

# Childhood Pesticide Exposures on the Texas–Mexico Border: Clinical Manifestations and Poison Center Use

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The US Environmental Protection Agency (EPA) estimates that more than 1 billion pounds of conventional-pesticide active ingredients are used annually in the United States<sup>1</sup> and that 85% of all families store and use pesticides in and around their homes.<sup>2</sup> Human exposure to pesticides can occur in the home through residues in food and water and through drift from agricultural activities.<sup>3–7</sup> Because they may be ubiquitous in and around households, pesticides represent a particular potential hazard to young children.

Hospital-based data and poison control center reports suggest that children are commonly involved in unintentional pesticide poisonings. According to hospital surveys, half of all pesticide-related hospital admissions are reported to be caused by nonoccupational exposures, and half of these admissions involve young children.<sup>8</sup> From 1997 through 2000, the Toxic Exposure Surveillance System (TESS) of the American Association of Poison Control Centers received 388 635 reports of human pesticide exposures, 52% of which involved children younger than 6 years. Among reported poison exposures occurring between 1997 and 2000, pesticides accounted for 4.4% of all pediatric cases and represented the eighth-most-common exposure category overall.<sup>9–12</sup>

Pesticides commonly encountered by young children include rodenticides and insecticides. Insecticides such as carbamates (e.g., Sevin, Baygon), organophosphates (e.g., malathion, diazinon), and pyrethrins (e.g., permethrin) are constituents of numerous ant and roach extermination products and are widely used in agriculture. Permethrin (e.g., Elimite, Nix) is contained in products used to treat lice and scabies; lindane, an organochlorine insecticide, also is used to treat lice and scabies.

Areas in the United States where urban communities are in close proximity to agriculture are of great concern with regard to pesticide exposures.<sup>13</sup> One such area is the Lower

**Objectives.** The purpose of this study was to describe differences in childhood pesticide exposures between counties on the Texas–Mexico border and nonborder counties.

**Method.** The authors reviewed all pesticide exposures among children younger than 6 years reported to the South Texas Poison Center during 1997 through 2000.

**Results.** Nonborder counties had twice the reported exposure rate of border counties. Parents of border children were significantly less likely to contact the poison center after an exposure and more likely to have their children evaluated in a health care facility.

**Conclusions.** Increasing residents' awareness of the poison center and identifying potential barriers to its use among residents of Texas–Mexico border communities may prevent unnecessary visits to health care facilities. (*Am J Public Health.* 2003;93:1310–1315)

Rio Grande Valley (LRGV) of Texas, which includes 2 Texas–Mexico border counties, Hidalgo and Cameron, and 1 nonborder county, Willacy (Figure 1).

On both sides of the Texas–Mexico border, the population has increased more than 25% since 1990.<sup>14</sup> These increases are higher than those observed in 2 of the most heavily populated nonborder counties, Bexar and Nueces, which have seen population increases of only 15% and 7%, respectively since 1990.<sup>15</sup> During this period of growth along the Texas–Mexico border, concerns have been raised about health conditions, including exposure to pesticides.<sup>14</sup> Studies conducted in the 1960s and 1970s revealed that agricultural workers were exposed to certain organophosphates commonly used in this region.<sup>16,17</sup>

In the early 1990s, the EPA coordinated a monitoring study in the LRGV to assess human exposures to various environmental contaminants.<sup>18,19</sup> In 1996, the Office of Border Health of the Texas Department of Health initiated the Texas–Mexico Border Environmental Health Survey as a follow-up project to address some of the issues identified in the EPA monitoring project, including pesticide exposures. The findings of this survey suggested that children in the LRGV might be exposed to potentially hazardous pesticides in nonoccupational settings.<sup>14</sup>

