Index

A standardized severity index [CDC, 2001a] was used to assign severity to all cases provided by SENSOR/CDPR. A *low severity illness or injury* consists of minimally bothersome health effects that generally resolve rapidly (e.g., dermatitis, headache, dizziness, nausea, vomiting, abdominal pain, cough, upper respiratory irritation, dyspnea, fatigue, and ocular inflammation). A *moderate severity illness or injury* consists of non-life threatening health effects that are more pronounced, prolonged, or of a systemic nature compared to low severity effects. A *high severity illness or injury* consists of life-threatening health effects or those that result in significant residual disability or disfigurement. HSEES collects limited information to assign severity. HSEES cases who were hospitalized were assumed to have *moderate severity illness or injury*. All other HSEES cases were assumed to have *low severity illness or injury*. HSEES collects insufficient information to identify high severity illnesses and injuries.

Case Definition

SENSOR-Pesticides and CDPR have similar case definitions. Cases identified by state agencies were included only if health effects developed subsequent to pesticide contact and the health effects were determined by state surveillance professionals to be consistent with the known toxicology of the pesticide product. Cases were classified as definite, probable, possible, or suspicious based upon the strength of evidence supporting the occurrence of a pesticide exposure, and whether the ill individual reported symptoms versus had signs observed by a health care professional. A full description of these standardized case definitions is beyond the scope of this study but is available elsewhere [Calvert et al., 2001; CDC, 2005b].

HSEES does not have a standardized case definition for occupational pesticide-related illness and injury; however, cases are defined as persons sustaining at least one injury or symptom as a result of the event. Events identified by HSEES can involve the release of several chemicals, including pesticides and non-pesticide chemicals. Generally, HSEES cases were associated with events involving the release of pesticides only. In events where pesticides and non-pesticides were released, one author (GMC) assessed whether the health effects were consistent with the pesticide exposure. HSEES cases were excluded if the released pesticide was not specifically identified, or if headache, heat stress, or trauma were the only health effects identified. Headache alone is considered too non-specific and insufficient for a diagnosis of pesticide poisoning, trauma was thought unlikely to be related to pesticide exposure, and heat stress was considered unrelated to pesticide poisoning.

Data Analysis

SAS software was used for data management and chi-square statistical analyses of categorical data. Incidence rates for each occupational category of interest were calculated for 1993 through 2002. The numerator was the total number of illness cases in the relevant occupational category. The denominator was obtained from the full time equivalent (FTE) estimates derived from the Current Population Survey (CPS) conducted between 1993 and 2002 [Bureau of Labor Statistics, 2004]. FTE data corresponds to the states and time periods included in the study. Incidence rates for all emergency responders combined were also calculated. Included in this calculation were emergency responders of unknown specific type. Poisson regression was used to test the trend of incidence rates across the years of exposure.

The rate calculations for firefighters had to be handled differently due to the limitations of the CPS data. CPS compiles industry and occupation FTE estimates only on workers engaged in paid employment. As such, unpaid volunteer firefighters do not appear in the FTE estimates.

Therefore, the incidence rate calculation for firefighters included the salaried career firefighters only. In addition, for those firefighters whose career versus volunteer status was unknown, we made the assumption that the proportion that were career was equal to the proportion that were career among those with known career versus volunteer status. These firefighters with unknown status but who were assumed to be career were included in the incidence rate calculations for firefighters and for all emergency responders combined.

The risk of acute pesticide-related illness among each occupational category was calculated by comparing their rate to that of all other non-agricultural workers aged 15–64 years [Rothman, 1986]. Non-agricultural workers were chosen as the comparison group because *a priori* it was thought that workers and emergency responders had a similar risk for pesticide exposure. Agricultural workers were thought to have a much higher rate of pesticide exposure because between 1998 and 2002, a rate of 163 cases/million agricultural worker FTEs was identified. The data on non-agricultural workers were obtained from the same state agencies (SENSOR/CDPR) that provided the data on emergency responders, but excluded were illnesses associated with non-occupational exposures, pesticide exposures that produced no health effect, emergency responders, and illnesses associated with intentional (e.g., suicidal, malicious intent) exposures. Because data on pesticide poisoning incidence is not available for states with a HSEES program only, this risk calculation was restricted to states with a SENSOR program. The incidence rate ratio (IRR) was calculated by dividing the acute pesticide-related illness incidence rate among emergency responders by the incidence rate among all other non-agricultural workers. A ratio that exceeds 1 suggests that emergency responders have a higher risk of acute pesticide-related illness compared to all other non-agricultural workers. Confidence intervals were calculated according to methods described by Rothman [1986].

