Establishment of the North Carolina Pesticide Incident Surveillance Program and the Integration of Its Findings into Pesticide Safety Education Programs

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Abstract

Pesticides are widely used in residential, agricultural, municipal, and commercial establishments to control a variety of pests. However, improper use of pesticides may result in adverse health effects. Reporting acute pesticide-related illnesses to the Centers for Disease Control and Prevention is voluntary, and the extent of unintentional pesticide exposures and resulting harmful effects is not known in most states. To address this issue, the North Carolina Division of Public Health established a pesticide incident surveillance program that requires all healthcare providers in the state to report pesticide-related injury and illnesses within 48 hours of diagnosis. We describe the steps involved in establishing this statewide program, an analysis of the cases reported over the first six years, and how the data collected are used in various pesticide safety education outreach efforts within North Carolina.

Keywords: pesticides, pesticide-related illnesses, pesticide exposure, pesticide incident surveillance program, pesticide safety education

Introduction

When used as directed, pesticides have been shown to be a significant benefit to society by protecting food sources, disinfecting water, preserving wood structures, and controlling public health pests, among many other uses. The U.S. Environmental Protection Agency (EPA) estimated that approximately 5.1 billion pounds of pesticides were used in the U.S. in 2007 (Grube et al., 2011). Human and (nontarget) animal exposure to pesticides, however, can cause injury, illness, or death if products are not handled or used correctly. A recent review of human pesticide exposure in the U.S. from 2005 to 2010 found an annual average of 130,136 calls to poison control centers; 20,116 people treated in healthcare facilities; 1,419 hospitalizations; and 23 deaths, mostly suicides (Langley and Mort, 2012). Reporting acute pesticide-related illnesses to the Centers for Disease Control and Prevention is voluntary (Coates et al., 2015), and the extent of unintentional pesticide exposures and resulting adverse health effects is unknown in most states. Currently, 12 states receive federal support to bolster pesticide-related illness and injury surveillance (CDC NIOSH, 2016).

North Carolina produces a large and diverse array of agricultural commodities. Census of Agriculture data for 2012 indicate that nearly 7.5 million acres of farmland in North Carolina were treated with pesticides to control insects, weeds,

nematodes, and diseases (USDA, 2012). Much of North Carolina agriculture is labor intensive and employs approximately 72,200 migrant and seasonal farmworkers, including those with H-2A temporary visas (N.C. Department of Commerce, 2014). The Structural Pest Control and Pesticides Division within the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) currently certifies 15,200 private pesticide applicators and 20,500 commercial pesticide applicators (NCDA&CS, 2015). Given these conditions, there is significant potential for inadvertent pesticide exposure. While the NCDA&CS has been investigating complaints about misuse or misapplication of pesticides since the early 1970s, information on documented adverse human health effects has rarely been reported (Buhler et al., 2007).

Development of the North Carolina Pesticide Incident Surveillance Program (NCPISP)

To monitor the impact of pesticide use on public health, the North Carolina Division of Public Health began case-based surveillance of acute pesticide-related illness and injury in 2007 with funding from EPA. Surveillance is a public health tool to determine how often a condition of concern occurs, what groups are most affected, and the factors contributing to exposure. Public health surveillance findings are customarily used for the development and evaluation of relevant risk-reduction training and for policy and regulatory review and revision. The basic components of a public health surveillance system include:

1. A mandatory statutory rule to obtain reports from healthcare providers.
2. A data management system (e.g., a means to collect and code data from reports in a database).
3. Case investigation and follow-up protocols used to obtain more circumstantial information about the exposure.
4. A protocol stipulating when and how a case is referred to the regulatory agency that administers the state pesticide laws.
5. An advisory group (e.g., stakeholders that can advise and use the surveillance data to promote safe handling methods in targeted groups).

How Exposure Cases are Reported

The first step in developing the NCPISP was to establish a mandatory reporting rule. Statutory language, as approved by the North Carolina General Assembly, was already in place that allowed the surveillance program to adopt standardized procedures to investigate health conditions of concern. In 2006, an official reporting rule was promulgated into law. This law required healthcare providers to report cases of acute (e.g., observable within 24 to 48 hours) pesticide-related illness or injury to the Carolinas Poison Center (CPC) within 48 hours after it was diagnosed and immediately if the event resulted in death (N.C. Office of Administrative Hearings, 2006). This is a customary protocol for most healthcare providers who rely on the CPC for treatment advice. About 92% of cases are routed to the Division of Public Health this way. Cases are accepted from any

source: some are obtained from the NCDA&CS, some from legal aid, and others from migrant and community health center outreach workers.