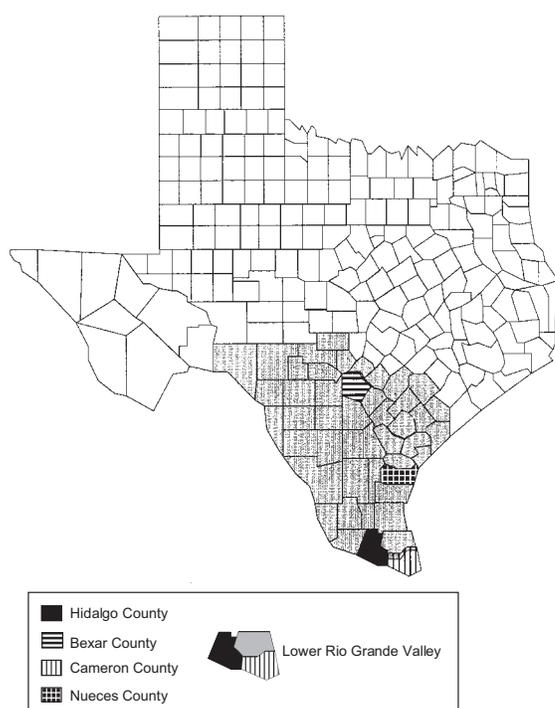
The objective of our study was to describe pesticide exposures reported among children younger than 6 years in southern Texas, in-

cluding the LRGV, and to evaluate differences in exposures between border and nonborder counties. The information obtained from this study can be used to determine whether a significant problem exists in terms of pesticide exposures among children of the border region, as well as other regions of southern Texas, and to develop intervention strategies designed to reduce the risk for pediatric pesticide exposures.

## METHODS

We obtained, from the Texas Department of Health, pesticide exposure data reported to the South Texas Poison Center (STPC) during 1997 through 2000. The database was reviewed to ensure that all reported case children met our inclusion criteria; to be included in the study, case children had to be younger than 6 years and residents of Texas. We excluded reports that involved telephone calls requesting information on pesticides, reports confirmed as nonexposures, and case children without recorded ages or counties of residence.

Pesticide categories included insecticides, herbicides, fungicides, rodenticides, and moth repellants. Insecticides were further grouped into one of the following categories included the American Association of Poison Control Centers listing: organochlorines, carbamates, organophosphates, or miscellaneous (e.g., pyrethrins, veterinary insecticides, repellants used for insects other than moths). Veterinary



Note. The 4 counties with the highest numbers of pesticide exposures reported to the South Texas Poison Center are indicated with patterns. The poison center is located in Bexar County.

**FIGURE 1—The 47 South Texas counties shaded gray from which pesticide exposures among children younger than 6 years (n = 2520) were reported to the South Texas Poison Center, 1997–2000.**

insecticide products included flea and tick collars, sprays, and powders.

Information available on the case children selected included age and sex, date of telephone call to the STPC, caller site, exposure site (including county location), reason for exposure, primary substance involved, and route of exposure (e.g., ocular). After it had been determined whether exposures were unintentional or intentional, reasons for exposure were subcategorized into various groups (e.g., general, therapeutic error, environmental) on the basis of TESS definitions.<sup>20</sup>

Other data available included management site, clinical effects, and medical outcome. We defined medical outcomes with TESS definitions and included the following categories: (1) no effect, (2) minor effect (rapid resolution of symptoms with return to preexposure state), (3) moderate effect (more pronounced or prolonged symptoms), (4) major effect (life-threatening or resulting in residual disability), (5) death, (6) not followed as a result of non-

toxic exposure, (7) not followed because only minimal clinical effects were possible, (8) unable to follow but potential existed for toxic exposure, and (9) unrelated effect. A case assigned a medical outcome code of no effect; minor, moderate, or major effect; or death was considered to involve a definitive outcome.

