Acute Occupational Pesticide-Related Illness and Injury — United States, 2007–2011

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Preface

CDC's National Institute for Occupational Safety and Health (NIOSH) collects data on acute pesticide-related illness and injury reported by 12 states (California, Florida, Iowa, Louisiana, Michigan, Nebraska, North Carolina, New Mexico, New York, Oregon, Texas, and Washington). This report summarizes the data on illnesses and injuries arising from occupational exposure to conventional pesticides from 2007 through 2011. This report is a part of the *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks — United States*, which encompasses various surveillance years but is being published in 2016 (*1*). The *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks* appears in the same volume of *MMWR* as the annual *Summary of Notifiable Infectious Diseases* (*2*). In a separate report, data on illnesses and injuries from nonoccupational exposure to pesticides during 2007–2011 are summarized (*3*).

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Background

Pesticides are substances or mixtures of substances intended to prevent, destroy, repel, or mitigate pests (pests include insects, rodents, fungi, and weeds). In 2007, the year with the most currently available data, an estimated 2.1 billion pounds of conventional pesticides were used in the United States (*4*), which represents approximately 22% of the entire worldwide use of these pesticides. Conventional pesticides include insecticides, insect repellents, herbicides, fungicides, and fumigants and exclude chlorine, hypochlorites, and other biocides.

The benefits of pesticides are well recognized and primarily include their role in protecting the food supply and in controlling disease vectors (*5*). However, no form of pest control using pesticides is perfectly safe. Tracking the associated health effects of pesticides can help ensure that no pesticides pose an unreasonable burden (*6*). For this reason, public health surveillance of acute pesticide-related illness and injury serves a vital societal role by assessing the magnitude and characteristics of such illness and injury. Surveillance of acute pesticide-related illness and injury has been endorsed by several professional organizations and federal agencies including the American Medical Association (*7*), the Council of State and Territorial Epidemiologists (*8*), NIOSH (*9*) and the U.S. Government Accountability Office (*10*).

Pesticide products must pass an extensive battery of testing prior to being registered by the Environmental Protection Agency (EPA). This testing forms the basis for the human health and environmental risk assessments conducted by EPA that guide identification of the conditions under which a pesticide can be used. These conditions of use are reflected in pesticide product labeling. Compliance with these use conditions is expected to prevent unreasonable adverse effects to human health and the environment. To verify the real-world effectiveness of pesticide product labeling in preventing adverse human health effects, EPA reviews findings from acute pesticide-related illness and injury surveillance systems. These surveillance data assist EPA in determining whether labeling is effective or if labeling improvements are needed. When health effects occur despite adherence to label instructions, and EPA determines the magnitude to be unreasonable, EPA requires that interventions be instituted that involve changing pesticide use conditions and/or modifying regulatory measures (*11*). Acute pesticide-related illness and injury also can occur because of lack of compliance with existing pesticide regulations. The appropriate interventions for these cases include enhanced training and enforcement.

Data Sources

Acute occupational pesticide-related illness and injury is one of several conditions under surveillance by NIOSH. In 1987, NIOSH established the Sentinel Event Notification System for Occupational Risks (SENSOR)–Pesticides program to track pesticide-related illness and injury in the United States. Detailed information on this program is available at http://www.cdc.gov/niosh/topics/pesticides/overview.html. During 2007–2011, a total of 12 states (California, Florida, Iowa, Louisiana, Michigan, Nebraska [2011 only], North Carolina, New Mexico [2007–2008 only], New York, Oregon, Texas, and Washington) participated in the SENSOR-Pesticides program. All 12 states that participate in the SENSOR-Pesticides program require physicians to report confirmed and suspected cases of pesticide-related illness and injury to state health authorities. Besides identifying, classifying, and tabulating pesticide poisoning cases, states periodically perform in-depth investigations of pesticide-related events, and develop interventions aimed at particular industries or pesticide hazards.

