Characteristics of Pesticide-Related Hospitalizations, Louisiana, 1998–2007

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SYNOPSIS

Objective. Pesticides are widely used on agricultural crops and in homes, workplaces, and public spaces. Exposure to pesticides can cause acute and chronic health effects. We analyzed data from the Louisiana Hospital Inpatient Discharge Database from 1998 through 2007 to characterize hospitalizations involving pesticides.

Methods. Data for the study period consisted of 384 pesticide-related hospitalizations. We used demographic information and diagnosis codes for analysis.

Results. Males consistently had higher hospitalization rates than females ($p=0.0073$). Children aged 0–4 years had the highest pesticide-related hospitalization rate of all age groups (2.69 hospitalizations per 100,000); children aged 5–9 years had the lowest rate (0.36 hospitalizations per 100,000). Compared with adults, children had a higher rate of disinfectant exposure (15% vs. 5%; odds ratio [OR] = 3.41, 95% confidence interval [CI] 1.61, 7.21; $p=0.0008$) and rodenticide exposure (14% vs. 2%; OR=8.55, 95% CI 3.07, 23.78; $p<0.0001$). Rural parishes (counties) were more likely than urban parishes to have higher pesticide hospitalization rates (OR=4.72, 95% CI 2.34, 9.54; $p<0.0001$). Intentional poisonings accounted for 27% of cases. Only eight cases were coded as work-related.

Conclusions. Analyzing pesticide-related hospitalization data provides important information about some of the most severe pesticide poisoning cases. Significant findings include the elevated rate of hospitalizations among young children and men, and the large proportion of self-inflicted poisonings. Health departments and health-care providers may use these findings to target outreach and prevention activities.

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Pesticides are defined under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) as any substance or mixture of substances intended to control a variety of pests such as insects, rodents, fungi, weeds, and microorganisms.[1] They are usually categorized by the type of pest they are intended to control; categories include insecticides, herbicides, fungicides, rodenticides, termiticides, miticides, disinfectants, and repellents. Although pesticides serve many useful purposes and are tailored to control specific pests, they can still harm humans.

In Louisiana, more than 11,000 pesticide products are registered for use. Some of these products are restricted for use by certified applicators or people under their supervision, while other pesticides are registered for general household use. The majority of pesticides are used on crops, but they are also widely used in and around homes, in workplaces, and in public places such as schools and parks. The U.S. Environmental Protection Agency (EPA) estimates that 74% of U.S. households use some type of pesticide, primarily insecticides and disinfectants.[2]

Given their widespread agricultural and household use, exposure to pesticides is common. Health effects from pesticide exposure vary based on factors such as age, preexisting health conditions, product toxicity, route of exposure, and dose.

Louisiana has been tracking pesticide exposures and associated health effects since the early 1990s. Louisiana's case-based surveillance program receives reports of pesticide exposures from several sources including Poison Control Center reports and complaints filed with the Louisiana Department of Agriculture and Forestry, the state agency responsible for enforcing pesticide use. Changes in disease reporting requirements in 2006 mandated that physicians and other health-care providers report all confirmed or suspected cases of pesticide poisoning and laboratory tests of pesticide metabolites or cholinesterase. In 1999, Louisiana bolstered its surveillance capacity through collaboration with the Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health's (NIOSH's) Sentinel Event Notification System for Occupational Risk (SENSOR)-Pesticides Program, which provides technical and financial support for state surveillance of acute, occupational pesticide-related illness and injury.[3] Although the SENSOR-Pesticides Program focuses on occupational exposures, Louisiana tracks all pesticide exposures, regardless of where or how the exposure occurred.

Analysis of the Louisiana Office of Public Health's pesticide surveillance data highlights common pesticide exposure scenarios, which guide targeted outreach and prevention activities. While a number of pesticide surveillance cases receive some type of medical care, very few hospitalized cases are reported to the Louisiana Office of Public Health's Pesticide Surveillance Program. To evaluate severe cases of pesticide poisoning, the Pesticide Surveillance Program analyzed hospitalization records for 1998 through 2007. This article summarizes the findings of all pesticide-related hospitalizations during the 10-year period.

METHODS

We used the Louisiana Hospital Inpatient Discharge Database (LAHIDD), which contains data from licensed, acute care hospitals in Louisiana for each year since 1998. Emergency room visits are not included in LAHIDD. About 89% of acute care hospitals provide data to LAHIDD. Information in LAHIDD includes patient demographics, admission and discharge dates, diagnoses and procedures, cost of hospitalization, and payer information. Diagnoses are coded using the International Classification of Diseases, Ninth Revision (ICD-9).

