AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 53:188–193 (2010)

Commentary

Using Surveillance Data to Promote Occupational Health and Safety Policies and Practice at the State Level: A Case Study

Geoffrey M. Calvert, MD, MPH[1]* and Sheila A. Higgins, RN, MPH[2]

Background *Following the investigation of a birth defects cluster involving migrant farmworkers employed in North Carolina and Florida, it became clear that greater efforts were needed to protect agricultural workers from pesticide exposure.*
Methods *Documentation is drawn from peer-reviewed published articles, government reports and news accounts.*
Results *The birth defects cluster was identified and investigated by state and federal pesticide poisoning surveillance system staff. Following the investigation, efforts were initiated to highlight pesticides as an important public health issue needing more attention. A series of subsequent events led to the creation and passage of important legislation recently enacted in North Carolina. The legislation resulted in funding to promote various activities to prevent harm from pesticides including strengthening surveillance, improving the quality of pesticide compliance inspections, and increasing and improving pesticide safety training. The legislation also broadened the coverage of anti-retaliation rules to include agricultural workers, and increased recordkeeping requirements pertaining to pesticide applications.*
Conclusion *The important and positive impacts that can occur through surveillance activities are highlighted. As such, it is important to continue to support and improve occupational illness and injury surveillance programs.* Am. J. Ind. Med. 53:188–193 2010. *Published 2009 Wiley-Liss, Inc.*†

KEY WORDS: congenital abnormalities; farmworkers; insecticides; pesticides; prevention and control; surveillance

INTRODUCTION

Legislation was recently enacted in North Carolina that resulted in funding to strengthen pesticide-poisoning surveillance, improve the quality of pesticide compliance inspections, and increase and improve pesticide safety training. The legislation also extended anti-retaliation rules to cover agricultural workers, and increased recordkeeping requirements pertaining to pesticide applications. This article describes the events that led to the creation and passage of this important legislation.

[1]Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio
[2]North Carolina Department of Health and Human Services, Raleigh, North Carolina
The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention, or the North Carolina Department of Health and Human Services.
*Correspondence to: Geoffrey M. Calvert, National Institute for Occupational Safety & Health, 4676 Columbia Parkway, R-17, Cincinnati, OH 45226. E-mail: jac6@cdc.gov

Accepted 5 April 2009
DOI 10.1002/ajim.20707. Published online in Wiley InterScience (www.interscience.wiley.com)

SENTINEL EVENT NOTIFICATION SYSTEM FOR OCCUPATIONAL RISKS (SENSOR)—PESTICIDES

This story begins with the Sentinel Event Notification System for Occupational Risks (SENSOR) program. Were it not for this program, the potential role of pesticides in the birth defects cluster described in this article may not have been discovered, and the cluster may have gained little attention. The birth defects cluster was a sentinel health event.

A *sentinel health event* is ''a condition that can be used to assess the stability or change in health levels of a population'' [Last, 2001]. It has been argued that pesticide poisoning, along with heavy metal poisoning, is a useful sentinel to trigger action against environmental toxins [Pew Environmental Health Commission, 2001]. Recognizing the importance of sentinel health surveillance, the National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention (NIOSH/CDC) supports such surveillance activities by providing cooperative agreement funding and technical support to state health departments through the Sentinel Event Notification System for Occupational Risks (SENSOR) program. Since 1987, acute occupational pesticide-related illness and injury has been one of the conditions under surveillance by SENSOR [Calvert et al., 2004]. The SENSOR-pesticides program is also partially funded by the US Environmental Protection Agency (EPA).

