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Preventing Occupational Exposure to Pesticides: Using Participatory Research with Latino Farmworkers to Develop an Intervention

Sara A. Quandt,[1,5] Thomas A. Arcury,[2] Colin K. Austin,[3] and Luis F. Cabrera[4]

Pesticide exposure is an occupational health hazard for migrant farmworkers. The US-EPA Worker Protection Standard (WPS) mandates training programs to prevent or reduce exposure. WPS implementation in a local context requires understanding individual, workplace, and community environmental factors that lead to exposure and influence intervention effectiveness. Participatory research within the PRECEDE–PROCEED planning framework was used to design a WPS training program for Mexican farmworkers in North Carolina cucumber and tobacco production. Research with farmworkers, farmers, health care providers, and Cooperative Extension agents identified modifiable behaviors and environmental factors, as well as structural and regulatory barriers requiring intervention. Data were gathered and analyzed through individual and group interviews, community forums, an advisory board, and a partnership between academic researchers and a community-based organization. The intervention's dominant features are (a) focus on key health behaviors, (b) relevance to local conditions, and (c) attention to issues of control in the workplace. Participatory research is effective for designing a health intervention where diverse social, cultural, political, and regulatory issues affect farmworkers' risk of exposure.

KEY WORDS: behavior change; pesticide; farmworker; migrant.

INTRODUCTION

The production of fruits, vegetables, and a variety of other economically important field crops in the United States depends on the labor of migrant and seasonal farmworkers. An estimated 4.2 million farmworkers in the United States today work in 42 of the 50 states (1). These workers are largely Hispanic and foreign-born (2). Agriculture in the United States relies on chemicals such as fertilizers, growth regulators, and pesticides. An estimated 1 billion pounds of such chemicals are applied each year (3, 4). Because of the hand labor involved in the cultivation and harvesting of many crops, migrant and seasonal farmworkers are at especially high risk of exposure to chemicals and their residues on the plants and in the soil and water surrounding them (5–7).

Exposure to pesticides and other agricultural chemicals is recognized by scientists and health practitioners as a human health hazard. Effects of exposure range from short- to long-term, and can be both mild and severe (8). Federal and, in some cases, state regulations mandate educational programs to reduce workplace exposure, as well as reporting systems to monitor exposure and its health consequences (e.g., US-EPA's Worker Protection Standard [9]). The full implementation of health education programs in a local context to meet the federal Worker Protection

[1]Department of Public Health Sciences, Wake Forest University School of Medicine, Winston-Salem, North Carolina.
[2]Department of Family and Community Medicine, Wake Forest University School of Medicine, Winston-Salem, North Carolina.
[3]MDC, Inc., Chapel Hill, North Carolina.
[4]North Carolina Farmworkers' Project, Benson, North Carolina.
[5]Correspondence should be directed to Sara A. Quandt, Department of Public Health Sciences, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, North Carolina 27157-1063; e-mail: squandt@wfubmc.edu.

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Standard (WPS) and state regulations requires an understanding of workplace factors that lead to exposure, as well as those that reduce its likelihood. These factors include aspects of the farming system, as well as the social and political environment in which the agricultural fieldwork occurs (10).

This paper reports research designed to document the factors related to agricultural chemical exposure of seasonal and migrant farmworkers in North Carolina, and to use these data to design a health education intervention to reduce exposure. The farmworker population in North Carolina is estimated at 140,000 migrants and their dependents, and twice that many seasonal workers who now live in the state year round (11). Until a few years ago this population was African American and White. Today its ethnic composition mirrors the national trend, with most workers being Latino, primarily from Mexico as well as Puerto Rico and the countries of Central America. These workers are employed in the production of a variety of crops, including tobacco, cucumbers, sweet potatoes, apples, and Christmas trees. Because this research is part of a larger study (PACE: Preventing Agricultural Chemical Exposure in North Carolina Farmworkers) using a community-participation framework to design, implement, and evaluate interventions to reduce chemical exposure of farmworkers, it brings together the beliefs and knowledge of a broad range of participants in the agricultural community: farmworkers, farmers, Cooperative Extension agents, and health care providers (12). Together these community members reveal the complete picture of issues surrounding exposure of farmworkers.

Reducing chemical exposure implies behavioral change. A number of theoretical frameworks have been developed for studying and predicting changes in health-related behaviors (13). They range from those focused on individual change, to those focused at the community or societal level. These different levels are brought together in the PRECEDE–PROCEED planning framework (14, 15). This is especially useful for problems in farmworker health because of the role personal actions, interpersonal relations, and regulations all play in potentiating or preventing exposure.