RESULTS

From 1993 through 2002, 291 individuals were identified who developed an acute occupational pesticide-related illness or injury from pesticide exposures incurred while engaged in emergency response or from care of a pesticide-contaminated patient. Of these, 183 (63%) were identified by SENSOR/CDPR, and 108 (37%) by HSEES (9 cases were identified by both SENSOR and HSEES, and were included in the SENSOR/CDPR totals only) (Table I). Most of those identified were firefighters (111 [38%]) or law enforcement officers (104 [36%]) (Tables I and II). The median age among the ill emergency responders was 34 years (range: 17–64 years) and 89% were male. Among the 183 SENSOR/CDPR cases, 40 (22%) were classified as definite, 89 (49%) as probable, 23 (13%) as possible, and 31 (17%) as

suspicious. There were 119 separate pesticide exposure events identified, and the median number of ill emergency responders per event was 2 (range 1–22). Most events ($n=55$, 46%) involved only 1 ill emergency responder, and among the 64 multi-victim events, the median number of ill emergency responders per event was 3. The largest event occurred in Texas in 1994 and involved aldicarb exposure leading to low severity illness among 22 unspecified emergency responders who wore no PPE.

Incidence Rates

Between 1993 and 2002, the average annual incidence rate among emergency responders was 33.6/million emergency responder FTEs (Table II). The incidence rates demonstrated a statistically significant decreasing trend ($P<0.01$) between 1993 and 2002, although the decrease was not monotonic (Table III, Fig. 1). A similar decrease in rates over time was observed for all other non-agricultural workers (Fig. 1). The incidence rates were highest among firefighters. Among US geographic regions, the incidence rate was highest among emergency responders in the West region states (Table IV).

Incidence Rate Ratios

Overall, the rate of acute occupational pesticide-related illness was significantly higher among those engaged in emergency response activities, compared to the rate among all non-agricultural workers (IRR = 2.13, 95% CI = 1.86, 2.44) (Tables II and III). The IRRs were elevated for all categories of emergency responders (i.e., firefighters, law enforcement officers, and emergency medical technicians) (Table II). The IRR was found to be highest in the Northeast (Table IV).

Pesticides Responsible for Illness

Information on the pesticides responsible for acute occupational pesticide-related illness in emergency responders is provided in Table I. Insecticides alone were responsible for 51% of the illnesses, and insecticides combined with another pesticide were responsible for an additional 4% of cases. Among the insecticides, organophosphates ($n=76$), pyrethroids ($n=31$), and carbamates ($n=22$) were most commonly responsible. Specific organophosphate insecticides included malathion ($n=42$), phorate ($n=14$), and diazinon ($n=10$). Among the specific pyrethroids associated with illness were, esfenvalerate ($n=14$), cyfluthrin ($n=7$), and allethrin ($n=7$). Aldicarb ($n=22$) was the specific carbamate most commonly associated with illness in emergency responders (all aldicarb-related illnesses occurred in a single event). Fumigants were also responsible for a high proportion of

TABLE I. Severity of Acute Pesticide-Related Illness and Associated Factors, 1993–2002