Health departments in seven states (California, Iowa, Michigan, New York, North Carolina, Texas, and Washington State) are provided federal funding to bolster pesticide-related illness and injury surveillance. Five additional states are unfunded SENSOR-Pesticides program partners (Arizona, Louisiana, Florida, New Mexico, and Oregon). Besides identifying, classifying, and tabulating pesticide poisoning cases using a standardized case definition and standardized variables, the states periodically perform in-depth investigations of pesticide-related events, and develop interventions aimed at particular industries or pesticide hazards. State programs are notified about potential pesticide poisoning cases most often from their state workers' compensation system, poison control centers, and other state and local government agencies (e.g., state department of agriculture, and local county health departments). Deidentified case data is submitted annually to NIOSH by each SENSOR-Pesticides state program. NIOSH aggregates this data to produce a national database consisting of acute pesticide-related illness and injury cases. However, the SENSOR-Pesticides program is most useful for timely identification of emerging pesticide problems which typically manifest as acute pesticide poisoning (e.g., total release foggers [CDC, 2008a], pesticide poisoning associated with pesticide exposures at schools [Alarcon et al., 2005], and pesticide poisoning associated with pyraclostrobin, a relatively new fungicide [CDC, 2008b]). Note that a birth defects cluster had not been previously detected by the program. NIOSH also supports and organizes workshops twice per year that are attended by representatives from each state that participates in the SENSOR-Pesticides program. The purpose of these workshops is to discuss significant pesticide-related topics, including emerging pesticide problems, and ways to increase the impact of the SENSOR-Pesticides program at the state and federal level.

A BIRTH DEFECTS CLUSTER IN A FARMWORKER POPULATION

One emerging problem identified by the SENSOR-Pesticides program was a cluster of congenital anomalies among three infants born to pesticide-exposed mothers [Calvert et al., 2007]. In February 2005, the Healthy Start program in the Collier County Health Department (CCHD) in Florida identified three infants with congenital anomalies who were born within 8 weeks of each other and determined that all three mothers worked for the same tomato grower. All three women worked on the grower's Florida farms in 2004 before transferring to its North Carolina farms. CCHD notified the Florida Department of Health (FLDOH) who notified the Florida Department of Agriculture and Consumer Services (FLDACS) and these two state agencies collaborated in investigating the cluster. US EPA Region 4 was notified about the cluster by FLDACS. In August 2005, the North Carolina Division of Public Health (NCDPH) was notified of these births by the North Carolina Department of Agricultural and Consumer Services (NCDACS), who was notified by EPA Region 4 in April 2005. The SENSOR-Pesticides program at NIOSH was alerted in September 2005 and with the assistance of State health departments in Florida and North Carolina collected case reports, and pesticide exposure histories.

During the period of organogenesis (approximately days 14–59 after fertilization) when birth defects are most likely to occur, all three mothers appear to have unknowingly worked in tomato fields that were under a restricted entry interval (REI) because the fields were recently treated with pesticides, some of which have been shown to be teratogenic when tested individually in animals [Florida Department of Agriculture and Consumer Services, 2005]. According to the Worker Protection Standard (WPS) for Agricultural Pesticides, which are a set of rules promulgated by EPA aimed at reducing pesticide exposures among agricultural workers (40 CFR 170), workers are prohibited from entering a field when an REI is in effect, unless the worker is provided appropriate personal protective equipment (PPE). There is no evidence that PPE was provided to these mothers.

During the period of organogenesis, one case (case 1) only worked on the grower's North Carolina farms and two

cases (cases 2 and 3) only worked on the grower's Florida farms. Due to jurisdictional limits, state government staff investigated only exposures that occurred in their own state. As a result both states initially discounted the cluster because neither state had data showing that all three mothers had potential pesticide exposure during the period of organogenesis [Collier County Health Department, 2005; Florida Department of Agriculture and Consumer Services, 2005]. During the January 2006 biannual workshop organized by federal staff from the CDC/NIOSH SENSOR-Pesticides program, staff from the CCHD and NCDPH presented their respective findings on the cluster. Following these presentations, it became clear to all workshop attendees that all three mothers had potential pesticide exposure during the period of organogenesis. This information was shared with EPA, and other public health partners. In addition, the SENSOR-Pesticides program began work on a manuscript describing the cluster, including specifics on the pesticide exposures experienced by each mother, that was ultimately published in Environmental Health Perspectives [Calvert et al., 2007].

