9. Developing Intervention Strategies and Evaluating Surveillance

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9.1 Designing Interventions Based on Surveillance Data

There are many types of interventions–education, adoption of engineering or administrative controls to mitigate exposure, implementation of more protective regulations, among others. The scope of these interventions may vary, with targets ranging from a single exposed person to the entire population, or from a single worksite to an entire industry. Interventions may involve a combination of techniques since adoption of even the simplest engineering control requires that some level of education and behavioral change also be adopted. Analysis of data to examine risk factors and identify areas for further investigation should be a routine activity of the surveillance program. Indeed, the expectation is that surveillance data will be used to develop intervention and prevention programs. Unfortunately, many PPSPs devote few resources toward such efforts.

When PPSPs implement intervention and prevention programs, they often do so without incorporating a careful strategy for evaluating efficacy. While this approach is expedient and less resource-intensive, it also makes it difficult to measure the impacts of program activities. Evaluation issues should be discussed and examined before embarking on any intervention activity. It is often advantageous, for example, to conduct a pilot intervention program that contains a component to demonstrate impact before implementing the intervention on a broader scale. To achieve this, PPSPs with limited resources may need to seek supplemental funding sources and collaboration with university or research institute partners.

9.1.1 Education

9.1.1.1 At Home and at Work

Interventions that involve education of the affected persons, their HCPs, and sometimes their employer are a common part of case investigation protocols. An example of one approach comes from an Oregon Health Division PPSP investigation of a food storage warehouse where a group of workers became ill following a pyrethrin fogging. The PPSP's site investigation identified 12 symptomatic workers, 6 of whom had sought medical care. The investigation also revealed that the warehouse had been posted indicating when reentry would be safe, but the posting failed to communicate that the warehouse should be ventilated for at least 1 hour before entry. That information had been verbally communicated by the applicator to at least one worker at the warehouse. As a result of its investigation, the PPSP provided several recommendations. It advised the employer, for instance, to develop routine procedures for mechanical ventilation after fogging treatments, and to require that the pesticide applicator provide written instructions for the timing of building opening and ventilation. Additional issues about managing possible exposures were also discussed. These recommendations were provided to the employer in writing, with a request for a response by a specific date. In his response, the employer indicated that the procedures had been implemented. This was confirmed by follow-up contact with employees. Ideally, additional follow-up should be conducted approximately 1 year later to confirm that the changes were still in place. This type of intervention and follow-up should be a routine part of all PPSP case investigation activities.

9.1.1.2 Educating the Educators

In 1993, the Oregon Health Division PPSP noted an annual pattern of multiple incidents of pesticide-related illness associated with pesticide applications in school buildings and/or school grounds. Three such incidents occurred in 1993, including one that resulted in at least 13 symptomatic persons and temporary school closure. The PARC multiagency board sent a mailing to all school district superintendents in the State containing suggested guidelines on pesticide use in schools, a checklist, and additional printed information [PARC 1993]. This letter was sent annually from 1993 to 1995, and then every other year. The mailing now incorporates additional information from the EPA on IPM in schools. This intervention has not been formally evaluated to determine whether the superintendents have adopted the guidelines or passed the information along to appropriate staff. However, illness incidents associated with applications on school property have declined to one per year since 1993 [Thomsen 2001a].

9.1.1.3 Educating the General Public

Some PPSPs conduct broad public education campaigns, especially when involved with surveillance of nonoccupational pesticide-related illness and injury. These programs may be created by PPSPs on their own, but are more commonly developed as cooperative activities with partner agencies and organizations. Campaign elements include dissemination of written materials (some formatted as fotonovelas) and use of multilingual radio programs and videos.

In addition to distributing these materials directly, PPSPs often partner with other programs to integrate pesticide safety information into diverse public health or educational efforts. Examples include child safety programs through migrant education and outreach programs for women on environmental health. Mexican consulates with Cultural Center programs have initiated traveling outreach campaigns to Mexican nationals, providing them with information about legal and social programs in the United States and Mexico. These efforts have integrated information about pesticide-related illness prevention and reporting and other occupational health issues.

Some States have distributed educational information about proper pesticide mixing and application through retail outlets that serve residential users. The Master Environmentalist program, promoted through the American Lung Association in the Northwest, addresses pesticide exposure prevention in information about household environmental hazards [Leung et al. 1997; American Lung Association of Washington 2001; EPA 2001]. Whenever possible, materials developed for individual educational presentations should be preserved in a form that allows them to be used with other audiences (e.g., PowerPoint presentations).