Case Investigation, Data Management, and Classification

After a report is received by the NCPISP, it is screened to determine if it meets the criteria of an acute pesticide poisoning case. These criteria include any acute adverse health effect resulting from exposure to a pesticide, as defined by the Federal Insecticide, Fungicide, and Rodenticide Act, and health effects due to an unpleasant odor, injury from an explosion of a pesticide product, inhalation of smoke from a burning product, and an allergic reaction. If the case meets these criteria, information on the person, the exposure, and the related health effects is entered into a database. All occupational cases – and select nonoccupational cases that reach a certain severity level (including death, hospitalization, exposure resulting from drift, group exposure, public exposure, and school exposure) – are investigated by obtaining medical records and interviewing the victim. This allows NCPISP staff to confirm the poisoning and gather more detailed information about the exposure that can be used to formulate risk-reduction measures.

After all the relevant data are collected, the case is classified as definite, probable, possible, or suspicious (DPPS). A case is coded as "definite" when there is objective evidence (e.g., laboratory, clinical, or environmental) that can confirm both the exposure and the health effect. A case is deemed "probable" if there is objective evidence of either exposure or health effects. A case is denoted as "possible" if only subjective information (e.g., self-reported) about the exposure or health effects is available. And a case is considered "suspicious" if there is insufficient toxicological information (e.g., pesticide may be new and little human toxicological information is available) to confirm a causal relationship between the exposure and the health effects (CDC NIOSH, 2005). Those cases that fall out of the DPPS classification scheme are not included in data analysis and prevention intervention planning.

A severity score is also applied to each case. The severity score designation is based on signs and symptoms, whether medical care was sought, whether the affected individual was hospitalized, and whether lost time from work or usual activities occurred. For instance, high severity means the illness was likely life threatening, the affected individual received treatment, was hospitalized, and lost significant time from work. Both the classification scheme (DPPS) and severity index (algorithm) were developed by the National Institute for Occupational Safety and Health (NIOSH), SENSOR Pesticides Program, Centers for Disease Control and Prevention (CDC NIOSH, 2005).

Referral to the State Lead Agency

NCPISP staff refer cases to NCDA&CS if they are severe enough to warrant concern of repeat exposure to the affected individual and coworkers. NCDA&CS is the state lead agency responsible for administering federal and state pesticide laws and conducting inspections of farms, homes, and businesses.

Advisory Group

An NCPISP advisory group meets twice a year to share surveillance findings and discuss exposure prevention strategies. It has representatives from the Cooperative Extension Service (including county pesticide applicator educators), academia, farm operator and farmworker advocacy groups, regulatory enforcement, citizen advocacy, public health, and structural pest control.

In the following section, we provide summaries and highlights of pesticide data collected from 2007 to 2012 and outline how findings are used for pesticide safety education in cooperation with agency partners.

Data Summary

From 2007 to 2012, NCPISP received 5,957 reports of acute pesticide illness or injury, an average of nearly 1,000 case reports per year. The reports represent 5,619 separate events. A total of 2,452 reported cases were classified as definite, probable, possible, or suspicious (DPPS), of which 233 (10%) were occupationally related and 2,219 (90%) were nonoccupational (Table 1). The number of occupational and nonoccupational cases varied by year (Figure 1), and a seasonal trend corresponding to outdoor pest activity was observed (Figure 2). The primary source of all reports (98%) was the Carolinas Poison Center (data not shown).

Only cases classified as DPPS are included in the data analyses for this report.

Table 1. Distribution of all pesticide illness cases reported to the North Carolina Pesticide Incident Surveillance Program, 2007 – 2012.

Status	Occupational	Nonoccupational	Total
Definite Case	21	79	100
Probable Case	30	124	154
Possible Case	182	2,015	2,197
Suspicious Case	0	1	1
Subtotal	***233 (10 %)***	***2,219 (90%)***	***2,452***
Unlikely Case	54	295	349
Insufficient Information	97	2,979	3,076
Exposed/Asymptomatic	16	25	41
Unrelated	17	22	39
Unknown/Uncoded	0	0	0
Subtotal	***184***	***3,321***	***3,505***
Total	**417**	**5,540**	**5,957**

Figure 1. Number of nonoccupational and occupational pesticide illness cases reported by year in North Carolina, 2007 – 2012.