Cases were selected if they had a pesticide ICD-9 code or E-code (external cause of injury or poisoning code) in any of the 10 diagnostic fields: primary diagnosis, eight secondary diagnoses, or E-code diagnosis. E-codes provide supplemental information about environmental events, circumstances, and other conditions related to a hospitalized case of injury or poisoning. The pesticide ICD-9 codes and E-codes used for case selection were recommended by NIOSH's Pesticide Program (Table 1).[4]

Variables included in the analysis were year and month of hospitalization, demographics (age, gender, and race), parish (county) of residence, length of hospital stay, ICD-9 codes, and E-codes. Year and month of hospitalization were based on the admission date. Age was stratified into children (aged ≤18 years) and adults (aged >18 years) for some analyses. Parishes were categorized into rural/urban groups based on the percent of the 2000 U.S. Census population living in a rural setting. According to the Census, a rural parish has 65% or more of its population residing outside of an urbanized area or urban cluster. An urbanized area consists of adjacent census block groups and census blocks with a population density of 1,000 people per square mile along with densely settled census blocks with a total population of at least 50,000 people. Urban clusters have a similar definition, although the overall population is between 2,500 and 50,000.[5]

A new variable, "Pesticide Type," was created to reflect the most specific pesticide information reported

Table 1. ICD-9 codes and E-codes used for selection of pesticide-related hospitalizations, Louisiana, 1998–2007 (*n*=384)[a]

Code number and definition	N	*Percent*[b]
ICD-9 code		
989.0 Toxic effect of hydrocyanic acid and cyanides	2	1
989.1 Toxic effect of strychnine and salts	1	<1
989.2 Toxic effect of chlorinated hydrocarbons	25	7
989.3 Toxic effect of organophosphate and carbamate	86	22
989.4 Toxic effect of other pesticides, not elsewhere classified	200	52
E-code		
Accidental exposure		
E861.4 Accidental poisoning by disinfectants	31	8
E863.0 Accidental poisoning by insecticides of organochlorine compounds	22	6
E863.1 Accidental poisoning by insecticides of organophosphorus compounds	47	12
E863.2 Accidental poisoning by carbamates	2	1
E863.3 Accidental poisoning by mixtures of insecticides	1	<1
E863.4 Accidental poisoning by other and unspecified insecticides	53	14
E863.5 Accidental poisoning by herbicides	8	2
E863.6 Accidental poisoning by fungicides	3	1
E863.7 Accidental poisoning by rodenticides	20	5
E863.8 Accidental poisoning by fumigants	4	1
E980.7 Agricultural and horticultural chemical and pharmaceutical preparations other than plants, foods, and fertilizers	20	5
Intentional exposure		
E950.6 Suicide and self-inflicted poisoning by agricultural and horticultural chemical and pharmaceutical preparation other than plant foods and fertilizers	88	23
E950.0–E950.5, E950.7–E950.9 Non-pesticide suicide E-code with a pesticide ICD-9 code	14	4

[a]Frequency of ICD-9 codes and E-codes among pesticide-related hospitalizations. These codes were recommended by the National Institute of Occupational Safety and Health Sentinel Event Notification System for Occupational Risk-Pesticides Program for analysis of hospital discharge data.

[b]Total percent is greater than 100 because some cases contained multiple pesticide diagnosis codes.

ICD-9 = International Classification of Diseases, Ninth Revision

E-code = external cause of injury or poisoning code

for each case. For example, if a case had an ICD-9 code of 989.4 (Toxic effect of other pesticides, not elsewhere classified) and an E-code of E863.0 (Accidental poisoning by insecticides of organochlorine compounds), Pesticide Type was coded as "organochlorines."