9.1.2 Engineering Controls, Modifications

Many types of engineering controls can be used as interventions to prevent or mitigate exposures, some of which are briefly described here. These controls can be voluntary or part of a regulatory intervention. All of these approaches are methods of reducing exposure through some form of mechanical change in the mixing, loading, or application process. Like all mechanical systems, they are effective only if properly maintained and the operators are trained in their proper use and maintenance.

9.1.2.1 Closed Mixing and Loading Systems

These are effective in reducing contact between the pesticide handler and the concentrated pesticide product. Closed systems for liquid formulations feature a probe inserted into the pesticide container which prevents fluid from spilling when transferring material to a spray tank or when connecting the pesticide container to the spray application system. Another component of closed systems are dry disconnects, which are fittings that prevent pesticide leakage when pipes or hoses accidentally become disconnected.

9.1.2.2 Creative Formulations and Technologies

Wettable powder formulations that come in dissolvable packets can significantly reduce the risk of pesticide exposure during the mixing and loading process. Newer technologies include the development of gel packs for liquid formulations. (Gel packs are water soluble packets of a liquid pesticide that has been converted to a gel material.) Other packaging and package opening systems combined with application equipment are available for some granular products.

9.1.2.3 Enclosed Cabs and Other Protection

The use of enclosed cabs for application or for workers responsible for flagging during aerial applications can serve as protection against dermal exposure. Cabs that are equipped with a ventilation system that includes a filtration device meeting ANSI/ASAE Standard 525-2 [ANSI/ASAE 1998] can be used to protect against inhalation exposure. This standard is referenced in the California Code of Regulations definition of an “Enclosed cab acceptable for respiratory protection” [California Code of Regulations 2002]. Specific performance criteria for ventilation systems in enclosed cabs appear in the EPA WPS [40 CFR Part 170.240(d)(5)]. Use of splash guards on mixing tanks may also reduce the potential for exposures.

9.1.2.4 Application and Equipment Modifications

Switching from hand application methods such as backpack or hand-held sprayer to powered spray equipment may reduce exposures. So may other modifications to material handling equipment, workstations, and ventilation in nurseries, packing sheds, greenhouses, and enclosed operations. Pesticide manufacturing and reformulation activities are also well suited to engineering controls to reduce worker exposure.

9.1.3 Administrative Controls and Regulatory Changes

The most desirable control is to substitute an equally effective but nontoxic control mechanism. Regrettably these are often not available. Collaboration with partners who are specialists in IPM may identify approaches that allow use of a less toxic compound or less frequent use of a more toxic compound. Additionally, workers can be rotated to reduce exposure to toxic chemicals that must be used.

Surveillance data may indicate that reentry intervals are inadequate for a particular pesticide in relation to a certain crop or other local conditions. Further evaluation may then lead to changes in reentry intervals. Periodic biological monitoring of workers is another method to help ensure that they are not overexposed to pesticides. The effectiveness of this intervention in reducing exposures and illness has not been well studied, however [Keifer 2000; Fillmore and Lessenger 1993]. It is not required in most States, the main exceptions being California and Washington State where cholinesterase monitoring is required for some agricultural workers.

9.1.4 Examples of Interventions

Following are examples of interventions that were developed by PPSPs to resolve emerging pesticide problems.

9.1.4.1 Automatic Insecticide Dispensers

In May 1999, the Florida Pesticide Illness Surveillance Program (PISP) identified an exposure event resulting from a restaurant's improperly placed automatic insecticide dispenser. Three persons developed illness associated with exposure to pyrethrin and piperonyl butoxide. Restaurants and other businesses use the dispensers to control indoor flying insects, usually placing them near entrances where they periodically spray pyrethrins or pyrethroids. After the PISP investigated the exposure incident, they contacted CDC/NIOSH, where surveillance data were reviewed to determine whether additional cases of illnesses were associated with automatic insecticide dispensers. Data were supplied by the Toxic Exposure Surveillance System of AAPCC, the Montana DA, the National Pesticide Telecommunication Network (now NPIC), the CDPR-PISP, and the Washington Department of Health PPSP.**

The review identified 97 cases of pesticide-related illness associated with these devices from 1986 through 1999. Three cases involved exposure to resmethrin; the rest involved the combination of pyrethrin and piperonyl butoxide. Fifty-five (57%) cases were work-related. Exposures were associated with dispensers placed too close to patron and workstation areas, dispensers placed in areas where pesticides were entrained in room air flow, and dispensers serviced by persons unfamiliar with them [CDC 2000].