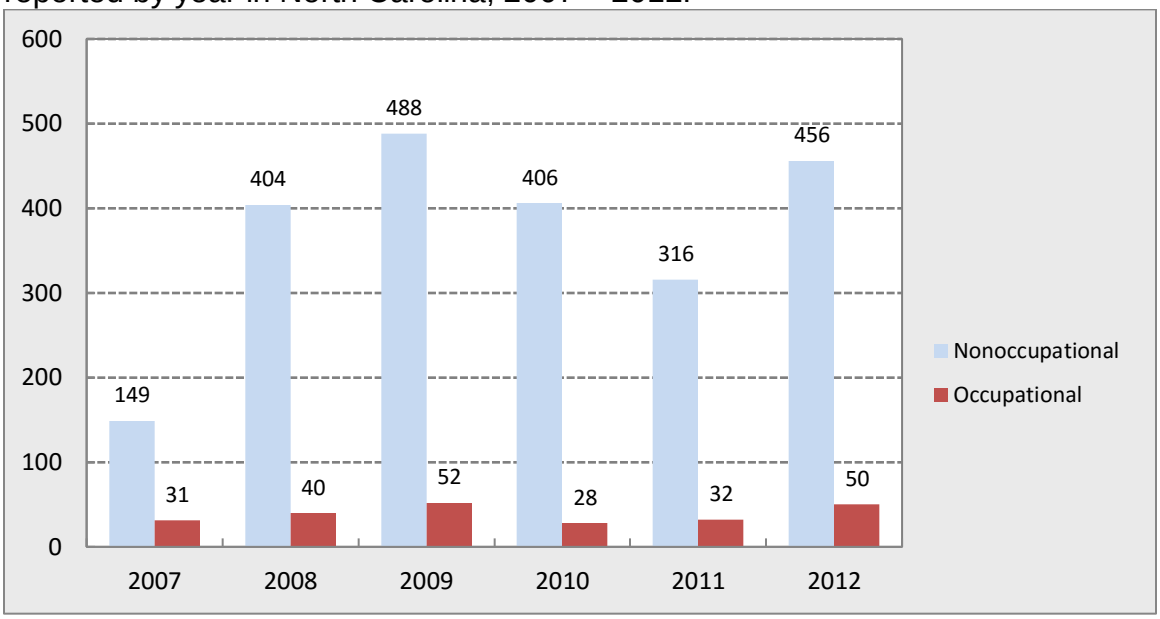
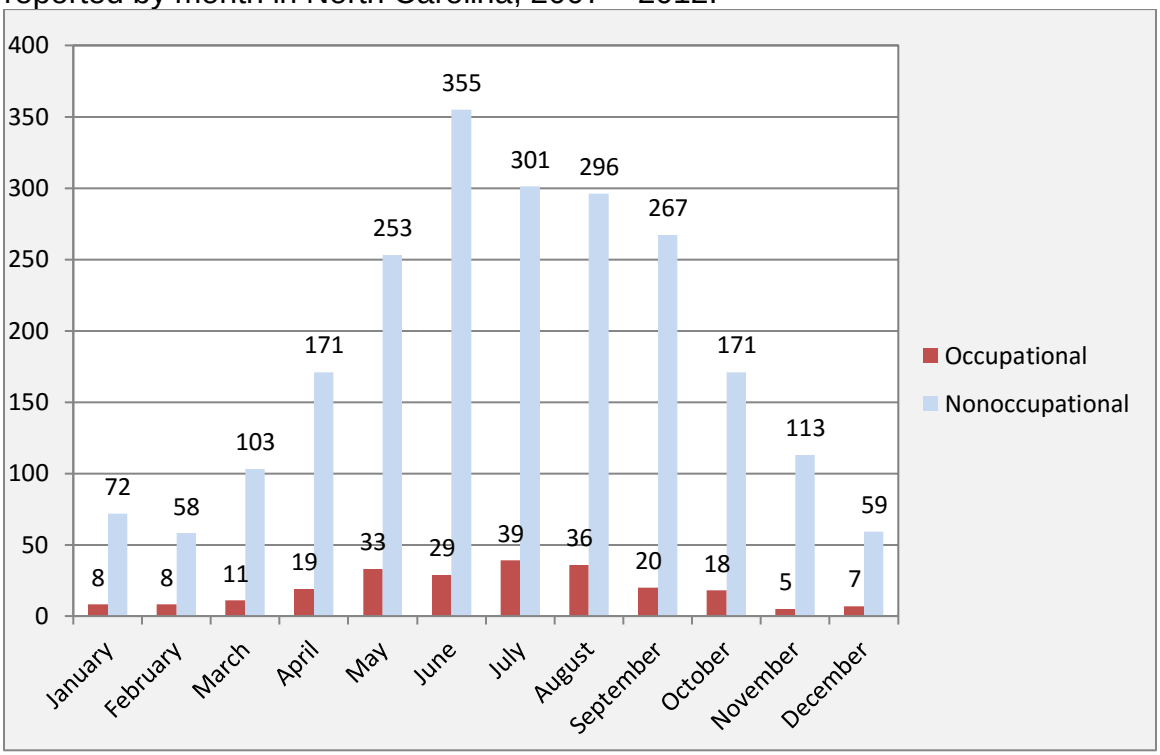


Figure 2. Number of nonoccupational and occupational pesticide illness cases reported by month in North Carolina, 2007 – 2012.