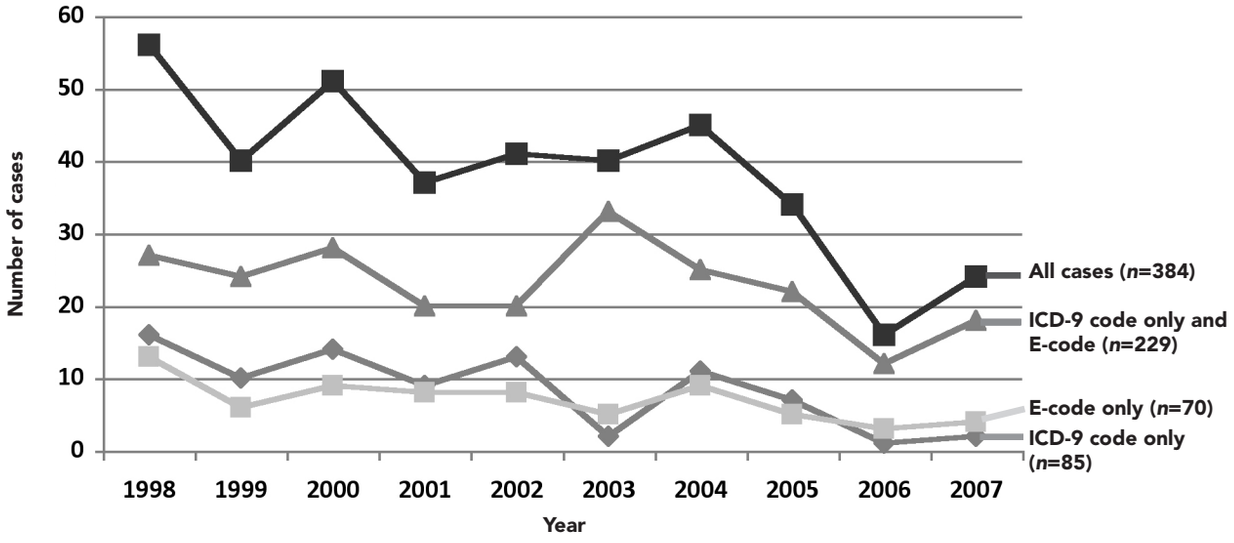
Data analysis

We used SAS® version 9.1[6] for data management and statistical analysis. We calculated rates of hospitalization for age, gender, and total cases using annual population data from the Current Population Survey.[7] Parish rates were calculated using 2000 U.S. Census data.[8] The difference in these population data estimates accounts for minor differences in parish rates compared with age, gender, and total rates. We used the Wilcoxon Rank Sum test to compare gender rates during the 10 years, rates for the age categories (0–4 years compared with all other ages and 5–18 years compared with >18 years), duration of hospital stay by intent of poisoning and age, and hospitalizations by parish and age. We used linear regression to compare annual rates for the 10 years. Odds ratios (ORs), 95% confidence intervals (CIs), and Chi-square (χ^2) values were calculated to analyze the relationship between age group and pesticide type, and hospitalization rates and rural composition. The annual mean rate of pesticide-related hospitalizations was 1.16 cases per 100,000 parish population, and this variable was dichotomized into high and low rates. One standard deviation (SD) greater than the mean rate (≥2.30 cases per 100,000 people) was defined as a high rate. We considered statistical significance for two-sided hypothesis testing at $p<0.05$.

RESULTS

From 1998 through 2007, a total of 416 cases of pesticide-related hospitalizations were identified. Thirty-two cases were excluded for the following reasons: out-of-state residents (n=14), readmissions for the same pesticide exposure incident (n=10), duplicates (n=7), and miscoded cases (n=1). These 32 deleted observations decreased the final dataset to 384 cases.

Figure 1. Pesticide-related hospitalizations by distribution of ICD-9 code and E-code, Louisiana, 1998–2007[a]



[a]Most cases had both a pesticide ICD-9 code and an E-code.

ICD-9 = International Classification of Diseases, Ninth Revision

E-code = external cause of injury or poisoning code

Frequency of pesticide diagnoses

Overall, 314 (82%) cases had a pesticide ICD-9 code and 299 (78%) cases had a pesticide E-code (Table 1). A total of 229 (60%) cases had both an ICD-9 code and E-code (Figure 1). The most commonly reported ICD-9 code was 989.4 (Toxic effect of other pesticides, not elsewhere classified) (200 cases, or 52%), and the most common E-code was E950.6 (Suicide and self-inflicted poisoning by agricultural and horticultural chemical and pharmaceutical preparation other than plant foods and fertilizers) (88 cases, or 23%). Overall, 58% of cases had a pesticide ICD-9 code in the principal diagnosis, with yearly rates ranging from 49% to 65%.

Annual pesticide-related hospitalization rates

For the 10-year period, there was a mean of 539,589 total hospitalizations per year. Hospitalizations related to pesticides had a mean of 38 cases per year and ranged from a low of 16 in 2006 to a high of 56 in 1998. We calculated annual pesticide-related hospitalization rates using yearly population totals obtained from the U.S. Census Bureau.[7] The mean annual rate was 0.89 hospitalizations per 100,000 residents and ranged from 0.39 in 2006 to 1.30 in 1998 (Figure 2).

Pesticide-related hospitalizations by season

The mean annual number of pesticide-related hospitalizations per month was 3.2. In general, the fall and winter months had lower-than-average numbers of pesticide-related hospitalizations. The smaller numbers during the cooler months may reflect a decrease in agricultural use and indoor pests for that season (Figure 3).

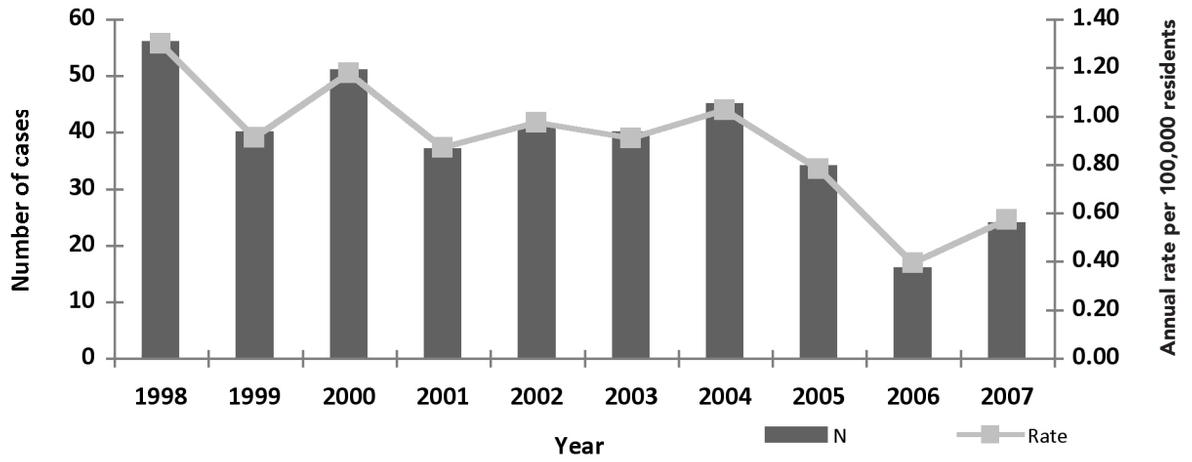
Demographics

Males consistently had higher rates of hospitalization than females. The mean annual rate for males was 1.15 cases per 100,000 vs. 0.66 cases per 100,000 for females (p=0.0073) (Figure 4). Eight cases were work-related based on the designation of workers' compensation payment as primary payer on the hospital discharge record; six (75%) of these work-related exposures were men.