	Moderate severity illness (n = 30)	Low severity illness (n = 261)	Total (N = 291)
Age, mean (range)	31.8 (18–53)	34.7 (17–64)	34.3 (17–64)
Male (%)	27 (90)	228 (89)	255 (89)
Occupation (%)			
Firefighter ^a	11 (37)	100 (38)	111 (38)
Law enforcement	14 (47)	90 (34)	104 (36)
Emergency medical technicians	5 (17)	29 (11)	34 (12)
Unspecified responder ^b	0	42 (16)	42 (14)
Organ system involved (%)			
Respiratory	27 (90)	172 (66)	199 (68)
Neurological	19 (63)	127 (49)	146 (50)
Gastrointestinal	12 (40)	102 (39)	114 (39)
Eyes	11 (37)	69 (26)	80 (27)
Skin	5 (17)	40 (15)	45 (15)
Cardiac	9 (30)	11 (4)	20 (7)
Pesticide functional class (%)			
Insecticide	21 (70)	128 (49)	149 (51)
Fumigant	3 (10)	45 (17)	48 (17)
Disinfectant	1 (3)	32 (12)	33 (11)
Herbicide	1 (3)	37 (14)	38 (13)
Fungicide	1 (3)	5 (2)	6 (2)
Multiple functional classes	3 (10)	14 (5)	17 (6)
Pesticide acute toxicity category (%)			
I	12 (40)	131 (50)	143 (49)
II	1 (3)	36 (14)	37 (13)
III	15 (50)	79 (30)	94 (32)
Unknown	2 (7)	15 (6)	17 (6)
Source of report (%)			
SENSOR-Pesticides/CDPR	26 (87)	157 (60)	183 (63)
HSEES	4 (13)	104 (40)	108 (37)
Total	30 (10)	261 (90)	291

^aThe number includes both paid (career, n = 47), and unpaid (volunteer, n = 42) firefighters. Also included are firefighters for whom career versus volunteer status is unknown (n = 22).

^bThis category consists of cases identified by HSEES as “responder (unknown type).”

cases (17%), most commonly chloropicrin (n = 28). Finally, herbicides (13%) and disinfectants (11%) were responsible for substantial numbers of cases. Common herbicides included glyphosate (n = 9) and atrazine (n = 7), while common disinfectants included chlorine (n = 8), sodium hypochlorite (n = 7), and calcium hypochlorite (n = 7).

Information on the EPA acute toxicity category was available for 274 (94%) of the cases. Of these, 143 (52%) were exposed to acute toxicity category I pesticides, 37 (14%) to category II pesticides, and 94 (34%) to category III pesticides. However, it should be noted that several emergency responders were exposed to fumes from burning pesticides. It is not known if the combustion fumes have the same toxicity as the parent compound.

Illness Severity

Most of the acute occupational pesticide-related illnesses among emergency responders were of low severity (261/291 [90%]) (Table I). Severity was moderate in 10% of the cases. No deaths and no cases of high severity were identified. Law enforcement officers accounted for the largest proportion of moderate severity illnesses (47%). Information on whether the illness resulted in lost time from work was available for 145 emergency responders. Among these 145, 36 (25%) had lost time (median lost time = 1 day, range 1–32 days). Those exposed to insecticides were more likely to have moderate severity illness (insecticide exposed = 14%, all others = 6%, *P* = 0.01) and lost time

TABLE II. Total Numbers of Cases of Acute Occupational Pesticide-Related Illness, Full Time Equivalent Estimates, Incidence Rates, and Incidence Rate Ratios, by Occupation, 1993–2002

Occupation (1990 BOC occupation codes)	Number (%) with acute occupational pesticide-related illness	Incidence rate ratio		
		FTE estimates ^a	Incidence rate ^b	(95% CI) ^c
All	291 (100)	7.12	33.57	2.13 (1.86, 2.44)
Firefighters ^d (416, 417)	111 (38)	1.51	39.07	2.67 (2.05, 3.47)
Law enforcement (418, 423)	104 (36)	3.91	26.60	1.69 (1.38, 2.07)
Emergency medical technicians (089, 208, 446 where 1990 BOC industry codes = 401, 831, or 910)	34 (12)	1.70	20.00	1.22 (0.84, 1.77)
Unspecified responder or other ^e	42 (14)	—	—	—

BOC = US Bureau of the Census; FTE = full time equivalent.