The PRECEDE-PROCEED framework consists of nine phases in the development and implementation of a health behavior change intervention. Phases 1–5 constitute the PRECEDE section, in which the health behavior of interest is identified (Phases 1–3), its context specified (Phase 4), and this information is used as the basis for planning an appropriate health promotion/behavior change intervention (Phase 5). Phases 6–9 consist of the implementation of the intervention, and the assessment of its success in changing the behavioral and environmental contexts of health behavior and, ultimately, improving health and quality of life.

The goals of this paper are to show how the PRECEDE–PROCEED planning framework was used to develop a community-based and community-driven intervention that could be tested using a community trials design. The paper will focus on phases 1–5 by 1) using social and epidemiological diagnosis to identify key behaviors related to pesticide exposure; 2) identifying the predisposing, reinforcing, and enabling factors related to agricultural chemical exposure that an intervention could address in this farmworker population; and 3) designing the intervention.

DESIGN AND METHODS

This intervention was developed in the context of the PACE project. PACE's community-based approach is centered on a partnership between academic researchers (from Wake Forest University School of Medicine and University of North Carolina at Chapel Hill) and a community-based organization (the North Carolina Farmworkers' Project [NCFP]), which provides services and advocates for farmworkers throughout the state.

The PACE project is being conducted in an 8-county area in east-central North Carolina. This is an area in which the greatest concentration of the state's migrant and seasonal labor force is employed. PACE is directed toward farmworkers employed in tobacco and cucumber production, as both these crops use a wide variety of chemicals and involve considerable hand labor.

Data for the PRECEDE phases come from a variety of sources, including existing secondary data sources (16), review of existing training materials (17), as well as primary qualitative data collected for PACE from four constituencies (18). From the first constituency, farmworkers, textual data come from qualitative in-depth interviews, focus groups, notes, and observations from community forums (12). From the others, farmers, Cooperative Extension personnel, and health care

Table I. Number of Participants, by Constituency, Completing In-Depth Interviews and Participating in Focus Groups, by Gender and Ethnic Group

	Female		Male		
Ethnic group	Interviews	Focus groups	Interviews	Focus groups	Total
Farmworkers					
African American	2	6	4	0	12
Hispanic White	3	6	16	32	57
Non-Hispanic White	1	0	0	0	1
Farmers					
Non-Hispanic White	0	0	7	0	7
Cooperative Extension					
Non-Hispanic White	0	0	4	0	4
Health care providers					
African American	2	0	0	0	2
Non-Hispanic White	2	0	1	0	3
Total	10	12	32	32	84

personnel, data come from individual in-depth interviews. All four constituencies participated in quarterly advisory committee meetings throughout the 4-year study, and notes and observations from those discussions are an additional data source.

Efforts were made to include a diverse group of farmworkers to help understand the range of beliefs held (Table I). They were recruited by the North Carolina Farmworker's Project and through contacts provided by migrant clinic outreach workers. The farmers interviewed were also a diverse group, including farmers with different size operations and from different counties. Extension personnel included agents from different counties with different backgrounds (e.g., years of experience, training). Health care personnel included outreach workers, nurses, and a physician assistant.

Interviews with Latino farmworkers were conducted in Spanish. In-depth and focus group interviews, were conducted by trained interviewers, using a standard interview guide. This included topics such as personal experiences with pesticides, safety training, beliefs about health effects of exposure and its prevention, and preferred methods of receiving additional information on pesticides and other health topics (18).

Interviews were tape recorded and transcribed verbatim. Spanish interviews were then translated by a professional translation service and edited by bilingual project staff. A systematic text analysis plan was developed and implemented (19). The analysis was designed to derive common "themes," or generalizations, from the interview sets. Codes were developed to label beliefs, knowledge, and practices related to pesticide exposure. Each transcript was coded by more than one coder to reduce bias. After segments were identified and coded, segments were retrieved and reviewed by academic and NCFP research staff to identify common themes relevant to understanding exposure and barriers to its prevention, as well as those representing predisposing, reinforcing, and enabling factors. *The Ethnograph* (Version 4.0) computer software (20) was used for search and retrieval of text segments.

PHASES 1 AND 2—SOCIAL AND EPIDEMIOLOGICAL DIAGNOSIS

The problem of farmworkers' exposure to pesticides was identified by local farmworker service providers, advocacy groups, and farmworkers themselves as a significant health concern when the study was first proposed. These groups reported that farmworker quality of life was adversely affected by pesticide-related symptoms and illnesses. One limited clinical study of pesticide exposure had been conducted in North Carolina previously, and found depressed cholinesterase levels in farmworkers (21). Reduction in cholinesterase in blood or acetylcholinesterase in red blood cells indicates inhibition of activity in the nervous system caused by organophosphorus pesticides. At least one farmworker death that was pesticide-related had occurred in the area within the past few years. The decision to focus on this particular issue in farmworker health was related to concerns by these stakeholder groups, as well as the potential for funding the development and testing of an intervention through the National Institute of

Environmental Health Sciences' Community Based Intervention/Prevention Research initiative.