Information on race was available for 269 cases, of which 164 (61%) were Caucasian, 88 (33%) were African American, and 17 (6%) were other races. Racial breakdown statewide in Louisiana is 64% Caucasian, 32% African American, and 4% other.[7]

The median age for pesticide-related hospitalization was 33.68 years (SD=24.45, range <1–94). As shown in Figure 5, the mean annual rate of pesticide-related hospitalizations was greatest among children aged 0–4 years (2.69 hospitalizations per 100,000) and lowest among children aged 5–9 years (0.36 hospitalizations per 100,000) and aged 10–18 years (0.44 per 100,000). The difference in mean rates (aged 0–4 compared with ≥5 years) was statistically significant (p=0.0004).

Figure 2. Count and rate of pesticide-related hospitalizations by year, Louisiana, 1998–2007[a]



[a]U.S. Current Population Survey data were used for annual populations and rate calculations.

Pesticide-related hospitalizations by product type and age

We analyzed cases by the type of pesticide as determined by the ICD-9 codes and E-codes. Insecticides were the most common pesticide type among all cases (170 cases, 44%). Of the 170 insecticide cases, 88 cases (52%) were an organophosphate or carbamate insecticide and 29 cases (17%) were organochlorines (Figure 6). Other pesticide types included disinfectants (31 cases, 8%), rodenticides (22 cases, 6%), herbicides (eight cases, 2%), fumigants (four cases, 1%), and fungicides (three cases, <1%). For 146 cases (38%), the type of pesticide was coded as "other pesticide."

Table 2 shows rates of hospitalization by pesticide type and age group: children (aged 0–18 years) and adults (>18 years). Exposure to insecticides was the most common type for both children and adults (43% and 45%, respectively). We conducted Chi-square tests to evaluate the difference in rates between age group and disinfectant and rodenticide hospitalizations. These statistical tests indicated that children had a significantly higher rate of disinfectant exposure than adults (15% vs. 5%; OR=3.41, 95% CI 1.61, 7.21; p=0.0008) and rodenticide exposure (14% vs. 2%; OR=8.55, 95% CI 3.07, 23.78; p<0.0001). The wide CI is attributed to the small number of adult cases. Among children aged 0–18 years, the majority of disinfectant and rodenticide exposures occurred among very young

Figure 3. Mean number of pesticide-related hospitalizations by month, Louisiana, 1998–2007

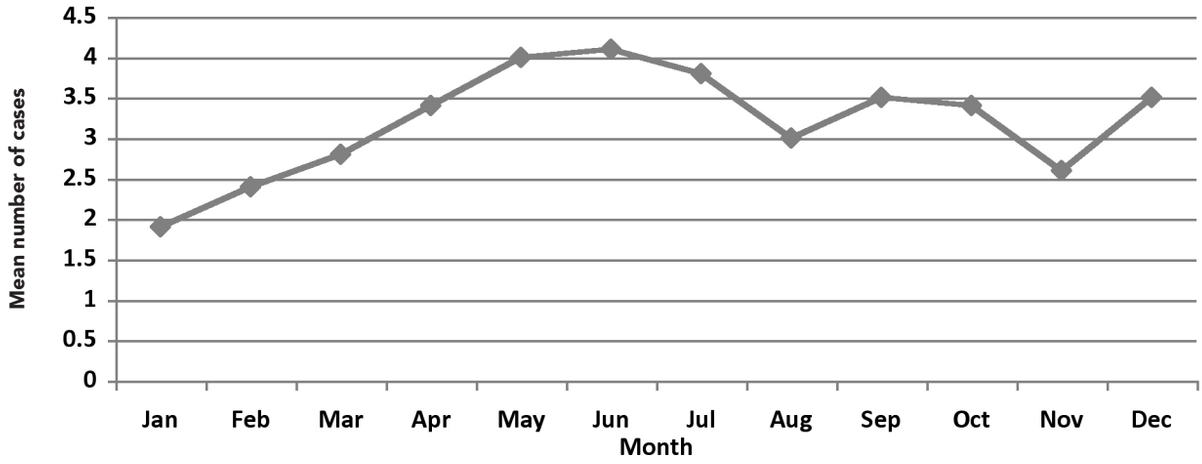
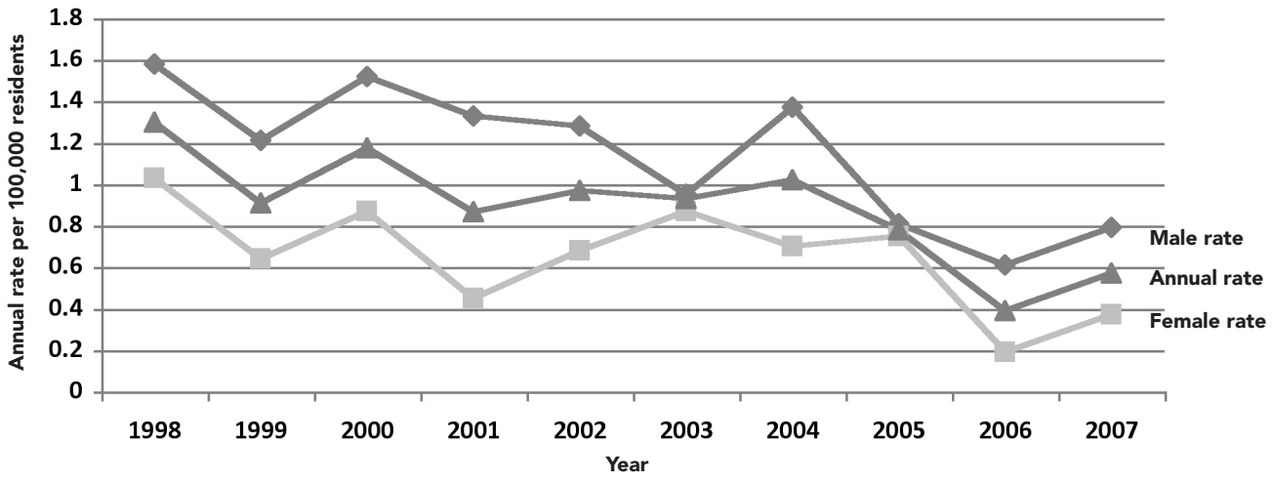