^aIn millions.^bPer million FTEs.^cCompares the risk of an acute occupational pesticide-related illness among category of interest with all other non-agricultural workers. Only, includes cases identified in states participating in SENSOR. The incidence rate among all other non-agricultural workers in the SENSOR states was 19.27/million FTEs.^dThe number includes both paid (career, n = 47), and unpaid (volunteer, n = 42) firefighters. Also included are firefighters for whom career vs. volunteer status is unknown (n = 22). However, because denominator data are unavailable for volunteer firefighters, the incidence rate includes the career firefighters and 12 of the unspecified firefighters only (12 of the unspecified firefighters were assumed to be career, as this represents the proportion [53%] who were career among those with known career vs. volunteer status).^eThis category consists of cases identified by HSEES as "responder (unknown type)". Although an incidence rate was not separately calculated for this category, these responders were included in the overall incidence rate.

from work (insecticide exposed = 26%, all others = 15%, $P = 0.09$) compared to those exposed to all other pesticides. Neither severity ($P = 0.09$) nor lost time from work ($P = 0.40$) was associated with the EPA acute toxicity category assigned to the pesticide. Most cases (268, 92%) were evaluated and treated in a health care facility, and 8 (3%)

of these were hospitalized. For all pesticides combined, the most commonly observed effects involved the respiratory system (68% of emergency responders reported health effects involving this system), followed by neurological (50%) and gastrointestinal effects (39%). Effects on the eyes (27%) and skin (15%) were less commonly reported.

TABLE III. Numbers of Cases of Acute Occupational Pesticide-Related Illness, Full Time Equivalent Estimates, Incidence Rates, and Incidence Rate Ratios, by Year, 1993–2002

Year	Emergency response workers			All other non-agricultural workers			
	Number with acute occupational pesticide-related illness	FTE estimates ^a	Incidence rate ^{b,c}	Number with acute occupational pesticide-related illness	FTE estimates ^a	Incidence rate ^{b,c}	Incidence rate ratio (95% CI) ^d
1993	29	0.51	54.90	1,017	33.13	30.70	2.33 (1.60, 3.39)
1994	41	0.54	68.52	973	33.08	29.41	2.93 (2.08, 4.12)
1995	43	0.62	66.13	990	33.54	29.52	2.66 (1.89, 3.74)
1996	45	0.60	43.33	1,012	34.22	29.57	1.61 (1.02, 2.53)
1997	26	0.63	34.92	754	35.52	21.23	2.17 (1.39, 3.38)
1998	17	0.77	12.99	790	42.37	18.65	0.92 (0.49, 1.72)
1999	19	0.78	24.36	666	45.47	14.65	2.17 (1.38, 3.42)
2000	31	0.84	28.57	613	51.15	11.98	3.43 (2.30, 5.12)
2001	21	0.96	19.79	501	50.46	9.93	2.20 (1.34, 3.62)
2002	19	0.86	15.12	526	48.04	10.95	1.17 (0.58, 2.34)
Total	291	7.12	33.57	7,842	406.98	19.27	2.13 (1.86, 2.44)

FTE, full time equivalent.

^aIn millions.^bPer million FTEs.^cVolunteer firefighters were excluded from the rate calculations. A statistically significant decreasing trend between 1993 and 2002 was found for the incidence rates ($P < 0.01$).^dCompares the risk of an acute occupational pesticide-related illness among category of interest with all other non-agricultural workers. Only includes cases identified in states participating in SENSOR.