Specialists in poison information at the STPC originally obtained all of the information available on case children. In a given case, medical outcome is usually the final determination made by these specialists. Such determinations, based on the clinical judgment of these specialists and on the definitions of the American Association of Poison Control Centers, take into account the information available at the conclusion of a case. Further details on options for coding medical outcomes and specific clinical examples for each code are available from the American Association of Poison Control Centers.<sup>20</sup>

Counties contiguous with the Texas–Mexico border were defined as border counties.<sup>21</sup>

Only reports that originated in the 47 counties of southern Texas served by the STPC were included in our analyses (Figure 1). We excluded reports originating outside this region that represented diverted calls from other Texas poison centers. We obtained the South Texas county population figures used in our age-specific analysis from the Population Estimates Program of the Texas State Data Center and from 2000 US census data.<sup>15</sup>

We conducted descriptive statistical analyses with SAS, version 8.<sup>22</sup> We assessed the presence of significant differences between border and nonborder counties using  $\chi^2$  tests.<sup>23</sup> A *P* value of .05 was used to indicate statistically significant differences.

## RESULTS

### Participant Data

The STPC received 98 485 telephone calls regarding human pesticide exposures during 1997 through 2000, 54% of which involved children younger than 6 years. Of these childhood exposures, 2885 (5.5%) involved pesticides. Our final review included 2520 (87%) of these 2885 exposures. Of the 365 case children excluded, 209 (57%) had no geographic location recorded, and 156 (43%) lived outside the group of counties defined as the coverage area of the STPC. Eight border counties accounted for 579 (23%) of the 2520 exposures, whereas 1941 (77%) of these exposures occurred within 35 nonborder counties (4 of the 39 nonborder counties in our database did not report any cases of exposure to the STPC).

The 8 border counties and 35 nonborder counties contained 39% and 61%, respectively, of the total childhood population younger than 6 years during the study period. Also, 14% and 10% of the border and nonborder counties' populations, respectively, consisted of children younger than 6 years. Approximately 1 pesticide exposure was reported for every 1180 children younger than 6 years residing in the border counties, and approximately 1 such exposure was reported for every 554 children residing in the nonborder counties.

The childhood pesticide exposures included in our review originated primarily in 1 of 4 counties. Forty-eight percent of the exposures among case children from border counties oc-

**TABLE 1—Numbers of Pesticide Exposures Reported to the South Texas Poison Center Among Children (n=2520) in Texas Border and Nonborder Counties, vs US Average, 1997–2000**

Pesticide Category	Border, No. (%)	Nonborder, No. (%)	Total, No. (%)	National Average, No. (%) <sup>a</sup>
Insecticide	248 (42.8)	1063 (54.8) <sup>b</sup>	1311 (52)	108 431 (53.8)
Rodenticide	275 (47.5) <sup>b</sup>	654 (33.7)	929 (36.9)	67 000 (33.3)
Moth repellent	46 (8)	187 (9.6)	233 (9.2)	13 541 (6.7)
Herbicide	9 (1.5)	28 (1.4)	37 (1.5)	10 931 (5.4)
Fungicide	1 (0.2)	9 (0.5)	10 (0.4)	1 597 (0.8)
Total	579 (100)	1941 (100)	2520 (100)	201 500 (100)

<sup>a</sup>Data reported by the American Association of Poison Control Centers Toxic Exposure Surveillance System for 1997–2000.<sup>9–12</sup>  
<sup>b</sup>Statistically significant difference ( $P < .001$ ) between border and nonborder counties.

occurred in Hidalgo County, and 25% occurred in Cameron County. Of the exposures among case children from nonborder counties, 50% took place in Bexar County and 12% took place in Nueces County (Figure 1). These 4 counties were the most heavily populated counties included in our review.<sup>15</sup>

The mean ages of border case children and nonborder case children were 1.9 and 2.0 years, respectively. Fifty-five percent of the 2520 case children were male. The percentages of male and female case children from border and nonborder counties were identical. Almost all pesticide exposures occurred in the child’s home or other residence (border counties: 99%; nonborder counties, 98%). Fewer than 1% of the exposures occurred in a workplace, school, or public area, regardless of county location.