Case ascertainment sources used by the state programs include poison control centers, specific government agencies (e.g., a state's Department of Agriculture), workers' compensation documents, and physician reports. In some states, there are other sources that infrequently identify cases (e.g., medical record reviews, news reports, and reports from worker representatives) (*12*). Staff from some state surveillance programs attempt to interview persons to obtain more details about the event. All states use standardized variables to code available information about a case systematically (*12*).

Persons are considered to have an occupational pesticide-related illness or injury if they became ill or injured soon (i.e., within seconds to hours) after exposure to one or more pesticides. An illness and injury is considered occupational if the pesticide exposure occurred at the person's place of work. Agricultural cases are defined as cases among persons employed in an industry with one of the following codes: agricultural production, excluding livestock (1990 Census Industry Code [CIC]: 010; 2002 CIC: 0170); agricultural production, including livestock (1990 CIC: 011; 2002 CIC: 0180); and agricultural services (1990 CIC: 030; 2002 CIC: 0290). All other occupational cases with known industry are defined as "nonagricultural" cases.

The SENSOR-Pesticides case definition has been described in detail elsewhere (*12*). The definition requires information about pesticide exposure and health effects, which is compared with the known toxicology of the pesticide. Cases are categorized as definite, probable, possible, and suspicious on the basis of the level of detail known for each case. Cases are defined as definite exclusively on the basis of objective data about exposure and health effects (e.g., residues were measured to confirm exposure, and health effects were observed by the examining clinician). Cases are defined as probable on the basis of a mix of objective and self-reported data. Cases are defined as possible on the basis of self-reported exposure and health effects data. With respect to definite, probable, and possible cases, the reported health effects are consistent with the known toxicology of the pesticide that the case was exposed to. Suspicious cases arise when toxicologic information is insufficient to determine a causal relationship between pesticide exposure and illness, often because the given pesticide is relatively new and limited toxicologic data involving humans exist. Often reports of illness and injury cannot be categorized as definite, probable, possible, or suspicious because insufficient information is available about the circumstances of the exposure event or because available evidence suggests that the pesticide exposure either was unrelated to or was unlikely to have caused the observed health effects. Such exposures are not included in the analysis of confirmed illness and injury cases provided in this report.

Illness and injury severity was categorized into four groups using standardized criteria for state-based surveillance programs (*12*). In low-severity cases, the condition usually resolves without treatment and <3 days are lost from work. In moderate-severity cases, the condition is not life threatening but requires medical treatment. No residual impairment is expected, and time lost from work is ≤5 days. In high-severity cases, the condition is life threatening, requires hospitalization, often has >5 days lost from work, and might result in permanent impairment. Fatal cases of pesticide poisoning were placed in a separate category.

To calculate incidence rates (IRs) of acute occupational pesticide-related illness and injury, CDC obtained denominator data (i.e., hours worked) from the Current Population Survey (CPS) (*13*). The hours worked data were used to derive full time equivalent (FTE) estimates, with one FTE equal to 2,000 hours worked. Denominator data correspond to the states and time periods of numerator availability.

This report includes only acute pesticide-related illness and injury arising from occupational exposures. Furthermore, 12 occupational cases involving exposures with suicidal or homicidal intent were excluded. During 2007–2011, of the 8,383 cases reported to SENSOR-Pesticides not involving suicidal or homicidal intent, 2,606 (31%) were from occupational exposures and are included in the analyses.

Interpreting Data

For multiple reasons, the data provided in this report (Table 1) (Table 2) are likely to be underestimates of the actual magnitude of acute occupational pesticide-related illness and injury (*14*). Many cases of pesticide-related illness or injury never are ascertained because affected persons neither seek medical care, nor call appropriate authorities. Furthermore, because the signs and symptoms of acute pesticide-related illnesses are not pathognomonic, and because most health care professionals are not acquainted with the recognition and management of these illnesses, many persons who seek medical care might not receive an accurate diagnosis (*15*). Even among those who do receive an accurate diagnosis, many cases are not reported to state surveillance systems, despite the fact that each of the participating states has mandatory reporting of occupational pesticide-related illness and injury (*6*). For these reasons, the reported counts and rates provided in this report must be considered minimum estimates. In contrast, some persons might have been categorized incorrectly as having