This marked the first time pesticide-related illnesses attributable to automatic insecticide dispensing devices had been documented, and it brought the issue to the attention of public health officials, consumer groups, and the EPA. The report recommended nonchemical alternatives to control flying insects plus recommendations for proper installation and warning stickers whenever automatic insecticide dispensers are used. EPA has requested that the registrants of these products respond to CDC recommendations for use modification and warning labels.

9.1.4.2 Mevinphos

Mevinphos is a highly toxic organophosphate insecticide that is readily absorbed through the skin [Formoli et al. 1994]. Its high volatility at normal farm field temperatures also makes it a respiratory hazard. Events that occurred in California, Washington, and Florida contributed to the voluntary cancellation of this pesticide in 1995. In 1978, California instituted requirements for closed mixing and loading systems for mevinphos. Despite these requirements, between 1982 and 1989, there were 112 cases associated with mevinphos alone, plus another 466 cases associated with tank mixes that included mevinphos. Sixty-eight (12.6%) of the 578 cases were hospitalized. Health officials determined that a potential of exposure from small spills and inhalation still existed even with the use of closed mixing and loading systems [Formoli et al. 1994]. There were additional concerns that using PPE in hot environments could lead to heat-related illness, and even short-term removal of a respirator between loading

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**Data from the first three sources were supplied through the EPA.

operations could result in exposures when working with this highly volatile compound.

In 1993, mevinphos was used in Washington State to address an infestation of aphids in apple and pear orchards. Phosphamidon, the chemical once commonly used to manage this pest, had been discontinued by the manufacturers. The Washington State DA (WSDA) issued emergency rules on the use of mevinphos with restrictions based on input from the manufacturer. These emergency rules included requirements for a 96-hour restricted entry period (increased from 48 hours), limits on the temperature at time of application, prohibition of hand application, and requirements for an observer during mixing and loading operations. As an additional requirement, the registrant was to make available training on safe use of the pesticide.

Despite these precautions, 26 poisonings were reported to the surveillance program within a 3-month period of use. Twenty-three of the cases (88%) were involved with mixing and loading of mevinphos, and seven of the 26 (27%) workers were hospitalized. Washington State Department of Health (WSDOH) PPSP's analysis of cases revealed that 22% of cases occurred despite compliance with all of the safety requirements. On August 19, 1993, WSDA required that only licensed applicators could mix, load, or apply mevinphos, and on August 30, 1993, they issued an emergency order to suspend the use of Phosdrin® (mevinphos) on fruit trees. It is interesting to note that although orchards in Oregon were also suffering from infestations of the same pest, no reports of mevinphos poisoning were reported during that period. Review of information from agricultural representatives indicated that Oregon growers in the affected areas had decided not to use mevinphos due to concerns about toxicity and the potential for drift from ground applications in the orchards.

The EPA had begun a data call-in to evaluate risk reduction measures needed to protect workers from mevinphos and four other organophosphate insecticides. In June 1994, the EPA considered suspending all mevinphos registrations but received a voluntary request from the only registrant to cancel all US registrations. The cancellation was granted and effective July 1, 1994, and later amended to extend the date to November 30, 1995 [EPA 2000b].

In this example, surveillance data were used to develop a regulation-mandated engineering control combined with administrative controls requiring protective equipment and procedures. Despite these changes, serious poisonings continued to occur. Prompt regulatory action prevented many additional cases. Data from California, additional information from Washington, and a report of field worker poisonings in Florida [Baer and Penzell 1993] all contributed to EPA's understanding of the hazards posed by this chemical. This information was taken into account as the chemical went through the reregistration process resulting in its voluntary cancellation in the United States. Mevinphos continues to be used in other countries.

9.1.4.3 Bis(tributyltin)oxide (TBTO) Paint Additives

This final example describes the circumstances that led to cancellation of some uses of TBTO because of concerns about nonoccupational exposures. TBTO is a fungicide commonly used as a paint additive to prevent mildew growth. Health problems from the indoor use of paints containing this pesticide have occurred in Oregon [Thomsen 1997], Washington, and Wisconsin [CDC 1991]. In all three States, investigations consisted of measurement and detection of this fungicide in the indoor environment. These findings raised concerns about acute and chronic effects of exposure and resulted in extensive efforts to remove wall materials or seal wall surfaces where the paint product was used.