DETAILS ON THE THREE CASES

Below is a brief description of each of the three birth defect cases. Additional details can be found in Calvert et al. [2007].

Case 1

This infant was born with tetra-amelia (absence of all four limbs). The parents had no other known birth defect risk factors. The period for limb development is 24–36 days after fertilization [Moore and Persaud, 2003]. During this period, this child's mother appears to have unknowingly worked in violation of the REI for up to 4 days involving exposure to several pesticides, including mancozeb. Mancozeb and its metabolite, ethylenethiourea (ETU), have been shown to produce limb reduction defects, cleft palate, and brachygnathia following high oral doses given to rats [Larsson et al., 1976].

Case 2

This infant was born with mild Pierre Robin syndrome (micrognathia, high arched palate, and mild persistent palatine rugae). The father of this child has micrognathia. During gestational days (i.e., days after fertilization) 14–57, this child's mother appears to have unknowingly worked in violation of the REI for up to 8 days. On seven of these days, the pesticides applied to the fields where the mother worked included methamidophos. In addition, on gestational days 7 and 10, the mother worked in fields when an REI was potentially in effect (mancozeb on both days, and abamectin and methylpyrrolidone on day 7). The mother has three other living children, none of whom have birth defects. This mother also had one previous stillbirth but without obvious birth defects. We are unaware of animal evidence for an association between the birth defects found in case 2 and methamidophos, abamectin, or methylpyrrolidone exposure, but there is evidence to suggest that these pesticides are teratogens [Florida Department of Agriculture and Consumer Services, 2005]. On the other hand, mancozeb and its metabolite ETU have been shown to produce abnormal shortening of the mandible [Larsson et al., 1976; Stula and Krauss, 1977].

Case 3

This infant had multiple severe malformations including cleft lip and palate, imperforate anus, solitary kidney, vertebral anomalies, dysplastic lowset ears, and ambiguous genitalia. These findings are reminiscent of a severe type of the Goldenhar Syndrome (also referred to as oculo-auriculo-vertebral sequence). Death occurred at three days of age. During gestational days 14–59, the mother appears to have unknowingly worked in violation of the REI for up to 10 days. On eight of these days, methamidophos was among the pesticides applied to the fields where the mother appears to have worked. The mother had two previous and one subsequent pregnancy. One previous pregnancy occurred 3 years earlier and resulted in a malformed fetus and ended in miscarriage. The mother worked for the same grower during this pregnancy. During the other previous pregnancy and the subsequent pregnancy the mother was not employed by the grower, and these pregnancies resulted in normal children. Methamidophos has been shown to be associated with anotia, anencephaly, paddle-shaped limbs, and microopthalmia in animals [Hanafy et al., 1986; Asmatullah and Aslam, 1999].

None of the three mothers reported tobacco or alcohol use, and none reported taking prescription, over-the-counter or folk medications. All three mothers immigrated from Mexico, had undocumented US immigrant status (i.e., they did not had a US visa, or other immigration document), and sought prenatal care late in their pregnancies.

INSPECTIONS BY THE STATE DEPARTMENTS OF AGRICULTURE

In 2005, the grower's Florida and North Carolina farms were inspected by FLDACS and NCDACS, respectively. A large number of health and safety violations were identified and the grower received among the largest fines ever imposed by FLDACS and NCDACS ($111,120 and $184,500, respectively). Violations included failure to prevent workers from entering pesticide-treated fields before REI expiration, failure of pesticide handlers to understand all pesticide label requirements, and failure to provide water either to wash off pesticides or to drink.