Figure 4. Pesticide-related hospitalizations by year and gender, Louisiana, 1998–2007



children. Children aged 0–4 years accounted for 64% of childhood rodenticide hospitalizations and 52% of disinfectant hospitalizations.

Pesticide-related hospitalizations by intent

Of the 384 cases, 27% (102 cases) were classified as self-inflicted poisonings (Figure 7). The mean age for these cases was 36.95 years (range 14–83 years). Age groups with the largest percent of self-inflicted poisonings were 19–29 years (28%) and 30–39 years (23%). Sixty-five percent of all self-inflicted poisonings were by men, although the difference in self-inflicted poisonings by gender was not statistically significant (OR=1.21, 95% CI 0.75, 1.93; p=0.4322). Approximately 21% of self-inflicted poisoning cases involved insecticides, while the majority of suicide attempts were coded as exposure to "other pesticides."

Pesticide-related hospitalizations by parish

The mean annual pesticide hospitalization rate by parish was 1.16 cases per 100,000 people. Parishes were designated as having a high pesticide-related hospitalization rate if their rate was one SD greater than the mean rate (high rate ≥2.30 cases per 100,000 people). Nine parishes had a high hospitalization rate; their rates were significantly higher than the remaining 55 parishes (p<0.0001).

A comparison between high-rate and low-rate parishes by age was not statistically significant (p=0.1023). A similar comparison between high-rate and low-rate

Figure 5. Pesticide-related hospitalizations by age group, Louisiana, 1998–2007

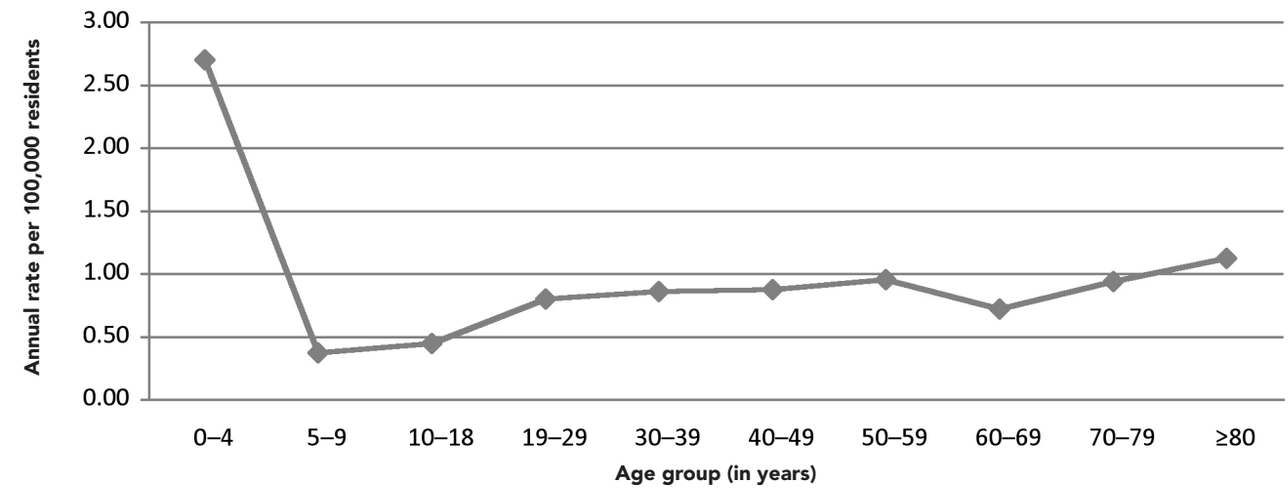
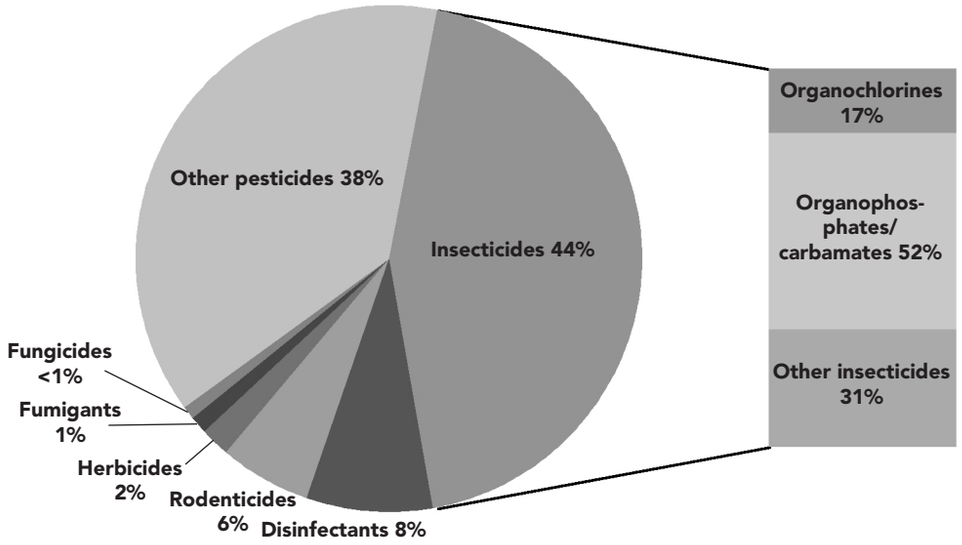