TABLE 1. Distribution of cases of acute occupational pesticide-related illness and injury, FTE estimates, and incidence rates per 100,000 FTEs, by industrial sector, state, sex, and year of exposure — Sentinel Event Notification System for Occupational Risk–Pesticides program, United States, 2007–2011

	Industrial Sector (CIC codes)								
	All			Agricultural (010–030)			Nonagricultural (all other codes)		
Characteristic	No.*	FTE estimates†	Incidence rate§	No.	FTE estimates†	Incidence rate§	No.	FTE estimates†	Incidence rate§
State¶									
California	**858**	**77,468,156**	**1.1**	306	1,529,999	20.0	483	75,938,157	0.6
Florida	**171**	**40,035,419**	**0.4**	13	222,155	5.9	87	39,823,264	0.2
Iowa	**170**	**7,447,061**	**2.3**	88	344,047	25.6	22	7,103,014	0.3
Louisiana	**98**	**9,394,549**	**1.0**	14	85,432	16.4	40	9,309,117	0.4
Michigan	**190**	**20,083,617**	**0.9**	23	287,402	8.0	153	19,796,215	0.8
Nebraska	**22**	**920,350**	**2.4**	6	61,932	9.7	1	858,418	0.1
New Mexico	**9**	**1,767,303**	**0.5**	0	47,773	0	4	1,719,530	0.2
New York	**38**	**42,269,131**	**<0.1**	5	219,275	2.3	20	42,049,856	<0.1
North Carolina	**168**	**19,837,941**	**0.8**	49	216,678	22.6	103	19,621,263	0.5
Oregon	**55**	**8,253,984**	**0.7**	8	281,245	2.8	28	7,972,739	0.4
Texas	**363**	**54,490,716**	**0.7**	25	882,039	2.8	276	53,608,677	0.5
Washington	**464**	**14,786,285**	**3.1**	296	308,556	95.9	160	14,477,729	1.1
Sex**									
Male	**1,734**	**169,412,691**	1.0	631	3,550,759	17.8	823	165,861,932	0.5
Female	**864**	**127,351,821**	0.7	202	935,774	21.5	550	126,416,047	0.4
Year									
2007	**637**	**61,979,631**	1.0	210	876,815	24.0	334	61,102,816	0.5
2008	**555**	**61,751,566**	0.9	202	909,306	22.2	288	60,842,260	0.5
2009	**431**	**57,059,520**	0.8	125	831,358	15.0	261	56,228,162	0.5
2010	**462**	**57,295,585**	0.8	139	883,451	15.7	249	56,412,134	0.4
2011	**521**	**58,678,210**	0.9	157	985,603	15.9	245	57,692,607	0.4
Total	**2,606**	**296,764,512**	**0.9**	**833**	**4,486,533**	**18.6**	**1,377**	**292,277,979**	**0.5**

Abbreviations: CIC codes = Bureau of the Census industry codes; FTE = full-time equivalent.
* For 396 cases (15%), information on industry was missing.
† The full-time equivalent (FTE) estimates were derived from the hours worked data obtained from the Current Population Survey (CPS) and summed for the years 2007 through 2011 (*9*). One FTE equals 2,000 hours worked. Denominator data corresponds to the states and time periods of numerator availability.
§ Incidence rate per 100,000 FTEs.
¶ All states provided data for 2007–2011 except Nebraska (2011 only) and New Mexico (2007 and 2008 only). The summed FTE estimates include only the years for which there are case data.
** For eight cases, information about sex was missing.