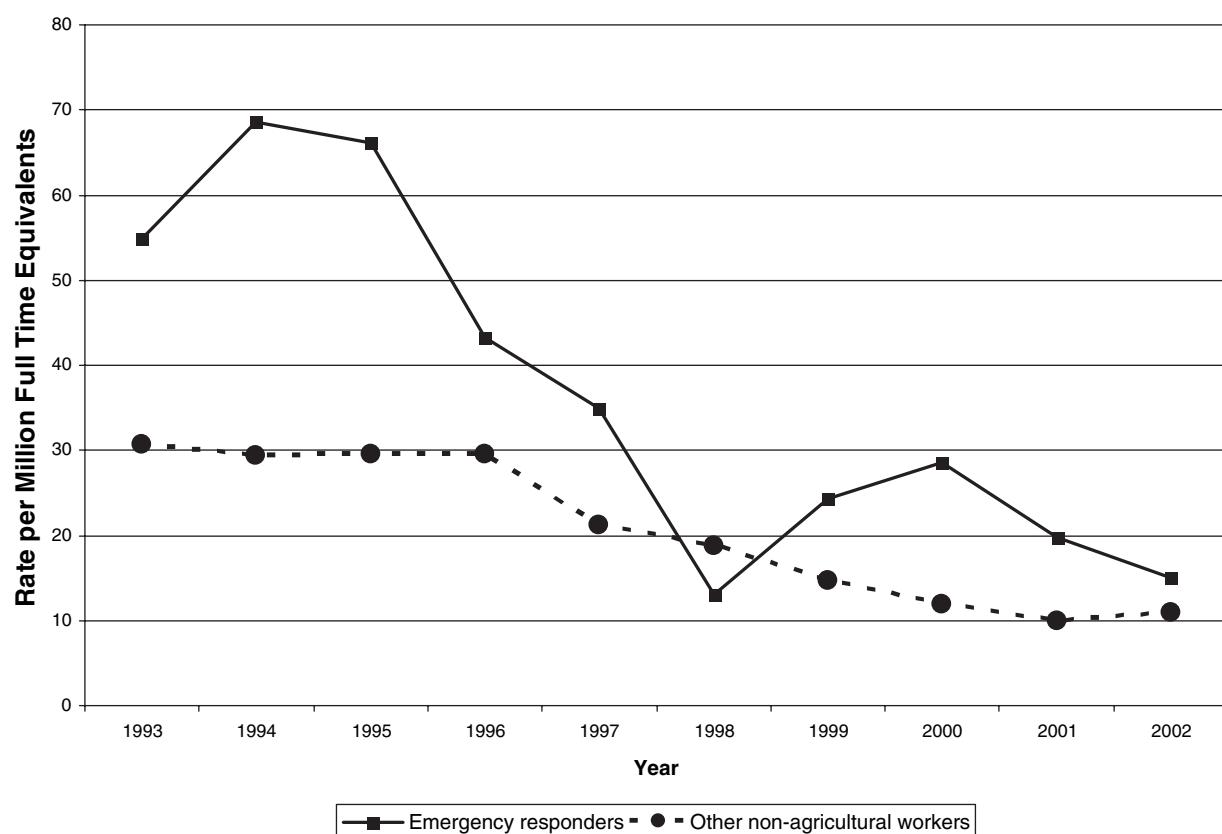


FIGURE 1. Rate of pesticide poisoning among emergency responders and other non-agricultural workers, 1993–2002.

TABLE IV. Numbers of Cases of Acute Occupational Pesticide-Related Illness, Full Time Equivalent Estimates, Incidence Rates, and Incidence Rate Ratios, by US Region, 1993–2002

Region	Emergency response workers			All other non-agricultural workers			
	Number with acute occupational pesticide-related illness	FTE estimates ^e	Incidence rate ^{f,g}	Number with acute occupational pesticide-related illness	FTE estimates ^e	Incidence rate ^f	Incidence rate ratio (95% CI) ^h
Midwest ^a	32	0.77	14.29	58	13.14	4.41	—
Northeast ^b	20	1.38	10.87	220	73.91	2.98	4.31 (2.55, 7.27)
South ^c	68	2.37	21.52	768	127.82	6.01	4.11 (2.99, 5.65)
West ^d	171	2.60	62.31	6,796	192.11	35.38	1.98 (1.69, 2.31)
Total	291	7.12	33.57	7,842	406.98	19.27	2.13 (1.86, 2.44)

FTE, full time equivalent.

^aIowa, Michigan, Minnesota, Missouri, Wisconsin.

^bNew Hampshire, New Jersey, New York, Rhode Island.