Demographics

People aged 20 to 29 accounted for the largest percentage of occupational cases (33%). Most occupational cases (73%) involved males (Table 2). The most common occupation among exposed workers was agricultural work (25%; Table 3), composed largely of farm laborers. The next most common occupation was building, grounds cleaning, and maintenance work (24%), mostly pest control operators and grounds keeping workers in lawn care and landscaping.

Table 2. Distribution of occupational pesticide illness cases by age group and gender in North Carolina, 2007 – 2012.

Age Groups	Female	Male	Unknown	Number	Percent
Unknown	0	7	2	9	3.9%
00-09	0	0	0	0	0.0%
10-19	1	11	0	12	5.1%
20-29	18	59	0	77	33.0%
30-39	11	33	0	44	18.9%
40-49	17	29	0	46	19.7%
50-59	6	17	0	23	9.9%
60-69	8	12	0	20	8.6%
70-79	0	2	0	2	0.9%
80+	0	0	0	0	0.0%
Total	**61**	**170**	**2**	**233**	**100.0%**

Table 3. Job classes of occupational pesticide illness cases in North Carolina, 2007 – 2012.

Occupation*	Number	Percent
Farming, Fishing, and Forestry	57	24.5%
Building, Grounds Cleaning, and Maintenance	55	23.6%
Office and Administrative Support	14	6.0%
Construction	14	6.0%
Transportation and Material Moving	13	5.6%
Sales and Related	11	4.7%
Management	8	3.4%
Healthcare Practitioner and Technical	7	3.0%
Protective Services	7	3.0%
Production	7	3.0%
Other	23	9.9%
Unknown	17	7.3%
Total	**233**	**100.0%**

* Categories based on 2002 Census of Occupation Codes.

Most nonoccupational cases (72%) involved adults aged 18 and above (Table 4). More than 570 cases (26%) involved people under 18, and most poisonings in this age group (59%) occurred in small children, five and under.* Just over half of nonoccupational cases (53%) were female.

Table 4. Distribution of nonoccupational pesticide illness cases by age group and gender in North Carolina, 2007 – 2012.

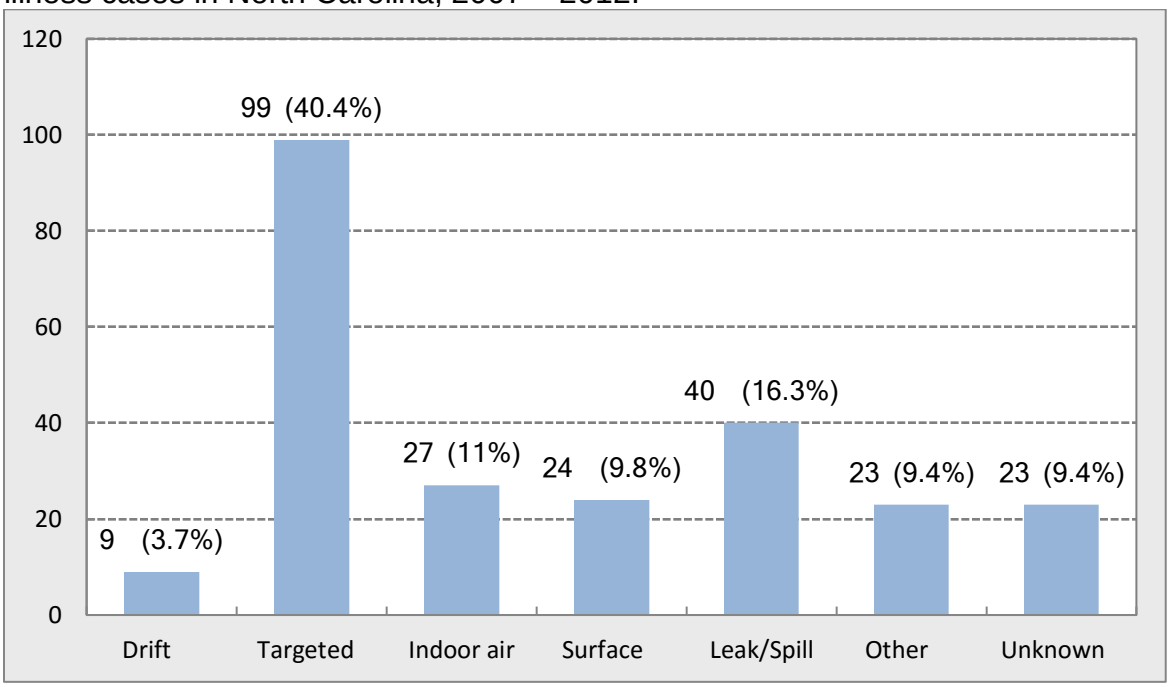
Age Groups	Female	Male	Number	Percent
Unknown	29	24	53	2.4%
00-<1: Infants	9	13	22	1.0%
01-02: Toddlers	81	91	172	7.8%
03-05: Preschool	58	85	143	6.4%
06-11: Child	53	72	125	5.6%
12-17: Youth	51	58	109	4.9%
18-64: Adult	785	639	1,424	64.2%
65+: Senior	104	67	171	7.7%
Total	**1,170**	**1,049**	**2,219**	**100.0%**