A review of the published literature on pesticide exposure found several lines of evidence useful in identifying points of intervention to reduce farmworker exposure. Studies from other occupational groups (e.g., chemical workers, farmers) link excess morbidity and mortality in humans to pesticide exposure (22, 23). The time lag from exposure to effects ranges from immediate effects to those delayed for years (24). Severity of effects ranges from mild to life threatening. A variety of human systems can be affected, including neurological, immunological, respiratory, and reproductive (25). Several potential means of exposure exist. Ingestion of concentrated pesticides and inhalation of vapors have been reported. However, transdermal exposure appears to be the most significant exposure route for agricultural workers. The greatest risk and highest toxicity is linked to skin contact with concentrated pesticides during mixing and application of pesticides. However, mixing and application in the North Carolina context are done by growers or professional applicators. For farmworkers involved in hand labor, exposure to concentrated pesticides can occur if they enter recently treated fields too soon or if workers are accidently sprayed or come in contact with wind-borne pesticides during application. Restricted entry intervals (REIs) are established for all agricultural chemical classes; these are the time periods during which workers may not enter a treated field. REIs range up to 72 h, depending on the toxicity category of the chemical. Farmworkers can also be exposed to dislodgeable residues remaining on plants, soil, and equipment even after the REI has passed; this is probably the most common exposure source (8). Residue exposure and its potential for causing nonlethal symptoms or chronic disease are not considered when setting REIs, so workers can be exposed to residues well after the REI has expired. Thus, the conclusions from Phases 1 and 2 were that *observance of the REIs* and *avoidance of dislodgeable residues* should be the focus of the intervention for farmworkers.

PHASE 3—BEHAVIORAL AND ENVIRONMENTAL DIAGNOSIS

We supplemented the existing literature with interview and observational data specific to the North Carolina situation. By collecting data on farmworker exposure from multiple perspectives, we were able to narrow down the behaviors and environmental factors to those that appeared key to reducing pesticide exposure.

Health Care Personnel

Health care personnel believe that pesticide-related health problems are underreported and undertreated. Farmworkers lack transportation to clinics, and may resist going for diagnosis or treatment for fear of losing wages or their jobs. Many symptoms of pesticide poisoning are nonspecific, such as nausea and vomiting. These are similar to those of other conditions that affect farmworkers: heat exposure, food poisoning, infectious diseases, and green tobacco sickness (26). Most are treated with palliative measures. Farmworkers may use home remedies rather than seeking treatment. If they present at a clinic or other health care setting, there may be no specific diagnosis of pesticide poisoning unless the workers state that they have been exposed.

Some health care personnel allege that farmers do not obey regulations requiring provision of handwashing stations in the fields, and showers and clothes washing facilities in camps. Because hand washing and showering are important practices to reduce transfer of pesticide residues to other skin surfaces and to the mouth, the lack of personal hygiene facilities increases exposure. Without facilities in the camps to wash clothes, residue-containing clothing may be worn for a second work day, reexposing the worker to pesticides. Health care personnel state that farmworkers usually are able to do laundry at local laundromats only once per week. Work and nonwork clothing are mixed, a practice that transfers pesticide residues to nonwork clothing. Many farmworkers do not have sufficient clothing to wear clean clothing every day of the type that will protect against pesticide exposure—long sleeved shirts and long pants. Outreach workers who visit camps note that the housing is often in poor repair. Pesticide-containing dirt is easily brought into the living spaces. Because the housing is frequently located adjacent to fields, there is considerable opportunity for contamination from dirt, as well as from airborne drift during application.

Although health care personnel provide some pesticide safety training through outreach activities, they believe that most farmworkers do not receive adequate training about pesticides and risks of exposure. While farmers are required to provide such training, health care providers believe many do not, so workers may not know about the dangers of pesticide

exposure, safe working practices, when to seek medical care, and their rights to a safe work environment.