^cAlabama, Florida, Louisiana, Mississippi, North Carolina, Texas.

^dArizona, California, Colorado, Oregon, Utah, Washington State.

^eIn millions.

^fPer million FTEs.

^gVolunteer firefighters were excluded from the rate calculations.

^hCompares the risk of an acute occupational pesticide-related illness among category of interest with all other non-agricultural workers. Only includes cases identified in states participating in SENSOR. No cases were identified in Midwest states participating in SENSOR.

Activities Associated With Illness

Job activities associated with illness were also identified. Of the 200 individuals with available information on job activity (this information was not available for 84% of cases identified by HSEES) most (n = 168, 84%) were exposed while investigating or responding to a fire or another type of pesticide release. Most of these were law enforcement officers (n = 95) or firefighters (n = 62). The remainder (n = 32, 16%) had evidence suggesting that their pesticide exposure occurred while caring for a pesticide-contaminated patient, including contact with contaminated clothing or body fluids. Most of these individuals were emergency medical technicians (n = 19). The remainder were firefighters (n = 9) and law enforcement officers (n = 4).

Information on use of PPE was available for 193 (66%) individuals (Table V). PPE was used by 42% (n = 81) of these emergency responders. The proportions who wore PPE varied significantly across the emergency response occupations ($P < 0.01$). Firefighters (77%) were most likely to wear PPE. The type of PPE worn is provided in Table V.

Representative Events

Two representative events that were detected through these surveillance efforts are briefly described below:

Event 1

In 2000 in California, several emergency responders went to a home where an individual committed suicide by ingesting and dousing himself with malathion. When the emergency responders arrived, they were not aware of the identity of the chemical. An unlabeled container sat next to the suicide victim. The chemical was not identified to be malathion until after the patient was taken to the coroner. A

total of nine emergency responders (four firefighters, three police officers, and two paramedics) developed low severity illness classified as probable. It is unknown whether cholinesterase testing was performed. Four were exposed while attempting to resuscitate the suicide victim or during transport, and five were exposed to the strong odor coming from the home. All of the responders wore hand protection (rubber or latex gloves) but none wore a respirator.

Event 2

In Florida in 2000, nine emergency responders developed acute pesticide-related illness when responding to a chemical fire on a farm where a tractor exploded. The tractor was carrying organophosphate insecticides, including phorate. The nine ill responders included six firefighters, two paramedics, and one police officer. Three had moderate severity illness classified as definite, and six had low severity illness classified as probable. All had involvement of the respiratory system, including upper airway irritation (n = 7), dyspnea (n = 2), chest pain (n = 2), and cough (n = 2). All received medical attention, and none were hospitalized. Five had cholinesterase concentrations measured, but all were within the laboratory normal range. Information on usage of PPE was not available.

DISCUSSION

Our findings of acute pesticide-related illness among emergency responders demonstrate that there are risks of placing oneself in harm's way while protecting others. Fortunately, the overall incidence rates were very low suggesting that pesticide emergency events may be rarely encountered. The rates may be low because the incidence of pesticide release events are low and/or because those who are present at release events are not exposed to pesticides. Zeitz

TABLE V. Type of Personal Protective Equipment Worn by Emergency Responder Occupation (n = 193*)

Type of PPE	Firefighters (n = 77)	Law enforcement officers (n = 60)	Emergency medical technicians (n = 14)	Unspecified responder (n = 42)	All (n = 193)
Respirator					
Supplied air	8	0	0	0	8
Air-purifying	3	0	0	0	3
Dust mask/disposable	0	0	0	0	0
Eye protection					
Goggles/faceshield	45	0	1	12	58
Hand protection					
Synthetic	44	3	5	12	64
Cloth/leather	14	1	0	1	16
Total (used any PPE)	59 (77%)	4 (7%)	5 (36%)	13 (31%)	81 (42%)

*Information on PPE use was available for only 193 (66%) of the emergency responders identified with acute occupational pesticide poisoning.

et al. [2000] found that pesticides were involved in just 8% of hazardous substances emergency events identified by HSEES. Nonetheless, because the risk exists, mechanisms are needed to rapidly and efficiently provide emergency responders with information both on the hazards they face, whether they be pesticides or other hazardous materials, and the PPE that is needed to prevent exposures to these hazards. Emergency responders also need to be trained on the nature and characteristics of these hazards and on the appropriate use and limitations of PPE. It is also recognized that the initial phases of an emergency response are often chaotic, and that ensuring and enforcing appropriate PPE use may be difficult as it is not unusual for these responders to have a mindset of “risk a life to save a life” [Jackson et al., 2002].