* Children under six were highlighted because of characteristics that can lead to increased risk of exposure (e.g., surface-area to body mass ratio, physical status and proximity to contaminated surfaces, frequent hand-mouth activity, poor hand washing, and rapid growth and development). There were 337 children under six, which represents 59% of all cases (571) involving people less than 18 years old.

Exposures

Occupational cases. Most workers (40%) contacted pesticides through targeted exposure (Figure 3). This occurs when the pesticide is released at the target site and exposes the applicator through direct projection, ricochet, wind blowback, or airborne exposure by moving through an area being actively treated.

Figure 3. Types of pesticide exposure associated with occupational pesticide illness cases in North Carolina, 2007 – 2012.*



* Total exceeds total number of occupational cases (N=233) because some individuals had more than one type of pesticide exposure.

Fifty-one percent of occupational-related pesticide illness cases involved insecticides (Table 5), and the chemical classes most commonly associated with insecticide exposures were pyrethroids (48%), followed by organophosphates (13%) (data not shown).

Table 5. Types of pesticides associated with occupational pesticide illness cases in North Carolina, 2007 – 2012.

Pesticide Type	Number	Percent
Insecticide	134	50.7%
Herbicide	61	23.1%
Disinfectant*	15	5.6%
Insecticide & Other	13	4.9%
Fungicide	11	4.2%
Insect Repellent	7	2.7%
Fumigant	6	2.3%
Insect Growth Regulator	2	0.8%
Rodenticide	1	0.4%
Herbicide & Other	1	0.4%
Other	4	1.5%
Multiple (not otherwise specified)	1	0.4%
Unknown	8	3.0%
Total **	**264**	**100.0%**

* Data collection for disinfectants ceased May 2007 except for algaecides reported by Carolinas Poison Center.
** Total exceeds total number of occupational cases (N=233) because some individuals were exposed to more than one type of pesticide.

Most workers were either applying pesticides when exposed (46%) or performing routine work tasks not involving pesticide application (43%) (data not shown). Examples of the latter activity are "feed store sales associate got pesticide residue on hands when customer brought in open bottle," "farmer cleaning a shed got pesticide on hands when moving pesticide bottles on shelf," and "cell tower grounds crew member drank from unmarked bottle that had stored a pesticide."

Factors contributing to exposure for occupational cases are listed in Table 6. Lack of, or inadequate, personal protective equipment (PPE) (e.g., gloves, eye protection, and respirator) was the factor that contributed the most to pesticide exposure. Other factors that accounted for many worker exposures included instances where the person contacted the pesticide despite general label warnings (violations not otherwise specified, or NOS); spills or splashes; and equipment failure. Types of label violations NOS included pesticide blowback to the applicator’s face or other body part, applicator accidentally touching his or her face with a contaminated hand or shirt, and off-label use.

Examples of label violations NOS

"A state park worker was applying pesticides and they were blown back by the wind and he got them on his skin and inhaled some."

"A helper on a farm was spraying corn and soy beans with fungicide and herbicide. He got it on his shirt and then wiped his face with the shirt."

"Seven farm workers were sent to the emergency department after eating watermelon from a garden the workers maintained on the farm. Someone had applied carbamate insecticide to the plants to prevent rats from eating the fruit."

Spills or splashes typically resulted from leaking pesticide containers, packaging failure, or accidents. Most of the equipment failure incidents involved leaky backpack sprayers (tank, hose, or other); handheld hoses with holes; other leaks or breaks; and fumigation line failure (holes or line breaks).