However, the grower contested the fines in both states, arguing that most of the alleged violations were based on records voluntarily recorded and retained by the grower. Although records are required that document when and what pesticide was applied to a given field, growers are not required to keep records on the movement of workers into that field. The grower voluntarily kept records to track the fields where the case mothers may have worked on a given day, but argued that the records were often imprecise. For example, the records might list 22 fields where the case mother may have worked on a given day. It is unlikely that the case mother worked in all 22 fields. So if one or more of the 22 fields were under a REI for that entire day, it is possible that the case mother was not required to work in any recently treated field. In contrast, the regulatory agencies used those records to support their citations. So in the 22-field example, if only one field was under an REI for that given day, the regulatory agencies may have cited the employer for allegedly allowing the case mother to work in that field. Thus, the grower argued that the records were misused and misinterpreted since one could not use the records to conclusively determine where workers worked on a given day. The grower also explained that some fields were so large that employees could be safely working in one area and pesticides applied acres away in the same field.

Note that according to records supplied by the grower, case 3 worked for 2 days during the period of organogenesis when all the fields where the case was scheduled to work were under an REI for the entire day. In addition, case 3 worked for three additional days during the period of organogenesis when all the fields where she could have labored were under an REI for several identical hours, suggesting that the case could not have escaped working in violation of the REI during those hours. All five of these days involved the Florida farm locations. In contrast, for cases 1 and 2, for each day worked during the period of organogenesis there was always at least one field where the case was scheduled to work that was not under an REI for that day. However, case 1 reported that she was occasionally sprayed with pesticides while working in the fields but it is not known if she was directly sprayed during the period of organogenesis [Chelminski and Higgins, 2006].

Judges in both Florida and North Carolina agreed with the grower's arguments and cited the gap in pesticide law that does not require growers to keep accurate records of when and in what fields farmworkers work [Layden, 2007]. The judge in North Carolina recommended that the number of violations and the level of fines be reduced to $6,000. Subsequently, the North Carolina Pesticides Board issued a fine of $21,000 in March 2008 for 42 of the original 369 violations [Collins, 2008] and an additional fine of $3,000 in February 2009 for another 6 of the original 369 violations [Layden, 2009]. The judge in Florida ordered that the number of violations be reduced and the level of fines be lowered to $8,400. To our knowledge, no subsequent regulatory or judicial action was taken in Florida with respect to the violations and fines.

INSUFFICIENT EVIDENCE TO ESTABLISH A CAUSAL RELATIONSHIP

The SENSOR-Pesticides report describing the cluster was prepared by representatives from NIOSH, EPA, FLDOH, NCDPH, and the National Center on Birth Defects and Developmental Disabilities [Calvert et al., 2007]. It concluded that the available evidence was inadequate to establish a causal relationship between the birth defects and pesticide exposures. For one, the complete cohort of female farmworkers employed by the grower could not be ascertained and studied due to lack of cooperation from the grower (~956 farmworkers were employed at the Florida location and 500 at the North Carolina location, 20% of whom were women). It addition, a genetic etiology could not be ruled out for cases 2 and 3. Furthermore, as explained in detail above, information on pesticide exposure was based on the growers records and could be inaccurate. Biomonitoring and environmental sampling were not performed during the period of organogenesis to confirm pesticide exposure. Additional limitations were the small number of cases, and despite suggestive evidence in animals, published epidemiologic studies of human birth defects and the pesticides of concern were not known to exist.

Nonetheless, this cluster pointed to the need to protect farmworkers from pesticide exposures by: (1) increasing efforts to publicize and comply with both the EPA WPS and pesticide label requirements; (2) enhancing procedures to ensure pesticide applicator competency, and; (3) recommending that growers be prescribed to adopt work practices to reduce pesticide exposures. In October 2005, the grower voluntarily agreed to discontinue using five pesticides (methamidophos, mancozeb, metribuzin, oxamyl, and avermectin) associated with teratogencity in animals.