Farmworkers

Farmworkers express concerns about pesticide exposure. However, their beliefs about the nature of exposure and its risk factors are at odds with scientific evidence and indicate that they might not be fully aware of the risks they experience (18). Almost all farmworkers indicate that a pesticide can be felt, tasted, smelled, or seen. They believe that if a pesticide is not detected by the senses, then it is not there. They believe that the skin is an effective barrier to absorption of chemicals. These beliefs are not consistent with scientific evidence on transdermal absorption of pesticides and pesticide residues. Farmworkers are concerned about inhaling chemicals or having them come into the mouth. They report (and were observed) wearing bandanas over the mouth to prevent inhalation. They believe that washing to remove pesticides can cause problems. The use of cool or cold water for hand washing in the field can lead to arthritis and rheumatism in the hands, and showering immediately after work before cooling down can damage health. For example, one farmworker described the health risk as analogous to pouring cold water over the engine of an overheated car: the farmworker's body would eventually break down. Although bathing water of any temperature when hot is seen as a problem, farmworkers are particularly reluctant to use wash water in circumstances where farmers provide only one container of water, iced, for both drinking and hand washing. These beliefs are consistent with the humoral medicine system common in Mexico (27, 28), but not with WPS recommendations to remove pesticide residues as soon as possible after exposure to reduce absorption.

Farmworkers believe that individuals vary in their susceptibility to pesticides. Some individuals are "stong" and inherently less susceptible to effects of chemicals, and others are "weak." Men believe women are more easily affected by chemicals than are men. There is no scientific evidence to support this belief. While there are probably some differences between individuals, this interindividual variation is not substantial enough to convey protection from pesticide effects. The effects of pesticides, farmworkers believe, are immediate. The symptoms are rashes, nausea, headaches, and other nonspecific symptoms that cause discomfort, but are not life threatening. Farmworkers think that there are long-term effects, but, when asked for specifics, they do not know what these might be.

Farmworkers believe that for contamination to occur, they must be working when the plants are wet in the mornings with dew or when they reenter fields too soon after pesticide spraying. This occurs, they say, because farmers are always in a hurry to order workers to reenter a field early, or farmers come too close to workers in the field with a sprayer. Farmworkers report that failure to comply with instructions to reenter a field or to work fast enough could cost them their jobs. Perhaps the most striking aspect of farmworker beliefs about exposure is their lack of knowledge of residues. They show no comprehension that anything remains on the plants after the REI has expired.

Only one in three farmworkers report ever receiving training (29). Even when training is received, it is short and there are often few opportunities to ask questions. In most cases, they are shown a safety training video, with little supplementary discussion or printed material. The videos show farmworkers wearing personal protective equipment (PPE), such as coveralls and masks. Farmworkers report that they do not have, nor does the farmer provide such PPE. When asked about different training formats, farmworkers are quite emphatic that they want to receive training from an expert. Formats other than a lay health advisor and train-the-trainer are preferred for two reasons. First, workers assert that a peer would not be able to know as much as an outside expert and might not be taken seriously. Second, because workers are largely migrants, a peer who receives lay health advisor training might leave. This would mean no one at the site would receive the benefit of the lay health advisor's or trainer's knowledge.

Farmers and Cooperative Extension

Cooperative Extension agents and farmers have very similar views, and there is little variation evident within each group. They see little need to train farmworkers in pesticide safety, as they perceive that there is currently no problem (18). They reason that farmworkers are not exposed to chemicals because they do not participate in mixing or application. Both farmers and Cooperative Extension agents argue that smaller amounts of chemicals are used today than in the past and that the herbicides used are not dangerous. Said one farmer, "This stuff is so safe you can eat it." They believe that once the REI has passed, there is

Table II. Summary of Factors Increasing Risk of Farmworker Pesticide Exposure

Category	Nonmodifiable factors	Modifiable factors
Behavior	Farmworkers lack personal protective equipment (PPE), such as rubberized coveralls	Farmworkers do not wash hands in the field
	Hot, humid weather makes use of PPE for routine fieldwork impossible	Farmworkers do not wear clean clothes each work day
		Farmworkers mix work and nonwork laundry
		Farmworkers do not use PPE (long sleeve shirts and long pants)
		Farmers do not observe REI regulations
		Farmers believe no danger exists after the REI has expired
Environment	Farmworkers live in substandard housing	Wash water not provided in fields
	Farmworker housing located near fields	Farmworkers lack control of work environment
	Farmworkers lack laundry facilities	
	Farmers and farmworkers speak different languages	Farmworkers introduce pesticides into housing on work clothes and shoes

no danger. One farmer referred to the REI as the "evaporation period," suggesting that pesticides evaporate without a trace. These views reflect the training farmers receive to obtain their certifications to purchase and apply chemicals. However, they show no knowledge of pesticide residues as a potential route of exposure.

Both farmers and Cooperative Extension agents comment on the increasing number of regulations farmers must follow. The WPS and field sanitation requirements add to this burden of regulation. Farmers must provide water for drinking (water fountain or water with individual cups); water, soap, and paper towels for hand washing; and toilet facilities. However, as one farmer said, "We give [farmworkers] water, but they will not wash." Instead of using the hand-washing stations, farmers report that farmworkers rub their hands with dirt to remove sticky juice from the tobacco plants that accumulate during the work day. Farmers question why they should follow the WPS requirements if farmworkers do not take advantage of their efforts. They claim that even when they supply field toilet facilities, for example, the farmworkers would rather go to the woods to relieve themselves. "You can carry those toilet facilities out to the field and put it right down in the path, and they just don't use them. I'm not down on anybody, but you're talking about people who don't even know what a damn toilet facility is."