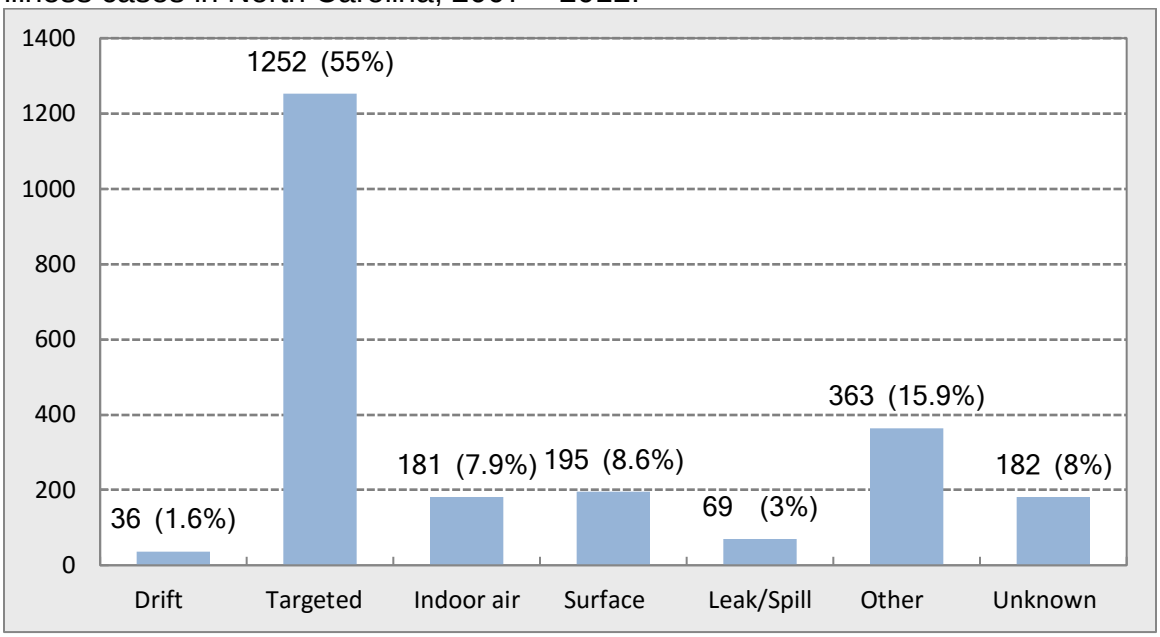
Table 6. Factors contributing to exposure for occupational pesticide illness cases in North Carolina, 2007 – 2012.

Contributing Factors	Cumulative	Percent
Required Personal Protective Equipment (PPE) Not Worn	50	18.2%
Label Violations Not Otherwise Specified (NOS)	31	11.3%
Spill/Splash of Liquid or Dust (not equip. failure)	29	10.6%
Application Equipment Failure	28	10.2%
No Label Violation Identified but Person Still Exposed / Ill	18	6.5%
People Were in the Treated Area during Application	15	5.4%
Excessive Application	10	3.6%
Other	35	12.7%
Unknown	59	21.5%
Total *	**275**	**100.0%**

*Total exceeds total number of occupational cases (N=233) because some individuals had more than one contributing factor.

Nonoccupational cases. Similar to occupational cases, nonoccupational cases involved contact with pesticides mostly through targeted exposure (55%; Figure 4), and insecticides accounted for a significant proportion of the exposures (58%; Table 7). The chemical class of insecticide most often used was pyrethroids (52%; data not shown). Nonoccupational poisonings occurred primarily at home (96%; data not shown), and pesticides were typically applied manually (e.g., pellets, baits, pet products, ant killer pellets/dusts, pool tabs, mothballs, or lice shampoo), or by using cans, trigger pumps, or foggers (Table 8). Cases involving crop spraying equipment (e.g., ground sprayer, airplane, or fumigator) were associated with drift from an aerial application or ground application on an adjacent farm. Application targets for nonoccupational pesticide use varied (Table 9), and most affected individuals were applying pesticides when exposed (43%; data not shown). Contributing factors are not presented for nonoccupational cases.

Figure 4. Types of pesticide exposure associated with nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.*



* Total exceeds total number of nonoccupational cases (N=2,219) because some individuals had more than one type of pesticide exposure.

Table 7. Types of pesticides associated with nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

Pesticide Type	Number	Percent
Insecticide	1,347	58.0%
Insect Repellent	236	10.2%
Herbicide	200	8.6%
Disinfectant*	207	8.9%
Insecticide & Other	119	5.1%
Rodenticide	43	1.9%
Insect Growth Regulator	40	1.7%
Fungicide	17	0.7%
Fumigant	9	0.4%
Herbicide & Other	3	0.1%
Multiple (not otherwise specified)	6	0.3%
Other	38	1.6%
Unknown	57	2.5%
Total**	**2,322**	**100.0%**

* Data collection for disinfectants ceased May 2007 except for algaecides reported by Carolinas Poison Center.
** Total exceeds total number of nonoccupational cases (N=2,219) because some individuals were exposed to more than one type of pesticide.