The incidence rate for all emergency responders combined decreased across time (Table III). It is not clear what was responsible for this decline. Among the possibilities are an overall decrease in emergency pesticide events, especially events involving highly toxic pesticides, and/or emergency responders making greater efforts to avoid exposure, especially after the lessons learned from the Tokyo subway sarin attack in 1995 [Nozaki et al., 1995].

The incidence of acute pesticide-related illness was highest among emergency responders in the West region states, which included California and Washington State. California and Washington State have the longest running surveillance programs and have greater staffing levels compared to surveillance programs in the other states. These characteristics have previously been cited to explain the higher overall pesticide poisoning incidence rates observed in these states [Calvert et al., 2004], and this likely is the explanation for our findings.

Firefighters

Firefighters had the highest incidence of acute pesticide-related illness, almost three times that of other non-agricultural workers. There are several potential explanations for these higher risks. For example, firefighters are often first to arrive at an emergency event and may be exposed before the pesticide hazards are identified. In addition, firefighters may feel a false sense of security by wearing turnout gear (helmet with facepiece, coat, pants, boots, and gloves), when in reality this gear may not protect against inhalation and dermal absorption of pesticides. Although most firefighters wore turnout gear, this PPE was insufficient to prevent acute pesticide-related illness. Few firefighters wore respiratory protection. This has been documented by other investigators who studied firefighters exposed to other inhalational hazards [Austin et al., 2001; Feldman et al., 2004]. In addition to the need for improved PPE and training on its use, firefighters need monitoring equipment that can quickly and accurately assess the chemical hazards that are present at emergency events.

Law Enforcement Officers

Law enforcement officers were also found to have a statistically significantly elevated risk of acute pesticide poisoning compared to other non-agricultural workers. Compared to other emergency responders, law enforcement officers were the least likely to wear PPE. In all probability, this is because law enforcement officers generally are not provided with PPE unless they are members of a specialized response team [Jackson et al., 2002]. Our findings reinforce the need for law enforcement officers to be given appropriate PPE and training on its proper use.

Emergency Medical Technicians

Emergency medical technicians were found to have the lowest pesticide poisoning rates among emergency responders, but their rates were elevated compared to all other workers employed in non-agricultural industries. One reason for this may be because emergency medical technicians are called to emergency events to care for the ill or injured, and not to directly control, contain, or confine the emergency event (e.g., put out a fire, clean up a spill, or police an area). An emergency medical technician’s exposure is more likely to be remote from where the pesticide release occurred, and their exposure is often limited to the quantity of pesticide on the patient, their clothing or personal effects. Although some poisoned emergency medical technicians wore PPE, this usually consisted only of synthetic gloves. Such PPE was inadequate to prevent pesticide poisoning.

Emergency medical technicians usually will care for patients before they have been decontaminated. Ideally, patients should be promptly decontaminated and emergency medical services need to develop and adhere to decontamination protocols [Pons and Dart, 1999; Macintyre et al., 2000]. Recommendations are available for preventing acute pesticide-related illness among health care professionals who are involved with medical stabilization of contaminated patients or involved with decontamination [Agency for Toxic Substances and Disease Registry, 2001; CDC, 2001b; OSHA, 2004; 29 CFR 1910.120]. At a minimum, these include use of level C protection (i.e., full face mask and powered/non-powered canister/cartridge filtration respirator, and non-encapsulated chemical-resistant suit, gloves, and boots). With level C protection, the type of canister/cartridge should be appropriate to the pesticide; if the pesticide cannot be identified, a high efficiency particulate air (HEPA)/organic vapor/acid gas cartridge is recommended [OSHA, 2004]. In many pesticide-related emergencies, the specific pesticide may be unknown, resource materials (e.g., pesticide label, material data safety sheet) may not be readily handy, and efforts to obtain this information may delay administering medical care to the