Farmers find it difficult to communicate with their workers. They often speak only a few words of Spanish, and the workers know little or no English. Some workers, in fact, have limited knowledge of Spanish, as they speak an indigenous Native American language. Despite communication difficulties, farmers believe that most of the Latino workers have a good work ethic compared to other workers hired in the past.

Summary of Factors Related to Pesticide Exposure

From these interviews and observations, factors related to the health problem, pesticide exposure, were identified. These are listed in Table II. They include both behaviors of farmworkers and environmental characteristics of the workplace and farmworker living quarters. To facilitate the next steps of the intervention development, behavioral and environmental factors were divided into those that are modifiable with a behavior change intervention directed at farmworkers, and those that need to be addressed in other ways.

This analysis, combined with knowledge of farmworker exposure sources in the local farming system and a review of behaviors known to increase or reduce the absorption of pesticides, suggested the specific behaviors to be addressed. These were limited to four: 1) wash hands while working before eating, drinking, smoking, or toileting; 2) wear long-sleeved shirts, long pants, socks, and closed shoes; 3) wear work clothes only one day before washing; and 4) wash work clothes separately from household laundry. To enhance the effects of these behavior changes, two environmental changes were chosen to be addressed in the intervention: 1) increase farmworker control of work environment and 2) reduce pesticides in housing.

PHASE 4—EDUCATIONAL AND ORGANIZATIONAL DIAGNOSIS

To incorporate the selected behavioral and environmental changes into an intervention, factors were identified that were likely to initiate and sustain the process of change among farmworkers. Green and Kreuter's (15) differentiation into predisposing, reinforcing, and enabling factors was used, and relevant behavior change theories were identified.

Predisposing factors included farmworker knowledge and perceived susceptibility. Two areas of knowledge were targeted. First, farmworkers seemed to have no knowledge of pesticide residues. This was evident in their belief that pesticides were only dangerous when they could be detected by the senses, particularly when they were wet. Changing these beliefs was judged to be a predisposing factor for farmworkers to change hygiene behaviors. The second area of knowledge was of rights and regulations (9). Farmworkers did not know that farmers are required to provide separate hand washing and drinking water in the fields and to post notices of pesticide application and REIs. They also did not know that farmworkers have a right to refuse to enter pesticide-treated fields before the REI expires.

Farmworkers did not perceive themselves as vulnerable to pesticide-related health problems. Their belief in individual susceptibility seemed to allow them to deflect danger: someone else was weaker and more likely to be harmed by pesticides than they were. Because they did not understand the concept of residues and understand that residues could be taken home on clothing, they did not perceive their families to be at risk.

The predisposing factors in the areas of knowledge and perceived susceptibility suggest an individual level theory of behavior change. The Health Belief Model was chosen, as it incorporates the constructs of perceived susceptibility, perceived severity, and perceived benefits (30). There appeared to be a clear need to personalize the risk for farmworkers, to specify the consequences of the risk (e.g., fertility problems, cancer), and to clarify the benefits of behavioral change.

Reinforcing factors appeared to be needed to help educate farmworkers about the concept of residues and to provide the social support through peer influence and significant others to sustain a behavior change. Because of the interpersonal nature of these, we drew on social cognitive theory (31). The key concepts from social cognitive theory are 1) environment, particularly providing social support for behavior change; 2) observational learning, providing role models who demonstrate the desired behaviors; 3) self-efficacy, increasing confidence in performing certain behaviors; 4) outcome expectations, increasing the belief that a change will be beneficial; and 5) behavioral capacity, skills for problem solving.

Finally, drawing on community organization and notions of empowerment (32, 33), we reasoned that enabling factors might include new skills and resources. These were intended to aid farmworkers in understanding and attempting to gain control of exposure-related aspects of their working and living environments. The most appropriate for this intervention were judged to be problem-solving skills and diagnostic techniques. Also at the community level, we decided that diffusion of innovation (34) should be considered in order to ensure dissemination of new behaviors among farmworkers.

PHASE 5—ADMINISTRATIVE AND POLICY DIAGNOSIS

Based on the diagnoses conducted in the first four phases, a behavior change intervention was designed. This intervention takes the form of a training program that meets the requirements of the WPS, as well as addresses the issues identified in the prior phases of the research. The PACE intervention has three components. The first is a direct safety training for farmworkers at work sites, which meets WPS requirements for content. This training is conducted by a Spanish-speaking trainer state-certified to conduct a WPS training. The second component is the recruitment and training of an interested individual from each worksite as a field safety promoter. The third component is the support of the field safety promoter with follow-up visits and educational materials (35).