More than 99% of case children were involved in acute, unintentional pesticide exposures. These unintentional exposures were further categorized into the following groups: general (96.0%), therapeutic error (2.8%), misuse (0.9%), and environmental (0.3%). The most common route of exposure was ingestion (86% of case children), followed by dermal exposure (8%), ocular exposure (6%), and inhalation (2%). In the case of 5% of the children, more than 1 route of pesticide exposure was documented (range: 1–4).

**Pesticide Exposures**

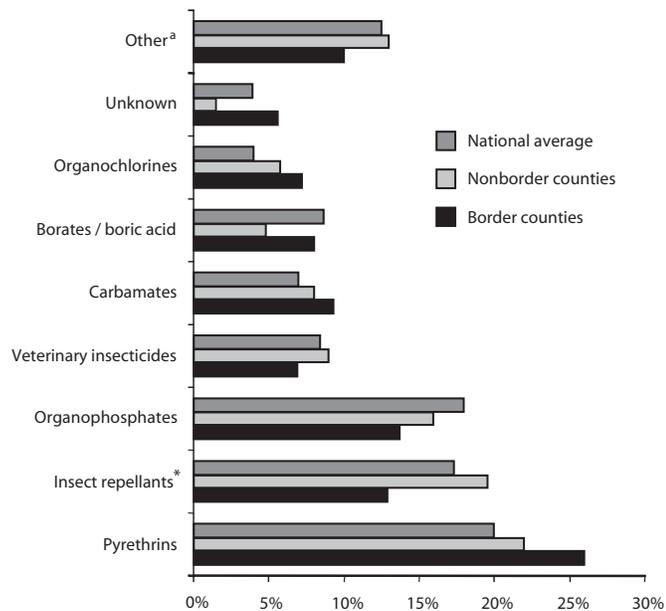
Rodenticide exposures were significantly more frequent among children from border counties than among children from nonborder counties, and insecticide exposures were significantly less frequent (Table 1). Most of the 929

rodenticide exposures involved long-acting anticoagulants (“superwarfarins”; n=765; 82%), followed by short-acting anticoagulants (“warfarins”; n=126; 14%); 2 exposures involved a strychnine rodenticide, and 36 (4%) exposures were documented as involving an “other or unknown” rodenticide.

Exposures were also examined in regard to specific pesticides in the insecticide category. Results showed that, compared with childhood exposures occurring in nonborder counties and with national pesticide data reported to TESS, childhood exposures occurring in Texas–Mexico border counties more commonly involved pyrethrins and organochlorines and less commonly involved insect repellants and organophosphates (Figure 2).

**Source of Contact and Management Site**

Table 2 presents data on the sources of contact and management sites associated with the 2520 cases reported to the STPC from border and nonborder counties. Of these 2520 exposures, 1917 (76%) were managed at the site of exposure, and 603 (24%) were managed in a health care facility. Among the latter, the STPC had recommended referral to a health care facility in 136 (23%) cases. In the remaining 467 (77%) cases, the child was taken directly



Note. The denominator for all percentages was derived from the total number of insecticide exposures reported to the South Texas Poison Center from border (n=248) and nonborder (n=1063) counties and from the national average (n=108 431), obtained from the American Association of Poison Control Centers Toxic Exposure Surveillance System for 1997–2000.<sup>9–12</sup>

<sup>a</sup>Examples of other insecticides include rotenone, metaldehyde, piperonyl butoxide without pyrethrins, and arsenic-containing insecticides.

\*Statistically significant difference ( $P < .001$ ) between border and nonborder counties.

**FIGURE 2—Data on the 1311 insecticide pesticide exposures reported to the South Texas Poison Center among 2520 children younger than 6 years in Texas border and nonborder counties, in comparison with US average, 1997–2000.**

**TABLE 2—Source of Contact and Management Site: Pesticide Exposure Cases Among Children (n = 2520) in Texas Border and Nonborder Counties Reported to the South Texas Poison Center (STPC), 1997–2000**

	Border (n = 579), %	Nonborder (n = 1941), %	P
Initial call to STPC from a residence <sup>a</sup>	60	82	<.001
Initial call to STPC from HCF	37	15	<.001
Child managed in HCF	40	19	<.001
Child brought to HCF without STPC referral	34	14	<.001
Child brought to HCF after STPC referral	6	5	.23

Note. HCF = health care facility.