TABLE 2. Distribution of cases of acute occupational pesticide-related illness and injury by industrial sector, pesticide functional class and illness and injury severity— Sentinel Event Notification System for Occupational Risk–Pesticides program, United States, 2007–2011

	Industrial sector (CIC codes)		
	All	Agricultural (010–030)	Nonagricultural (all other codes)
Characteristic	No. (%)	No. (%)	No. (%)
Pesticide functional class			
Insecticides	**912 (35)**	207 (25)	526 (38)
Herbicides	**464 (18)**	146 (18)	246 (18)
Fungicides	**129 (5)**	82 (10)	36 (3)
Fumigants	**229 (9)**	73 (9)	135 (10)
Insecticides and fungicides	**179 (7)**	128 (15)	37 (3)
Other *	**401 (15)**	49 (6)	291 (21)
Multiple†	**292 (11)**	148 (18)	106 (8)
Severity category			
Low	**2,093 (80)**	665 (80)	1,105 (80)
Moderate	**479 (18)**	153 (18)	257 (19)
High and death	**34 (1)**	15 (2)	15 (1)
Total	**2,606**	**833**	**1,377**

Abbreviation: CIC = Bureau of the Census industry codes.
* This category includes plant growth regulators, insect growth regulators, wood treatment products, preservatives and insect repellants.
† Exposed to pesticide products that were classified into more than one functional class, or to more than one pesticide product with each having a different functional class.

acute occupational pesticide-related illness because symptoms for acute illnesses associated with pesticides are nonspecific and not pathognomonic, and diagnostic tests are either not available or rarely performed. In addition, rates of pesticide illness and injury might have been affected by inaccurate estimates of the agricultural industry population. Many workers in this industry are difficult to count because of the transient employment of seasonal and migrant farmworkers and because workers with undocumented U.S. immigration status tend to avoid government contact (*16*). In addition, many agricultural workers have more than one job, and one of these other jobs not involving farming might be the one at which they work the greatest part of the day (*17*). Because CPS employment estimates include only the one job at which the worker worked the largest number of hours, some persons employed in agriculture might not be included in the agricultural employment estimates (*18*). Furthermore, the denominator inaccuracies might vary across states because some states might be more likely to have agricultural workers whose usual residence is elsewhere. Agricultural workers are not included in the CPS population estimates of those states in which they reside only temporarily (*18*).

Although the incidence rates for acute occupational pesticide-related illness and injury were highest in Washington, this finding might not necessarily mean that pesticide exposures are more hazardous or more prevalent in that state. Washington has stronger protections for agricultural workers and a larger and more robust pesticide illness and injury surveillance program when compared to other states, which likely accounts for some of the differences in incidence rates. As an example of stronger worker protections, Washington gives farmworkers the right to organize and bargain collectively, and requires cholinesterase monitoring for some pesticide handlers (*6*). These protections might make farmworkers in Washington less hesitant to seek medical care for pesticide illness and injury. In addition, Washington has a larger number of surveillance program staff (3.75 full-time equivalents [FTEs] versus an average of 1.3 FTEs in other states), and all but one are bilingual Spanish/English speakers. The odds of identifying agricultural worker cases might be improved when surveillance programs have a bilingual staff of ample size, as agricultural workers are often Spanish-speaking (*19*). Although workers' compensation systems can be an important source of case reports, only two states (Washington and California) received reports from this source between 2007 and 2011. The workers' compensation system can be an especially useful reporting source when it is organized as in Washington. For example, the Washington workers' compensation system covers the first visit for any suspected work-related illness or injury, even if the illness or injury is determined not to be work-related. In so far as is known, this benefit does not exist in any other state. In addition, unless Washington employers are able to self-insure, workers' compensation insurance is provided by an exclusive state-fund operated by the Washington State Department of Labor and Industries. No other private workers' compensation insurers exist in the state. This avoids problems that can occur in other states when state authorities either do not receive or incorrectly process information from private workers' compensation insurers. No other SENSOR-Pesticides state provides workers' compensation insurance through an exclusive state-funded program. For all these reasons, case estimates might be more accurate for Washington than for other states, although even the Washington estimates likely underestimate the actual level of occupational pesticide-related illness and injury.