Figure 1 summarizes the intervention. Linkages are shown through the predisposing, reinforcing, and enabling factors to the behaviors and environmental factors originally identified to be changed. Throughout development of the intervention, we placed emphasis on three ideas: 1) the intervention needed to *focus* on key concepts and not present too much information; 2) it needed to be *relevant* to the local or regional farming situation (e.g., presenting information on residues rather than pesticide application in North Carolina); and 3) it needed to include ways of assisting workers in asserting *control* of as many aspects of the work and home environment relevant to pesticide exposure as possible.

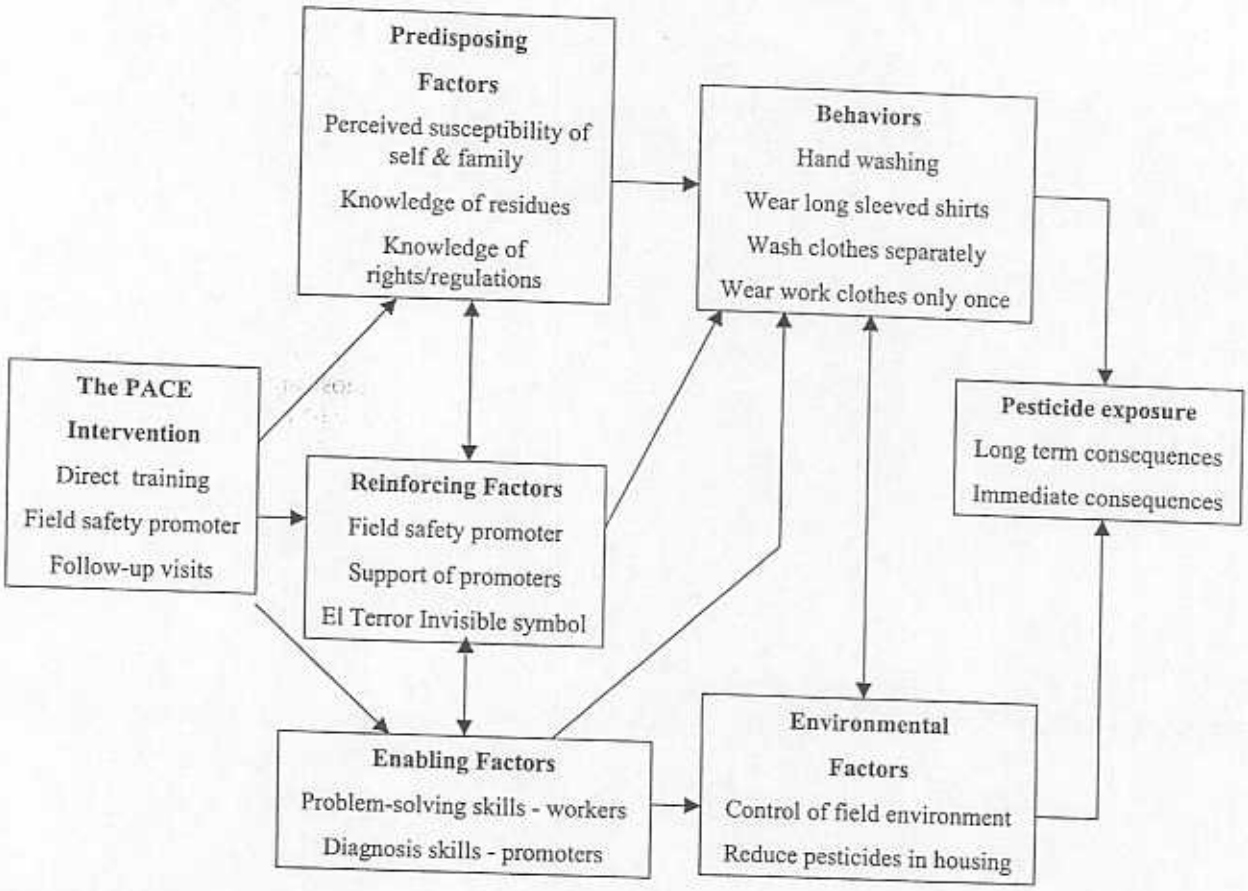

Fig. 1. Application of the PRECEDE–PROCEED planning framework to development of an intervention to reduce pesticide exposure of farmworkers.