LEGISLATION PASSED IN NORTH CAROLINA

Following the investigation of this birth defects cluster, NC DPH, initiated efforts to highlight pesticides as an important issue needing more attention, including the drafting of a proposal to create a Governor's task force. In these efforts, the NC DPH received advice and technical support from the North Carolina Agromedicine Institute/ Southern Coastal Agromedicine Center, and federal partners (NIOSH/CDC and EPA). These efforts led in February 2008 to Governor Mike Easley assembling the ''Governor's Task Force on Preventing Agricultural Pesticide Exposure'' which

consisted of key North Carolina governmental leaders in health and agriculture. The purpose of the task force was to examine current pesticide regulations and pesticide use practices and to make recommendations to protect the health of agricultural workers. The task force presented its recommendations in April 2008 [Devlin et al., 2008]. Many of these recommendations were made into law through legislation passed in North Carolina in July 2008 that resulted in funding to: (1) strengthen surveillance; (2) improve the quality of pesticide compliance inspections; and (3) increase and improve pesticide safety training. The funding to the NC DPH will: (1) continue support of surveillance of acute pesticide poisonings and includes an annual appropriation of $79,000 to hire an epidemiologist to operate the state-based pesticide poisoning surveillance program; (2) provides a one time $50,000 allocation that will be used to educate physicians about pesticide poisoning and the state's mandatory reporting law; and (3) support adaption of the current surveillance database to one that is compatible with the National Emergency Disease Surveillance System (NEDSS).

Task force recommendations also resulted in enactment of new anti-retaliation and recordkeeping laws to protect agricultural workers. The new law gives agricultural workers the same protections against retaliation in the workplace as are granted to workers employed in other industries. As such, the law now protects agricultural workers from retaliation who file a workers' compensation claim, complain about working conditions, and initiate workplace investigations. The law also requires more detailed record keeping with respect to pesticide applications. When a pesticide application is made, the time and day when the application was *completed* must now be recorded. The federal WPS requires pesticide applicators to record the time and date when a pesticide is to be applied, but not when the application was completed. The REI is calculated using the time the application is completed. By knowing the time and day when the application was completed, the time and date when entry into a treated area is permitted can be accurately determined. Also, pesticide application records for both restricted use and general use must be retained for 2 years, whereas the retention period was 30 days for general use pesticides before this law was passed. Unfortunately the new law does not require detailed records on the dates and times when an agricultural worker works in specific fields.

As for Florida, in 2006 the state legislature agreed to add 10 new pesticide inspectors to FLDACS to monitor pesticide use and enforce pesticide regulations on Florida farms [Gomez, 2006]. The number of FLDACS agricultural inspectors to enforce pesticide regulations currently stands at 40 [Bryant, 2009]. There are ~47,000 farms in Florida [US Department of Agriculture, 2009]. North Carolina has 23 agricultural inspectors to enforce pesticide regulations on its ~53,000 farms [US EPA, 2009; US Department of Agriculture, 2009].

CONCLUSIONS

This report highlights the important and positive impacts that can occur through surveillance findings. The most important use of surveillance data is to guide prevention activities, including regulatory, enforcement, consultative, and educational interventions [Thacker and Berkelman, 1988]. As demonstrated by this case study, it is important to continue to support and improve surveillance programs for pesticide-related illnesses.

REFERENCES

Alarcon WA, Calvert GM, Blondell JM, Mehler LN, Sievert J, Propeck M, Tibbetts DS, Becker A, Lackovic M, Soileau SB, Das R, Beckman J, Male DP, Thomsen CL, Stanbury M. 2005. Acute illnesses associated with pesticide exposures at schools. JAMA 294:455–465.

Asmatullah, Aslam T. 1999. Toxicity of methamidophos in pregnant mice and developing fetuses. Punjab Univ J Zool 14:141–151.

Bryant C. 2009. Florida Department of Agriculture and Consumer Services. Personal communication.

Calvert GM, Plate DK, Das R, Rosales R, Shafey O, Thomsen C, Male D, Beckman J, Arvizu E, Lackovic M. 2004. Acute occupational pesticide-related illness in the US, 1998–1999: Surveillance findings from the SENSOR-pesticides program. Am J Ind Med 45:14–23.