WSDOH investigated an unpublished case series of six exposure incidents involving nine symptomatic persons from 1987 through 1991 [State of Washington 1987a,b,c, 1988a,b,c,d,e, 1991]. In 1988, the WSDOH issued a health warning about the use of the paint additive on interior surfaces. The manufacturer of the product involved in all of the Washington cases initiated a label change in 1987 specifying that the product should be used only for exterior applications. In July 1988, the WSDA enacted rules that prohibited both the use of paint additives, paints, and stains that contain tributyltin in inhabited structures, and the registration of products that do not clearly warn on the label that they are not for use on interior surfaces. With the exception of one case in 1991, no additional cases have occurred in Washington State. In 1992, based on the Washington investigations and a series of investigations in Oregon, the Oregon DA agreed to cancel or deny registration of TBTO paint additive products with labels that listed interior use, or did not state *for exterior use only*, and to issue stop-sale orders for those found to be in the channels of commerce. There have been no reported cases in Oregon involving use of TBTO paint additives in interior paints since 1993 [PARC 1992; Thomsen 2001b].

9.2 Evaluation of the Surveillance System

All systems should be reviewed periodically to determine whether they are effectively meeting objectives and carrying out activities efficiently. Complete guidelines for evaluating surveillance systems appear in several excellent references [CDC 2001; Romaguera et al. 2000]. Since these guidelines are readily available, this manual will not describe them in detail but will only touch on a few pertinent areas. Going through a formal evaluation of the program can highlight areas of strengths and weaknesses in the surveillance program. This information is useful for developing strategies for improvement. PPSPs are urged to schedule periodic evaluations of their programs.

The evaluation process involves a structured approach for clearly stating the goals of surveillance and determining if they are being met. If one goal of the system is to provide an estimate of the magnitude of pesticide-related illness and injury, the evaluation should determine if this goal is being met. The ability of the system to identify new emerging problems and populations at risk and to define areas for further research and studies are all PPSP functions that can be examined.

Evaluating the operational aspects of the system is a helpful tool to ensure that the system is running effectively. Operational evaluation should examine the roles of surveillance program staff, information flow, protocols for data collection and management, dissemination of findings, feedback to reporting providers and cases, and the effectiveness of interventions.

Other attributes of the surveillance system that should be evaluated include simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness, and stability. Because some attributes can conflict with other attributes (that is, excelling in one attribute may hamper the ability to satisfy another attribute), it is important to identify and strengthen those attributes that are most important to a particular surveillance system. It should be recognized that it may not be possible to fully achieve the less important attributes. Recommended approaches on how to assess these attributes are available [CDC 2001].

The productivity of the surveillance system should also be assessed. This includes determining (1) the number of investigative reports that are issued, (2) the number of case reports received and followed up, (3) the number of interviews conducted, (4) the number of site inspections performed, (5) the number of phone consultations performed, and (6) the frequency of summary surveillance reports. A summary of outreach activities to stakeholders should also be prepared (e.g., number of newsletter articles published and the number of presentations delivered). Having an electronic tracking system can facilitate the collection and evaluation of this information.

Conclusions and recommendations should be provided when evaluating a surveillance system. An assessment should be made about whether the surveillance system should be continued (that is, can justification be made for the resources applied to it?). If the answer is yes, the need for any modifications to the system should be identified. Finally, when making recommendations for modifications, it is prudent to recall that the costs and attributes of the system are interdependent (e.g., improvements in one attribute may increase costs or affect the performance of another attribute). Therefore, these consequences should be considered when recommending modifications. An evaluation should examine whether recommendations made by the PPSP to prevent pesticide poisoning were implemented, or if other actions were taken as a result of surveillance data (e.g., are data used for generating research or interventions?). If the PPSP has an advisory committee (see Section 5.9.3), this committee can often contribute to the evaluation process.

9.3 Conclusion

The strategies and examples described in this chapter demonstrate how surveillance data can be used to identify new emerging pesticide problems, and thus estimate the magnitude of pesticide poisoning.

Throughout this instruction guide, our goal has been to provide tools that NIOSH partners can use to identify pesticide poisoning risk factors and target interventions toward them. Those tools include

- Information about the importance of pesticide poisoning surveillance
- Mechanisms to improve reporting of cases to surveillance programs
- Methods to investigate reported cases
- Guidance on using the case definition, and
- Additional resources relevant to pesticide poisoning surveillance.

They are based on the experience of public health professionals who are directly involved in the field. Developed over many years, these tools can provide a strong base for any State or local entity initiating a pesticide surveillance program.

It is our hope that others will continue to build on this body of knowledge and expand on the surveillance activities being performed today. In particular, we look forward to a repository of successful intervention and prevention strategies and an examination of their ability to reduce the occurrence of pesticide related-illness and injury. Much remains to be done in assessing the effectiveness of IPM techniques, administrative controls, and the use of low-toxicity pesticides when nontoxic methods are impractical or unsuccessful.