Content of the Intervention

Direct Training

The work-site direct trainings are conducted during evening or weekend hours at the residential sites (camps, houses, trailer parks) of workers from a particular farm. Trainers are project staff, generally including bilingual university graduates, as well as former-farmworkers on the staff of NCFP. A mixed media format is used, incorporating directed discussion, demonstration, video, and printed materials (flip chart and brochures). In the course of the training, considerable attention is given to the idea of pesticide residues. A demonstration that includes spraying powder on a newspaper and then noting its transfer to hands, clothing, and other surfaces when carried as tobacco leaves are typically carried is used to stimulate discussion of residues.

The concept of residues is further reinforced by the use of a symbol designed with input and evaluation from farmworkers during the development of the intervention (Fig. 2). This symbol is a ghost called "El Terror Invisible" [The Invisible Terror]. It is the focus of a low-literacy, trifold comic discussed with and distributed to farmworkers at the training (36). The ghost symbol is also used on hats and t-shirts distributed to training participants and worn by trainers.

In addition to basic facts about pesticide exposure, the direct training incorporates teaching problem-solving skills that can be applied to the behavior and environmental changes. For example, the trainers hold facilitated discussions of how to assure access to hand-washing water if a farmer does not provide it. Examples of solutions generated include asking the farmer directly to provide the water and bringing one's own water to the fields in plastic jugs. Drawing from social cognitive theory, the use of

Fig. 2. *El Terror Invisible*: A cartoon character designed to communicate the danger of pesticide residues to farmworkers (© Wake Forest University School of Medicine, 2000).

problem-solving skills is intended to provide workers with the skills necessary to solve problems related to pesticides, to foster the belief that solving the problem will be beneficial, and increase workers' confidence in their ability to modify the environment and their own behavior to reduce pesticide exposure.

Promoter Training

At the direct training a volunteer is recruited to become a Field Safety Promoter (FSP). These volunteers from different worksites attend a training conference at the offices of the NCFP. Like the direct training, the promoter training uses a mixed media format to engage workers. In addition to reinforcement of the knowledge and skills included at the direct training, the FSP training focusses on diagnostic skills. Using popular education techniques such as risk mapping, FSPs are taught how to evaluate the work place and living area for potential pesticide exposure problems (37). These could include pesticide storage areas adjacent to housing, improper disposal of pesticide containers near child play areas, and storage of soiled work clothes in living areas. FSPs practice mapping their worksites and using problem-solving skills to remediate problems (38). Role-playing is used to demonstrate how to communicate ideas learned to fellow workers, as well as how to effectively confront situations with growers. The power of collective rather than individual action and responsibility is stressed.

FSPs are given additional copies of health education brochures (including the *El Terror Invisible* comic) to distribute to coworkers. They are also provided with contact information for regional health care facilities, poison control centers, and other resources relevant to farmworker health.

Follow-Up Visits

To reinforce the content of the FSP training and provide support to FSPs, trainers conduct follow-up visits to worksites during the summer. At these, they meet with the FSP to discuss problem solving in which the FSP had engaged, and pesticide and other health-related issues that have arisen. They reinforce the notion that FSPs are not expected to provide trainings, but rather to be a resource for farmworker actions to decrease pesticide exposure. Project staff also provide additional printed materials as necessary.

The PACE training approach and information are compiled into a manual (35). A selection of low literacy print materials that can be used in either the direct training or the FSP training are included.

DISCUSSION

The PRECEDE–PROCEED planning model provides a structure in which data from a range of sources can be critically examined and methodically interpreted to choose the most relevant theoretical constructs around which to build a health behavior intervention. In PACE, the analysis of interview and observational data was paralleled by compiling an annotated bibliography and a critical review (17) of existing pesticide education materials. The major gap in farmworker and farmer knowledge revealed by this study—residues—helped highlight the fact that almost none of the existing materials stressed residues. While the materials included instructions on hand washing and other personal hygiene behaviors, they failed to connect this behavior with the reason for its importance—the removal of pesticides and their residues. Thus, an individual-level theory (Health Belief Model) that included the constructs of knowledge and of perceived susceptibility was identified as appropriate for structuring the intervention.

The behavioral and environmental diagnosis section of the PRECEDE–PROCEED model was instrumental in tailoring the PACE intervention to the North Carolina farming system. Workers' descriptions of their work tasks were corroborated by farmers and Cooperative Extension agents. Farmworkers in tobacco and cucumber production do not participate in mixing chemicals and applying them. The possible dangers of pesticide exposure associated with these tasks must be included in a training program for it to meet WPS requirements and because workers may encounter these hazards elsewhere, but this should be deemphasized in favor of other hazards more relevant to eastern North Carolina farmworkers.