<sup>a</sup>Sites of initial calls for border and nonborder counties were recorded as either "other" or "unknown" in the case of 3% of child exposures.

to a health care facility before the STPC was contacted.

### Medical Outcomes

In 587 (23%) of the 2520 pesticide exposures, medical outcomes were definitively established through case follow-ups. Among these 587 exposures, 324 (55%) were managed in a health care facility.

On the basis of the clinical judgment of the poison information specialists involved, the remaining 1933 exposures (78% of nonborder exposures and 76% of border exposures) were not followed to a known outcome; 300 (12%) were judged as nontoxic exposures, 1580 (63%) were considered to involve the possibility of only minimal toxicity, and 53 (2%) were potentially toxic but follow-up could not be completed. Of the 603 exposures managed in a health care facility, 289 (48%) were not definitively followed up by the STPC. There were no statistical differences between border and nonborder county exposures in any of the medical outcome categories.

Of the 587 exposures followed up on after initial STPC contact, 510 resulted in no clinical effects, and 61 resulted in minor clinical effects. Moderate effects (e.g., vomiting with dehydration) were involved in 13 (0.5%) of the 2520 pesticide exposures, and major effects (e.g., status epilepticus) were involved in 3 (0.1%) of these 2520 exposures. No deaths were reported. Thirty-eight percent of children with minor clinical effects were managed on-site, and 62% were managed at a health care facility. All but 1 of the 16 children with either moderate or major clinical effects were managed in a health care facility.

### Clinical Effects

Clinical effects developed in 77 (3%) of the children exposed to pesticides during the study period. The proportion of children who developed clinical effects was similar between border and nonborder counties. Sixty-six (86%) of these exposures involved insecticides (0.5% of all insecticide exposures), 6 (8%) involved rodenticides (0.007% of all rodenticide exposures), and 5 (6%) involved moth repellants (0.02% of all moth repellent exposures).

Symptoms observed among the 61 patients with minor clinical effects included vomiting (n=35; 57%), ocular involvement (n=17; 28%), coughing/choking (n=5; 8%), and skin irritation or rash (n=4; 7%). Three (5%) of these patients exhibited other symptoms, and 3 exhibited multiple symptoms. The most common pesticides involved in these 61 exposures were ant or roach organophosphates (n=21; 34%), insect repellants (n=7; 11%), flea and tick products (n=6; 10%), and lindane (n=5; 8%).

Of the 13 children with moderate clinical effects, 6 had ocular involvement, 3 experienced vomiting, 1 had a seizure, and 3 had other symptoms. The most common pesticides involved in these 13 exposures were lindane (n=4; 31%), ant or roach organophosphates (n=2; 15%), and insect repellants (n=2; 15%). Two of the 4 case children exposed to lindane developed seizures.

Of the 3 case children with major clinical effects, 1 developed a coagulopathy secondary to ingestion of a rodenticide, 1 had ocular involvement after an exposure to a lice shampoo, and 1 developed status epilepticus after ingesting lindane.

## DISCUSSION

Pesticides represent a diverse group of chemical compounds and are among the toxic chemicals most commonly encountered by children. Whereas most children are at some degree of risk for pesticide exposure, those whose parents are farmers or farm workers or those who live adjacent to agricultural areas are at increased risk.

Our study sought to describe childhood pesticide exposures in an agricultural area, the LRGV on the Texas–Mexico border, and to compare them with exposures from nonborder counties of southern Texas. In a recent health survey involving many of these border counties, more than 21% of households surveyed were located within a quarter mile of a crop field, and 66% of these crop fields reportedly used pesticides.<sup>14</sup>

Our data suggest that agriculture-related pesticide exposures are rare among young children residing in the LRGV border counties as well as among those residing in other Texas border counties. Poison center coding criteria suggest that most of these exposures occurred in the household rather than in a workplace or a crop field and that the exposures primarily involved household pesticide products as opposed to work-related pesticides brought into the residence.