Table 8. Types of equipment associated with nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

Application Equipment	Number	Percent
Manual Placement	522	23.5%
Pressurized Can/Bomb	477	21.5%
Trigger Pump/Compressed Air	321	14.5%
Total Release Fogger	274	12.4%
Ground Sprayer	12	0.5%
Aerial Application Equipment	7	0.3%
Sprayer, Backpack	5	0.2%
Handheld Granular/Dust Applic.	4	0.2%
Spray Line, Handheld	3	0.1%
Soil Injector	2	0.1%
More Than One Type of Equipment	6	0.3%
Other	15	0.7%
Not Applicable	133	6.0%
Unknown	438	19.7%
Total	**2,219**	**100.0%**

Table 9. Application targets associated with nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

Application Target	Number	Percent
Building Surface	533	24.0%
Human - Skin/Hair	151	6.8%
Veterinary - Domestic Animals	138	6.2%
Landscape/Ornamentals	99	4.5%
Pool, Spa, Hot Tub, Jacuzzi	74	3.3%
Building Structure	71	3.2%
Undesired Plant	58	2.6%
Humans	41	1.8%
Bait For Rodent, Bird, Predator	38	1.7%
Building Space Treatment	19	0.9%
Other	110	5.0%
Not Applicable	304	13.7%
Unknown	583	26.3%
Total	**2,219**	**100.0%**

Health Outcomes

Occupational cases. Most occupational cases (91%) were of low severity (Table 10). The most common route of exposure was dermal (36%), followed closely by inhalation (Table 11). Those affected experienced a variety of symptoms (Table 12). Most sought treatment advice from the Carolinas Poison Center (56%; data not shown).

Nonoccupational cases. Most nonoccupational cases (94%) were of low severity (Table 10). The most common route of exposure was inhalation (36%; Table 11), and affected individuals experienced a variety of symptoms (Table 12). Advice from Carolinas Poison Center was the most common source of treatment (78%; data not shown).

Table 10. Severity of occupational and nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

	Occupational		Nonoccupational	
Severity	**Number**	**Percent**	**Number**	**Percent**
Fatal	0	0.0%	4	0.2%
High	4	1.7%	19	0.9%
Moderate	18	7.7%	114	5.1%
Low	211	90.6%	2,082	93.8%
Total	**233**	**100.0%**	**2,219**	**100.0%**

Table 11. Routes of exposure for occupational and nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

	Occupational		Nonoccupational	
Route of Exposure	**Number**	**Percent**	**Number**	**Percent**
Dermal	100	36.0%	607	23.9%
Inhalation	92	33.1%	910	35.7%
Ocular	41	14.7%	610	24.0%
Ingestion	28	10.1%	285	11.2%
Injection	0	0.0%	2	0.1%
Unknown	17	6.1%	131	5.1%
Total *	278	**100.0%**	**2,545**	**100.0%**

* Totals exceed total number of occupational (N= 233) and nonoccupational (N= 2,219) cases because some individuals had more than one route of exposure.

Table 12. Reported signs and symptoms associated with occupational and nonoccupational pesticide illness cases in North Carolina, 2007 – 2012.

	Occupational		Nonoccupational	
	Number	**Percent**	**Number**	**Percent**
Neurological	102	19.9%	528	14.1%
Gastrointestinal	91	17.7%	638	17.1%
Dermal	88	17.1%	547	14.6%
Respiratory	85	16.6%	875	23.5%
Ocular	69	13.5%	707	19.0%
General	52	10.1%	252	6.8%
Cardiac	24	4.7%	171	4.6%
Renal	2	0.4%	11	0.3%
Total *	**513**	**100.0%**	**3,729**	**100.0%**

* Totals exceed total number of occupational (N= 233) and nonoccupational (N= 2,219) cases because some individuals had more than one type of symptom.

Pesticide Safety Education Outreach

The NCPISP uses trends seen in surveillance data to target various pesticide safety education audiences and topics, as discussed below.

Applicators and University Students

Pesticide safety education emphasizes which work activities put the applicator at risk for exposure, how applicators in the field are actually being exposed, and the fundamental principles of pesticide exposure prevention. Trend data as described in this article and case studies provide compelling evidence that accidental exposures happen and there are benefits to basic pesticide safety measures. The NCPISP established a relationship with the North Carolina Pesticide Safety Education Program in an effort to incorporate surveillance data into continuing education trainings with private pesticide applicators. The NCPISP has reached applicators with pesticide safety education by delivering poster presentations at the Annual Crop Protection School and the Annual Pest Control Technician's School, by securing a booth at the annual North Carolina Farm Show, and by delivering live presentations at the North Carolina Agricultural Aviation Association Annual Meeting.

The NCPISP also uses frequency data and case narratives to provide pesticide safety education in lecture format to two-year (associate's degree) agricultural students enrolled in the "Pesticides and Their Utilization" course at North Carolina State University. These students typically sit for a pesticide applicator certification exam after completing the course.