Calvert GM, Alarcon WA, Chelminski A, Crowley MS, Barrett R, Correa A, Higgins S, Leon HL, Correia J, Becker A, Allen RH, Evans E. 2007. Case report: Three farmworkers who gave birth to infants with birth defects closely grouped in time and place-Florida and North Carolina, 2004–2005. Environ Health Perspect 115:787–791.

Centers for Disease Control and Prevention. 2008a. Illnesses and injuries related to total release foggers-eight states, 2001–2006. MMWR 57:1125–1129.

Centers for Disease Control and Prevention. 2008b. Acute pesticide poisoning events associated with pyraclostrobin fungicide-Iowa, 2007. MMWR 56:1343–1345.

Chelminski AN, Higgins S. 2006. Assessment of maternal occupational pesticide exposures during pregnancy and three children with birth defects: North Carolina, 2004. Raleigh, North Carolina: North Carolina Department of Health and Human Services. Available: http://www.epi.state.nc.us/epi/oii/Agmartreleasereport.pdf. [accessed 30 September 2008].

Collier County Health Department. 2005. Collier County Health Department investigation into the occurrence of congenital malformations in Immokalee, Collier County, Florida, 2005. Naples, Florida: Collier County Health Department, Florida Department of Health.

Collins K. 2008. Ag-Mart faces renewed pesticide charges. The News and Observer Mar 11.

Devlin L, Beauregard K, Borre K, Buhler WG, Engel J, Melton TA, Parks J, Price J, Troxler S. 2008. Report to the Honorable Michael F. Easley, Governor of the State of North Carolina from the Governor's Task Force on Preventing Agricultural Pesticide Exposure. Tallahassee, Florida: Office of the Governor. Available: http://www.ncdhhs.gov/pressrel/2008/2008-04-23-pesticideexposure.pdf. [accessed 27 April 2009]

Florida Department of Agriculture and Consumer Services. 2005. Teratogenic potential of pesticides associated with Florida Ag-Mart farmworker investigation. Tallahassee, Florida: Florida Department of Agriculture and Consumer Services.

Gomez A. 2006. Proposals benefiting migrants quietly having successes. Palm Beach Post. May 01.

Hanafy MSM, Atta AH, Hasim MM. 1986. Studies on the teratogenic effects of tamaron (an organophosphorus pesticide). Vet Med J 34:357–363.

Larsson KS, Arnander C, Cekanova E, Kjelberg M. 1976. Studies of teratogenic effects of dithiocarbamates maneb, mancozeb, and propineb. Teratology 14:171–183.

Last JM, editor. 2001. A dictionary of epidemiology. 4th edition. New York: Oxford University Press.

Layden L. 2007. Judge: Drop most violations against Ag-Mart. Naples Daily News. Mar 23.

Layden L. 2009. Ag-Mart fines are less in North Carolina. Naples Daily News. Feb 20.

Moore KL, Persaud TVN. 2003. The developing human: Clinically oriented embryology. 7th edition. Philadelphia, Saunders, Pennsylvania.

Pew Environmental Health Commission. 2001. Strengthening our public health defense against environmental threats: Transition report to the new administration. Baltimore, Maryland: John Hopkins School of Public Health, Pew Environmental Health Commission.

Stula EF, Krauss WC. 1977. Embryotoxicity in rats and rabbits from cutaneous application of amide-type solvents and substituted ureas. Toxicol Appl Pharmacol 41:35–55.

Thacker SB, Berkelman RL. 1988. Public health surveillance in the United States. Epidemiol Rev 10:164–190.

U.S. EPA. 2009. Certification and training plan and annual report. Pullman. Washington: Washington State University. Available at: http://cpard.wsu.edu/ [accessed 27 February 2009].

USDA. 2009. 2007 Census of agriculture. Washington DC: National Agricultural Statistics Service, U.S. Department of Agriculture. Available at: http://www.nass.usda.gov/index.asp [accessed 27 February 2009].