Nearly half of pesticide exposures that occurred in the border counties and were reported to the STPC involved anticoagulant rodenticides, compared with approximately one third of pesticide exposures occurring in nonborder counties (Table 1). This difference might be explained by the proliferation of *colonia* settlements, most of which are found in the LRGV and other Texas–Mexico border counties.<sup>14</sup> *Colonias* are rural, unincorporated communities characterized by a lack of basic public services like sewage and garbage pickup and thus likely to attract rodents. Also, housing conditions and construction in *colonias* are such that primary prevention of rodent infestation is suboptimal (R.J. Dutton, Texas Department of Health, written communication, December 2001).

In our study population, relatively few incidents of clinical effects resulted from pesticide exposures, and most of the clinical effects observed were medically insignificant.

Only 3% of the children exposed to pesticides experienced clinical effects (0.6% of these cases involved moderate or major effects). The STPC identified three quarters of these exposures as either nontoxic exposures or exposures involving only possible minimal toxicity, largely because of the prevalence of cases involving anticoagulant rodenticides. Unintentional ingestion of these rodenticides by a child rarely results in clinically significant coagulation abnormalities.<sup>24,25</sup>

Children in our review who reportedly experienced clinical effects were exposed primarily to household insecticides. Ten (8%) children who developed toxicity were exposed to the organochlorine lindane, and 5 of these children developed moderate or major effects. Furthermore, of the 49 lindane exposures covered by our review, 10 (5%) resulted in clinical toxicity. Lindane continues to be prescribed for lice and scabies even though safer preparations are available. Lindane poses a serious risk in terms of central nervous system toxicity if it is ingested or misused topically.<sup>26,27</sup>

After population adjustments had been made, it was evident that more than twice the number of pesticide exposures occurred in nonborder counties as in border counties. Although this proportion may represent the actual occurrence of childhood pesticide exposures within these counties, it more likely represents an underreporting of exposures within the border counties. According to 1999 STPC data regarding poison calls, there were 4.5 calls per 1000 people from Hidalgo County (a border county) and 8.5 calls per 1000 people from Bexar County (a nonborder county). This discrepancy in rates of contact may have resulted partly from differences in the number of residences with working telephones: 88% of residences in Hidalgo County have working telephones,<sup>14</sup> compared with approximately 98% of Bexar County residences (N. Vella, Bexar Metro 911 Network District, oral communication, January 2002).

The variability between border and nonborder county pesticide exposure rates also may have been owing to differences in use of and reporting to the STPC. Relative to contacts in nonborder counties, poison center contacts for case children within border counties were more frequently made after a child had presented for health care rather than at

the time of exposure. Previous research has identified race and ethnicity as risk factors for underuse of poison centers.<sup>28–30</sup> For example, 1 study showed that Spanish-speaking mothers in focus groups had limited knowledge of poison centers and were concerned about language barriers.<sup>28</sup> According to 2000 census data, 88% of residents of Hidalgo County were Hispanic, compared with 54% of Bexar County residents.<sup>15</sup>

The STPC recently completed a survey of more than 500 adults with children younger than 5 years from 5 counties along the Texas–Mexico border to determine whether and how the language spoken in the home influenced residents' awareness of the poison center, as well as perceived barriers to use of the center.<sup>31</sup> Compared with residents of homes where only English was spoken, residents of homes where only Spanish was spoken were significantly less aware of the existence of the poison center and were less likely to have access to the center's telephone number. Moreover, the Spanish speakers who were aware of the poison center were less likely to contact the center in the event of a childhood poisoning, citing concerns regarding lack of confidentiality and their belief that the poison center would not be able to provide services in Spanish.