The qualitative methods used for behavioral and environmental diagnosis were instrumental in identifying a number of cultural factors that had to be incorporated into the intervention. As farmworkers described why iced wash water was dangerous for hand washing and why they needed to cool down after work before showering, the relevance for farmworkers of humoral medicine concepts became clear. At the same time, frustrated comments by farmers about the farmworkers' failure to use hand-washing facilities brought out the lack of cultural understanding by farmers. Providing knowledge to farmworkers, as well as ideas of control (e.g., asking farmers not to ice hand-washing water) was used to address this issue.

Careful attention to data gathered in the behavioral and environmental diagnoses also challenged our preconceived ideas about the appropriateness of certain types of interventions. Lay health advisor and train-the-trainer programs are appealing as ways to effectively empower community members to bring about local change (39–43). In fact, the NCFP regularly uses such approaches in community organizing activities. However, farmworkers were able to articulate problems with these, related to the migratory nature of the labor force. We were able to design an intervention that retained some aspects of these approaches, but ensured that all workers received at least basic WPS training from a certified instructor. The community participation framework within which PACE was implemented also helped ensure its fit with community ideas, values, and realities. By incorporating the ideas of farmworkers and facilitating their involvement in all tasks from planning through implementation, the intervention was true to the farmworkers' situation and a sense of ownership developed. As others have shown, the community participation framework is particularly appropriate in communities which have traditionally had little input into identifying community problems and developing appropriate solutions (44).

The PACE intervention differs from other programs developed for farmworker pesticide education. Most WPS training programs use one of the available videos as a focus for training and questions (45). While selecting a video that covers the materials well can enhance the training, this type of learning is passive, usually considered less effective than a process that incorporates active learning, as does the PACE intervention. In addition, videos with subtitles or other written materials are problematic because of the low literacy skills of many farmworkers. Two well-developed models for farmworker pesticide education exist elsewhere. The Farmworker Health and Safety Institute in Glassboro, New Jersey, for example, uses a Freirian popular education approach (46) called "El Diagnostico" to challenge farmworkers through multiple visits to diagnose and solve exposure problems (47). This method requires intensive trainer contacts with workers, and does not assure training to those workers who leave before the diagnostic process is completed. In fact, this approach sees the transformation of the site, not education of individuals, as the goal. While the PACE intervention does not make as extensive use of popular education techniques, it does ensure that all workers receive WPS training. Those in residence longer receive the reinforcement and additional diagnostic skills of the FSP. The Camp Health Aide program from Michigan is based on a lay health advisor model. Volunteer camp health aides undergo extensive training in a variety of health and safety areas, including occupational health (48, 49). The training itself must take place over a series of months. The program, like all lay health advisor programs, depends on the initiative and commitment of the person trained (50, 40). While this program provides well-trained resource persons for farmworker labor camps, its broad health and safety mission makes it possible that pesticide education will not be sufficiently emphasized to provide a full WPS training.

Despite its emphasis through the PRECEDE–PROCEED planning framework on thorough behavioral and environmental diagnoses, the PACE intervention falls short of the ideal. Bringing farmers into the intervention would increase the likelihood of environmental changes. However, most farmers work long days as do their workers, and have little

time for additional training. They are also wary of any program that focuses on migrant and seasonal farmworkers, as it might attract attention of the Immigration and Naturalization Service or of groups attempting to organize farmworkers into unions. The PACE project was able to involve several farmers in its activities. However, this took several years of trust-building, a process that is not practical for having a widespread impact where there are many small farms as in North Carolina. The PACE intervention is also not able to directly address regulatory issues, such as better enforcement of WPS provisions and changes to REIs to cover the effects of residues (29). However, as part of the "control" aspect of the intervention, the training did actively encourage farmworkers to report infractions and become involved with the activities of the community-based organization. Direct intervention on such issues is well beyond the scope of a behavior change intervention, although, in the long run, it may have the greatest impact on immigrant worker health and safety.

The use of the PRECEDE–PROCEED framework was an effective and efficient means to assess the local work environment and develop an appropriate intervention. Further work needs to be done to evaluate the intervention. While the content of the intervention might need to be changed in some situations (e.g., Christmas tree workers who apply chemicals themselves), it is likely to be effective where similar conditions prevail: a highly mobile labor force, an agricultural system based on hand labor on many small farms, and where farmworkers do not work as applicators. Even with changes in content to match local conditions, the format of the intervention is likely to be widely applicable.

Clearly, farmworker education alone is not the only change needed to protect farmworkers from pesticide exposure. Greater enforcement of regulations regarding field sanitation and housing are needed as well. Although these are beyond the scope of the intervention possible with this project, the use of the PRECEDE–PROCEED model serves to highlight needed changes and has provided data for farmworker advocates and policymakers to begin the required steps.

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