Figure 6. Pesticide-related hospitalizations by pesticide type, Louisiana, 1998–2007



parishes by gender was also not statistically significant (OR=1.17, 95% CI 0.70, 1.98; p=0.5470). Cases from high-rate parishes were slightly less likely to be hospitalized for self-inflicted poisonings than cases from low-rate parishes. This association was statistically significant (OR=0.40, 95% CI 0.20, 0.80; p=0.0078).

To determine the influence of living in a rural setting on pesticide-related hospitalization, U.S. Census data were used to calculate the percent of rural population for each parish. High-rate parishes were compared with other parishes on percent of rural composition. Rural parishes were significantly more likely than urban parishes to have high pesticide hospitalization rates (OR=4.72, 95% CI 2.34, 9.54; p<0.0001).

Duration of pesticide-related hospitalization

The median length of stay was two days (SD=3.73, range 1–26). Sixty-two percent of the cases were admitted for two days or less, and approximately 5% were admitted for longer than 10 days. The difference between mean hospital stay for children (1.68 days) and adults (3.87 days) was statistically significant (p<0.0001).

The mean hospital stay for self-inflicted poisonings (3.47 days) was compared with the mean hospital stay

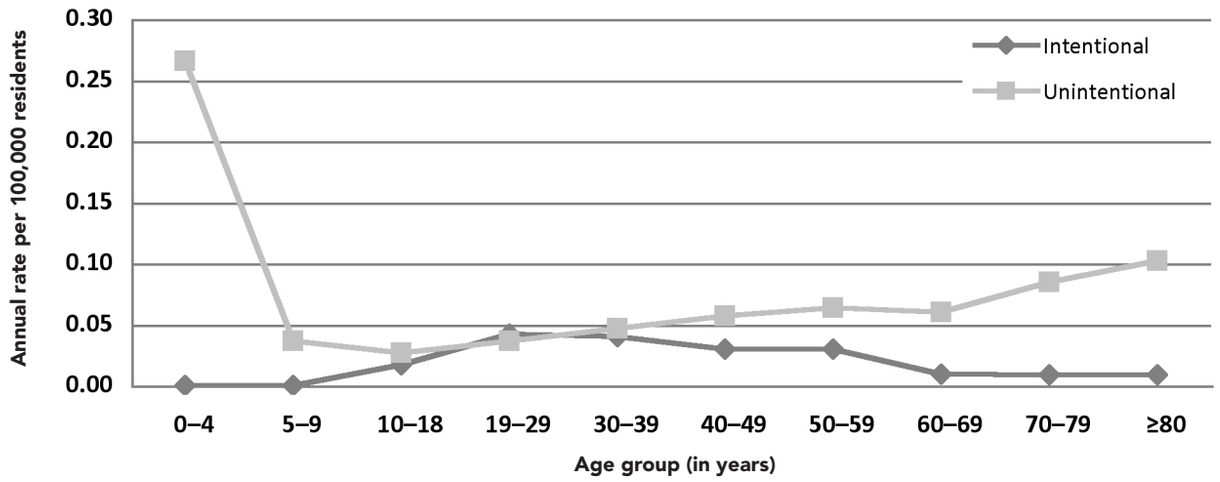
Table 2. Pesticide-related hospitalizations by pesticide type and age group, Louisiana, 1998–2007[a]

	Children (0–18 years)		*Adults (>18 years)*		*Total*	
Pesticide type	N	*Percent*	N	*Percent*	N	*Percent*
Herbicides	3	3	5	2	8	2
Fungicides	1	1	2	1	3	1
Rodenticides	17	14	5	2	22	6
Disinfectants	18	15	13	5	31	8
Fumigants	0	0	4	2	4	1
Insecticides	51	43	119	45	170	44
Organochlorines[b]	6	12	23	19	29	17
Organophosphates/ carbamates[b]	29	57	59	50	88	52
Other insecticides[b]	16	31	37	31	53	31
Other pesticides	30	25	116	44	146	38
Total	120		264		384	

[a]Rodenticide and disinfectant hospitalizations were more likely to occur among children than adults. Both age groups had similar rates of insecticide exposure.

[b]Percentages based on total insecticides

Figure 7. Pesticide-related hospitalizations by age group and intent, Louisiana, 1998–2007



for accidental poisonings (3.08 days). The difference was not statistically significant (p=0.3180).