Healthcare Providers

The NCPISP inserts frequency data and case studies into seminars given to medical professionals working in rural communities with farm operators and migrant farmworkers. Examples include the annual agricultural medicine course provided by the Agromedicine Institute at East Carolina University, annual trainings delivered to healthcare providers working in migrant and community health centers serving counties with many farmworkers, and in-service training sessions provided to outreach workers employed by migrant and community health centers affiliated with the North Carolina Farmworker Health Program and the North Carolina Community Health Center Association.

Emergency Responders

Through ongoing, near real-time data collection, the NCPISP can identify sentinel events that alert public health and safety officials to hazards that could affect a larger population. The program has used such an event to develop a large-scale outreach intervention for a certain group. For instance, in March 2013, four firefighters responded to a call in rural eastern North Carolina where a fumigant had drifted from a nearby field to a private home. The family had to evacuate the home, and upon arrival, all four firefighters became ill and were treated at the local emergency department. The firefighters were not prepared to encounter fumigant pesticides at a residence. As a result, a hazard alert was developed and

shared with all firehouses in the state to help raise awareness about agricultural fumigation practices and the associated risks.

Other

The NCPISP provides data to federal partners to document trends and emerging issues and to inform policy change. For instance, state data are shared annually and as needed with NIOSH to analyze national trends and to describe unsafe products or practices. Findings are published in scientific journals and provide a means to reach broader audiences with pesticide safety education. State data are also shared with EPA to aid in evaluating product safety and labeling and to strengthen pesticide safety education programs, such as the revised Worker Protection Standard.

Discussion

In North Carolina, public health case-based surveillance is used as a tool to monitor the effects of pesticide use at work and at home. Periodic analysis of the data collected provides insight on how often pesticide poisoning incidents occur, to what groups, and how to evaluate risk factors for exposure. From 2007 through 2012, the North Carolina Division of Public Health received an average of 1,000 pesticide poisoning reports annually. Most pesticide poisonings occurred at home and during the summer months. High numbers of domestic exposures are consistent with data from the American Association of Poison Control Centers and other state surveillance programs (Mowry et al., 2013; Schwartz & Stanbury, 2012). One out of four nonoccupational cases involved children under 18. People used pesticides at home for many reasons, thereby increasing the chance of harmful chemical exposure.

Occupational exposures were less common and involved mostly younger people and those who worked on a farm or performed structural pest control or outdoor groundskeeping tasks. These same occupations account for most occupational exposure in national data (Calvert et al., 2004). People doing routine work (not involving pesticide application) were exposed to pesticides almost as often as those directly applying pesticides. Most cases were of low severity and involved insecticides, primarily pyrethroids. The predominance of pyrethroid-related exposure in North Carolina mirrors national trends (Mowry et al., 2013; Calvert et al., 2014). The primary factor contributing to occupational exposure was neglecting to use proper PPE.

North Carolina uses surveillance trends for the development and evaluation of risk-reduction activities. The NCPISP has identified the following areas for additional education or emphasis with the goal of reducing pesticide exposure:

- Educate the public on the safe use and storage of pesticides to reduce exposure, especially in children. Partnerships with the Carolinas Poison Center, the North Carolina Cooperative Extension Family and Consumer Sciences Department, and the North Carolina Lead and Healthy Homes Outreach initiative could be useful in formulating a strategy to do this. Training on integrated pest management should be included.

- Promote pesticide safety training for new hires and younger workers. Training should address exposure risks during all phases of work – not just application – and reinforce the importance of personal protective equipment based on label requirements. Pesticide users should also be trained to "expect the unexpected" and prepare accordingly. When applying pesticides, it is important to anticipate how weather conditions may affect applications, identify scenarios in advance that could result in spills and splashes, have PPE and cleanup materials available, and inspect application equipment before use to identify possible leaks and other defects.
- Educate all users on the types of pesticides most commonly associated with exposure. Pyrethroid insecticides account for most pesticide exposures at home and at work. At home, these pesticides are formulated as household sprays, aerosol bombs, insect repellents, pet shampoos, and lice treatments. At work, they are used in agricultural and structural pest control. While this class of insecticides is less acutely toxic than most other insecticides, these products are not risk free. Following label instructions is critically important. Although pyrethroids have gradually replaced organophosphates (OP) over time (Robert & Reigart, 2013), surveillance findings suggest that OPs continue to be used and present a significant risk to human health.
- Educate all users about all risks associated with pesticides, including possible chronic health effects linked to low-level or subacute pesticide exposure over time (Robert & Reigart, 2013).

Limitations

Counts in this report are likely underestimates. Not all people who become ill from pesticides recognize the source of their illness or seek healthcare. If care is sought, clinician reporting may not be consistent. Additionally, many cases are eliminated from data analysis due to lack of complete data. Investigations are performed on all occupational cases, but approximately half of these cases are lost to follow-up (no callbacks or refusals). Limited follow-up is done with nonoccupational cases. Lack of follow-up limits what we know about pesticide exposure cases.

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