Such perceived barriers might explain why a parent or guardian who resides in one of the border counties, and is thus more likely to speak only Spanish, would be inclined to take his or her child directly to a health care facility after a pesticide exposure rather than contacting the poison center for advice. Increased public awareness of poison center services in the LRGV and other Texas border counties, as well as education aimed at minimizing barriers, is critical. It is well documented in the United States that use of poison centers significantly lowers health care costs by decreasing unnecessary visits to health care facilities for minor unintentional childhood poisonings that can be successfully managed in the home.<sup>32–34</sup>

Given the high rate of health care facility visits among children of the border counties (40%) for largely minor exposures, significant health care dollars could have been saved had the poison center been more frequently used. Therefore, the public's knowledge of the poison center and its willingness to contact the

center both need to increase in these counties if the centers' full financial and resource-use benefits are to be achieved. Poison centers that have achieved the greatest success in regard to regional awareness frequently target prevention campaigns to areas with low call-to-population ratios.<sup>35</sup> This strategy could be incorporated into general education efforts aimed at adults in the border communities regarding poison prevention among children. Increased funding to poison control centers to help promote their use and increased community education would be beneficial.<sup>36</sup>

Our study has several potential limitations. For example, although chronic exposures to pesticides are likely to have an important impact on children's health, we were able to fully assess only acute exposures with the poison center database. In addition, our data may not have captured all of the reported childhood pesticide exposures in the 47-county region studied, because some calls to the STPC may have been diverted to other Texas regional poison centers when telephone lines were occupied. Also, poison center data underestimate the number of poison exposures in general, because some exposures are not reported by health care workers or the public.<sup>35</sup> We were unable to analyze the data from 7% of the exposures documented, because the patient's county of residence had not been recorded. The limited follow-up resulting from our lack of access to patient medical records may have led to underestimates of the frequency of delayed symptoms and treatment effects. In addition, because some of the exposures reported may not have been true exposures, we may have underestimated the prevalence of toxic effects.

Finally, exposure misclassifications may have occurred. For example, an exposure that occurred in a crop field near a child's home or that involved a work-related pesticide product brought to the home could have been recorded by the STPC as an unintentional general exposure rather than an unintentional environmental exposure. Because the environmental category is intended to include exposures to pesticides applied to a field or that has contaminated soil, water, or food, we may have underestimated the number of agriculturally related pesticide exposures. Poison centers serving agricultural

areas need to emphasize this specific category code if they are to capture such data.

Our study showed that most unintentional pesticide exposures among children in an agricultural area of southern Texas were acute and occurred in the children's homes, and that serious clinical effects appeared to be uncommon. However, given the high incidence of lindane toxicity, poison prevention education in this region, especially in the Texas–Mexico border counties, should focus on this insecticide.

Children living along the Texas–Mexico border who are exposed to pesticides frequently present to health care facilities without having had contact with the regional poison center. Increasing residents' awareness of the poison center and identifying potential barriers regarding its use among residents of the LRGV may prevent unnecessary visits to health care facilities. ■

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This article was accepted January 30, 2003.

### Contributors

M. Belson assisted in collection and review of data, contributed to the data analysis, and was the primary author of the article. S. Kieszak provided statistical support and contributed to the data analysis. W. Watson reviewed and analyzed the data and assisted in preparing the article. K.M. Blindauer was responsible for original development of the study and reviewed the article. K. Phan assisted with the collection and review of data. L. Backer and C. Rubin assisted with the plan of the study and reviewed the article.

### Acknowledgments

Support for this project was provided by the Environmental Protection Agency.

We would like to thank the specialists in poison information of the South Texas Poison Center for their collection of the data. Also, we appreciate the support of Jacklenn Shannon and R.J. Dutton of the Texas Department of Health.

### Human Participant Protection

This study was exempt from institutional review board approval because no personal identifiers were involved.

No informed consent was obtained, as study participants were not enrolled.

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