DISCUSSION

This study provides the first comprehensive review of pesticide-related hospitalizations occurring in Louisiana. Analyzing pesticide hospitalization data expands our understanding of the extent and severity of pesticide poisonings and can guide prevention activities. The findings indicate that pesticide exposures among some Louisiana residents result in hospital admissions although hospitalization rates are low and cases are mainly of low severity. The myriad uses and formulations of pesticides create a wide range of exposure scenarios and health outcomes. This study captures health effects related to acute events, but not chronic exposures.

While the set of ICD-9 codes and E-codes is comprehensive, it is likely that our analysis did not capture all pesticide-related hospitalizations. Indeed, a comparison of 84 confirmed pesticide-related hospitalizations identified by the Louisiana Office of Public Health's Pesticide Surveillance Program for the same time period yielded an additional 54 cases not included in this study because their ICD-9 codes in LAHIDD did not include any pesticide diagnoses. These 54 cases were reported to the Pesticide Surveillance Program directly from other state agencies or through the Louisiana Poison Control Center. It is beyond the scope of this review to determine the extent of missed cases.

Further complicating the selection of pesticide-related hospitalizations is the lack of specificity of ICD-9 codes and inconsistent use of E-codes. Our data show that 58% of the cases had a principal diagnosis indicating pesticide exposure. The remaining cases either had a secondary pesticide diagnosis or only a pesticide E-code. This variation points to the inconsistent coding of poisoning exposures and the value of a case definition that includes secondary diagnoses. Limiting our selection only to cases with a principal diagnosis would have reduced our cases by approximately 42%. The proportion of cases with a secondary pesticide diagnosis remained relatively stable during the 10-year period.

While the number of pesticide hospitalizations included in the study is small, health effects from pesticide exposures are an important public health issue. Data from Poison Control Centers indicate that pesticides are one of the chemicals most frequently involved in human exposures. In 2006, there were approximately 112,000 nationally reported exposures to a pesticide (including disinfectants), of which about 19% were treated in a health-care facility.[9] During the same time period, the Louisiana Poison Control Center received approximately 2,000 human pesticide exposure reports, of which about 22% involved treatment in a health-care facility.

The high rate of hospitalizations observed among young children is consistent with other studies indicating that young children experience more pesticide-related exposures and hospitalizations than other age groups.[10,11] Analysis of poison center data from Milan, Italy, found that most reported acute pesticide exposures occurred in children younger than 5 years of age.[10] Similarly, a study of Minnesota Poison Control Center data for 1998 found that half of the pesticide exposures reported during the study period occurred

among children younger than 3 years of age.[11] In addition to an increased risk of pesticide exposure, children may experience greater amounts of pesticide exposure than adults in the same exposure scenario due to differences in respiratory rate, heart rate, and metabolism.[10]

The exploratory, hand-to-mouth behavior of young children and their accidental contact with household chemicals such as pesticides and cleaning products reflect exposure patterns unique to this age group. The significantly elevated exposure rates to disinfectants and rodenticides among young children in our study reflect this behavior pattern. Cleaning products, such as liquid detergent and floor cleaners, are often used in the presence of children and are stored in accessible areas and unlocked cabinets. Rodenticide pellets are similarly placed in areas accessible to children. Although the route of exposure was not directly captured in this study, other studies have found that ingestion is the most common route of pesticide exposure among children.[10–14] A study of national Poison Control Center data from 1993 to 1995 indicated that 84% of children younger than 6 years of age were exposed to pesticides via ingestion.[14] Similarly, a review of Louisiana's pesticide surveillance data of children 6 years of age and younger found that approximately 70% of the exposures resulted from children unintentionally spraying or ingesting a pesticide.

The trend observed among young children reinforces the importance of protecting children from exposure to hazardous products such as pesticides. Important advances in the adoption of integrated pest management (IPM) programs by schools in Louisiana and nationwide have protected children from pesticide exposure while at school.[15] Young children, however, remain at risk of exposure at home, and continued efforts are needed to educate parents about IPM practices in addition to proper use and storage of household chemicals. In response to the number of hospitalizations involving young children, our Pesticide Surveillance Program is working with childcare providers to educate parents and caretakers about the risks of household chemicals. Efforts at the national level include an EPA regulation recently put forth requiring new safety measures to protect children from accidental exposure to rodent-control products. Beginning in 2009, many rat poisons sold to the public in retail outlets require packaging in dispensers called "bait stations" that cannot be easily tampered with by children.[16]

Exposure scenarios among adults differ from those observed among children. Common exposures identified in the Louisiana Office of Public Health's Pesticide Surveillance Program include inhalation of pool products or noxious fumes from mixing incompatible chemicals (e.g., bleach and ammonia), improper use of or accidental exposure to household pesticides such as foggers or insect sprays, and occupational exposure. The consistently high rate among men noted in this review may reflect the higher proportion of men compared with women working in occupations involving pesticides, such as pest control operators, farmers, farm workers, and aerial applicators. A small number of cases in the study were identified as work-related based on the designation of workers' compensation payment as primary payer on the hospital discharge record. This designation, however, does not capture all work-related cases, as many individuals with work-related illnesses or injuries do not file for workers' compensation.[17] In Louisiana, all employers are required to carry workers' compensation insurance to cover the costs of employees' medical services for work-related illnesses or injuries. There are a few exemptions from this coverage, such as some agricultural workers of unincorporated farms and crew members of an airplane engaged in spraying or dusting operations.[18]