patient [Levitin and Siegelson, 1996]. Given these constraints and the rarity with which emergency medical technicians will encounter a pesticide-contaminated patient, one all-inclusive PPE policy should be adopted by emergency medical services when caring for these patients. This PPE policy should minimize confusion, allow timely donning of PPE, and permit quick provision of medical care to patients by emergency medical technicians who are adequately protected. Emergency medical technicians should stay upwind and upgrade from any hazardous releases. Note that level C protection does not maximally guard the skin and lungs. Entry into areas with known or suspected hazardous materials contamination requires a determination that the PPE worn affords adequate protection. In addition to adhering to these guidelines, emergency medical services need to train staff in the proper use of PPE [Pons and Dart, 1999; Macintyre et al., 2000]. Emergency responders who may need to wear respiratory protection must be deemed medically fit to do so according to the OSHA Respiratory Protection Standard (29 CFR 1910.134).

Limitations

Our data and analysis have several potential limitations. The illness rates that we observed are likely to be underestimates since many emergency responders may not have been ascertained. Many are never identified because they neither seek medical care, nor contact appropriate authorities (e.g., poison control). Furthermore, because the signs and symptoms of acute pesticide-related illness are not pathognomonic, many emergency responders/health care professionals who seek medical care may not be correctly diagnosed and therefore are not ascertained. Even among those who are correctly diagnosed, many are not reported, despite the fact that 30 states have mandatory reporting of occupational pesticide-related illness [Calvert et al., 2001]. However, some of the cases identified in this report may be false positive cases because non-specific symptoms may have been coincidental and not caused by the exposure. In addition, because only CDPR and HSEES capture cases associated with disinfectant exposure, the magnitude of disinfectant cases described in this report may be underestimated.

For 14% of our cases, the specific occupational title of the responder was not available. The incidence rates for firefighters, law enforcement personnel, and emergency medical technicians would likely increase if the specific occupation of these cases was known. In addition, little information was available to assign severity to the cases identified by HSEES. Only 4% of HSEES cases were identified as having moderate severity, which is significantly lower than the 14% of SENSOR/CDPR cases with moderate severity ($P < 0.01$). It is possible that the number of moderate severity HSEES cases was underestimated.

TABLE VI. Recommendations to Prevent Acute Pesticide-Related Illness Among Emergency Responders

Findings and Recommendations

- Pesticide emergency events are relatively rare, and emergency responders may be unfamiliar with pesticide hazards
- Firefighter turnout gear may not protect against pesticide exposure
- Mechanisms are needed to rapidly provide emergency responders with information on the pesticide hazards at a scene
- Emergency responders need to wear appropriate PPE when responding to pesticide events
- Respiratory protection is especially important (65% of responders reported respiratory symptoms)
- Emergency responders need to be trained on the appropriate use and limitations of PPE
- Emergency responders need to know how to locate information on chemical hazards

It would have been useful to determine the incidence of pesticide illness among emergency responders who specifically attended a pesticide-related emergency. Knowing this illness incidence would have provided a truer estimate of risks associated with such events; however, this denominator information was not available.

CONCLUSION

Emergency personnel responding to pesticide release events have an increased risk of pesticide poisoning compared to all other workers employed in non-agricultural industries. Fortunately, the overall pesticide poisoning incidence rates were very low among emergency responders. Among emergency responders, the incidence rates were highest for firefighters. A vast majority of the illnesses were of low severity. The mitigation efforts we recommend are relevant regardless of the size of the pesticide emergency, whether it is a small scale emergency or a catastrophic terrorist attack (Table VI). Emergency responders are placed in harm's way whenever they respond to an emergency chemical event, including those involving pesticides. It is essential to reduce these risks and protect the health of responders.

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