The pesticides most often implicated in acute occupational pesticide-related illness and injury are listed (Table 3). Data are stratified by whether the affected person was exposed to a single substance (i.e., a pesticidal active ingredient). When affected persons were exposed to a single substance, it is very likely that that substance was responsible for illness or injury. However, this might not be so for persons who were exposed to multiple substances because one of the other substances might have produced the illness or injury. Furthermore, pesticide products also contain solvents and other nonactive ingredients, some of which might produce illness. Because the

TABLE 3. Number and percentage of acute occupational pesticide-related illness and injury, by pesticides most often implicated — Sentinel Event Notification System for Occupational Risk–Pesticides program, United States, 2007–2011

Pesticide category	Pesticide functional class	Exposed to single substance* No. (%)	Exposed to multiple substances No. (%)	Total No. (%)
Pyrethroids	Insecticide	299 (54)	256 (46)	**555 (21)**
Organophosphorous compounds	Insecticide	188 (56)	150 (44)	**337 (14)**
Glyphosate	Herbicide	135 (64)	76 (36)	**211 (8)**
Sulfur compounds	Insecticide/Fungicide	83 (39)	128 (61)	**211 (8)**
Pyrethrins	Insecticide	76 (47)	85 (53)	**161 (6)**
Chloropicrin	Fumigant	4 (5)	82 (95)	**86 (3)**
Organochlorine compounds	Insecticide	12 (16)	62 (84)	**74 (3)**
N-methyl carbamates	Insecticide	47 (64)	27 (36)	**74 (3)**
Dipyridyls	Herbicide	34 (49)	36 (51)	**70 (3)**
Phosphorus	Fumigant	61 (95)	3 (5)	**64 (2)**
Thiocarbamates/Dithiocarbamates	Fumigant	46 (79)	12 (21)	**58 (2)**
Pyraclostrobin	Fungicide	33 (67)	16 (33)	**49 (2)**
Fipronil	Insecticide	6 (13)	39 (87)	**45 (2)**
Imidacloprid	Insecticide	1 (2)	40 (98)	**41 (2)**
Triazines	Herbicide	16 (41)	23 (59)	**39 (1)**
Naphthalene	Insect repellent/Fumigant	23 (70)	10 (30)	**33 (1)**
All other		525 (50)	525 (50)	**1,050 (40)**
Total		**1,589 (61)**	**1,017 (39)**	**2,606 (100)**

* A substance is a pesticidal active ingredient.
† Pesticide categories are not mutually exclusive for multiple exposures. Case counts for persons exposed to multiple substances are included in the totals of more than one pesticide category. Therefore, the sum of all case counts (3,158) exceeds the total number of exposed persons (2,606).

identity of nonactive ingredients present in pesticide products is almost never available, attribution of illness and injury to these ingredients is rarely possible. In addition, only illnesses and injuries caused by exposure to conventional pesticides were included in this report. Illnesses and injuries caused by chlorine, hypochlorites, and other disinfectants are not included in this report because not all states capture such illnesses (often because of resource constraints in the state health department) and therefore including them would have made the rate estimates not comparable across the 12 states.

Publication Criteria

Cases met the print criteria if the affected person had confirmed acute occupational pesticide-related illness or injury, the person was exposed to conventional pesticides, the pesticide exposure occurred at the person's place of work, no suicidal or homicidal intent was associated with the exposure, and the illness occurred during January 1, 2007–December 31, 2011.

Highlights

During 2007–2011, a total of 2,606 cases of acute occupational pesticide-related illness and injury were identified in 12 states (Table 1). Rates of illness and injury among agricultural industry workers (18.6/100,000) were 37 times greater than the rates for nonagricultural workers (0.5/100,000). Rates were found to be highest in Washington. Most affected persons were exposed to insecticides or herbicides (Table 2). Among persons exposed to insecticides, the chemical classes most often involved were pyrethroids, organophosphates, sulfur compounds, and pyrethrins (Table 3). Among persons exposed to herbicides, the specific herbicides most commonly involved were glyphosate and the dipyridyls (i.e., paraquat and diquat). A total of 80% of cases were classified as low severity, 18% were moderate severity, and 1% were high severity. Two affected persons died.

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