One-third of the adult cases in our study were due to self-inflicted exposures. Pesticides are often involved in self-inflicted poisoning deaths as indicated by research involving decades of data from participating countries of the World Health Organization.[19] China and India have documented frequent use of pesticides in suicide attempts, especially in rural, agricultural communities.[20] Suicide rates reported from South America, Europe, and Asia in emergency care facilities have often involved pesticides.[21] A study of U.S. mortality data over six years revealed that 64% of the deaths involving an agricultural or horticultural chemical were suicides.[22] One study found that restricting the use of parathion in Finland was associated with a reduction in self-inflicted poisonings by this pesticide.[23] Another prevention tactic is the addition of emetics to the formulation, as was done with paraquat, a highly toxic herbicide.[24] While our study confirmed the continued use of pesticides in self-inflicted poisonings, we were unable to determine if the poisonings involved agricultural or household pesticides.

An interesting finding is the association between rural parishes and elevated hospitalization rates. U.S. Census data classify rural parishes regardless of agricultural and nonagricultural land use. In other words, an area can be classified as "rural" and not have any agricultural activity. In addition, hospital discharge data do not provide enough information to determine if the hospitalization resulted from exposure to an agricultural chemical. Further in-depth analysis is needed

to determine if the high rate of pesticide exposure among rural parishes is agriculturally related. Studies have shown that agricultural communities have a higher exposure rate to pesticides than nonagricultural areas.[10]

Limitations

Our analyses have several potential limitations in addition to the issue of using U.S. Census data to characterize an agricultural setting. The number of cases is likely an underestimate of the true number of pesticide-related hospitalizations. Accurate counts of pesticide-related hospitalizations are difficult to obtain due to the miscoding of ICD-9 codes. Approximately two-thirds of the hospitalized cases identified in our pesticide surveillance system were not included in this review because they did not have a pesticide-related ICD-9 code. Because the actual number of individuals who are hospitalized due to pesticide exposure is unknown, it is not possible to determine the degree of undercoding. Some cases may also be missed due to the incomplete participation of all hospitals in LAHIDD.

Using secondary diagnoses to select cases may have resulted in the inclusion of some cases whose pesticide exposure was incidental to their hospitalization. Other studies have suggested that the utilization of multiple diagnostic codes is increasing as hospitals place more emphasis on recovery of costs.[25] The limited variation over time regarding cases selected by a secondary diagnosis code suggests, however, that an increased use of secondary—and potentially unrelated—diagnoses was not a factor in our study. Lastly, our case definition may include some cases that were exposed to a chemical other than a pesticide. For example, hydrogen cyanide (ICD-9 989.0) is used as a fumigant and in the production of nonpesticidal substances such as methyl methacrylate and chelating agents. The small number of cases with this code (n=2), however, suggests that the potential for misclassification is minimal.

CONCLUSIONS

Our review revealed important information about pesticide hospitalizations and exposures occurring in Louisiana. Significant findings include the elevated rate of hospitalizations among young children and men, and the large proportion of self-inflicted poisonings. Several specific recommendations are shown in Figure 8. ICD-9 coding of pesticide-related hospitalizations varies widely, and this study highlights the numbers of cases likely missed because a pesticide ICD-9 code was not included in any of the diagnoses. Improving the accuracy of ICD-9 coding and the consistent use of E-codes by hospital staff would increase the sensitivity of the set of codes used to detect pesticide hospitalizations. Improved surveillance of pesticide poisoning also requires the timely reporting of cases by health-care providers to the health department. Pesticide poisoning is a reportable condition in 30 states, including Louisiana.[26]

Parents and guardians can protect children from inadvertent pesticide exposure by not using pesticides in their presence and by storing pesticides in locked or inaccessible cabinets. The high proportion of disinfectant cases suggests that children are particularly at risk of exposure to household cleaning products. Exposure among all age groups can occur when a pesticide is misapplied or misused. Reading and following the label directions is essential for all products. Consumers often discount the toxicity of residential use products and ignore simple instructions such as "use only in a well-ventilated room."

Health-care providers should be aware that cases of intentional exposure may involve pesticides. New products and formulations are continuously emerging; therefore, health-care providers are encouraged to contact the Poison Control Center for accurate identification of product ingredients and treatment recommendations. The consultation of Poison Control Centers by health-care providers also aides public

Figure 8. Recommendations from Louisiana Hospital Inpatient Discharge Database pesticide hospitalization data analysis, 1998–2007

Concern	*Recommendation*
Child exposure	Keep pesticides in original containers and locked cabinets.
Product misapplication	Read the label.
Product misuse	Incorporate emetics into pesticide formulas at manufacturer level.
Identification of pesticides at health-care facilities	Consult the Poison Control Center for detailed product information and treatment.
Improve ICD and E-code classification	Train hospital staff how to correctly code pesticide hospitalizations.

ICD = International Classification of Diseases

E-code = external cause of injury or poisoning code

health officials in tracking pesticide exposures, as Poison Control Centers are the primary source of pesticide poisoning data for many state health departments.

Pesticide poisonings are preventable, and analysis of hospital discharge data along with case-based investigations can guide outreach and prevention efforts to reduce pesticide poisonings.

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