Culturally Relevant Model Program to Prevent and Reduce Agricultural Injuries

D. L. Helitzer, G. Hathorn, J. Benally, C. Ortega

ABSTRACT. *Limited research has explored pesticide injury prevention among American Indian farmers. In a five-year agricultural intervention, a university-community partnership, including the University of New Mexico School of Medicine, New Mexico State University, Shiprock Area Cooperative Extension Service, and Navajo Nation communities, used a culturally relevant model to introduce and maintain safe use of integrated pest management techniques. We applied the Diffusion of Innovations theory and community-based approaches to tailor health promotion strategies for our intervention. In a longitudinal study with repeated measures, we trained six "model farmers" to be crop management experts in pesticide safety, application, and control. Subsequently, these model farmers worked with 120 farm families randomized into two groups: intervention (Group 1) and delayed intervention (Group 2). Measurements included a walk-through analysis, test of knowledge and attitudes, and yield analysis. Both groups demonstrated improvements in pesticide storage behaviors after training. Test scores regarding safety practices improved significantly: from 57.3 to 72.4 for Group 1 and from 52.6 to 76.3 for Group 2. Group 1 maintained their knowledge and safety practices after the intervention. Attitudes about pesticides and communication of viewpoints changed across the study years. With pesticides and fertilizer, the number of corn ears increased by 56.3% and yield (kg m^{-2}) of alfalfa increased by 41.2%. The study combined traditional farming practices with culturally relevant approaches and behavior change theory to affect knowledge, safety practices, attitudes, communication channels, and crop yield. Storage behaviors, use of pesticides and safety and application equipment, and safety practice knowledge changed significantly, as did attitudes about social networking, social support, and the compatibility and relative advantage of pesticides for farms.*

Keywords. *American Indian farms, Community-based participatory research (CBPR), Diffusion of innovations, Injury prevention, Pesticides.*

Agricultural workers nationwide are at greater risk of pesticide poisoning than non-agricultural workers. In a data study by the California Department of Pesticide Regulation, agricultural workers accounted for 93% of pesticide poisoning cases between 1998 and 2001 (Kent et al., 2005). Although some agricultural health studies have been conducted on minority groups, most research concentrates on Hispanic season-

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al and migrant farm workers in the western and southeastern U.S. (Mills and Yang, 2005; Salazar et al., 2004; McCauley et al., 2004; Flannery et al., 2003; Arcury et al., 2002; Schenker et al., 2002; Robson et al., 2001; McCauley et al., 2001; Quandt et al., 2001a; Stallones and Sweiter, 1999; Garcia et al., 1996; Warwick et al., 1992) and African-American farmers in the southern U.S. (McGwin et al., 2000; Dosemeci et al., 1994; Omishakin, 1994).

In New Mexico, American Indians experience significantly higher farm-related occupational mortality as compared to other ethnic groups (Fullerton et al., 1995; Crandall et al., 1997). Work-related farming industry deaths account for a high proportion of deaths statewide (NASD, 2014). In 2002, the Inter-Tribal Council of Arizona held a series of workshops designed to reduce the risk of pesticide illness and injuries among American Indian farmers (Weber, 2002), but few interventions have been implemented in community settings.

Intervention Research

Interventions have been implemented to reduce the risks of pesticide exposure, but little is known about their effectiveness (MacFarlane et al., 2008; Rao et al., 2006). Many researchers have found that farmworkers believe their ability to engage in safe practices is outside their control, and these researchers advocate for health education interventions to address ways in which farmworkers can reduce pesticide exposure (Austin et al., 2001; Palis et al., 2006; Rao et al., 2006; Perry et al., 2000; Strong et al., 2008; Salazar et al., 2004). Arcury et al. (2002) conducted a survey of farmworkers to assess perceptions of safety risk among farmworkers in North Carolina and found that farmworkers had high perceived risk and low perceived control (based on the tenets of the Health Belief Model). Perceived risk was reduced and perceived control was increased after a pesticide safety intervention.

For American Indian communities, for which there is limited information on pesticide-injury prevention, application of community-based participatory research strategies holds great potential for agricultural-injury prevention. To tailor health promotion strategies to the local context, community-based approaches are increasingly viewed as essential. Participatory approaches, including role-modeling behaviors, show great promise (Goodman et al., 1998; Rosskam, 2001; Arcury et al., 2000, 2001). To educate and take action or to effect social change, participatory research should be conducted through systematic inquiry in collaboration with those affected by the problem being studied (Green et al., 1997). In community-based participatory research, researchers and stakeholders from the community who are intended to benefit from the intervention, as well as representatives from local agencies, together identify and define the health problem; design, implement, and evaluate the intervention; and then disseminate the research findings to the community (Wallerstein and Bernstein, 1994; Cornwall and Jewkes, 1995; Duran and Duran, 1999; Green and Mercer, 2001; Green et al., 2003; Israel et al., 1998; Parker et al., 1998; Flocks et al., 2001; O'Fallon and Dearry, 2002; Austin et al., 2001; Quandt et al., 2001b; Minkler and Wallerstein, 2010; Farquhar et al., 2008).

Both the literature and the partnership experience in agriculture and science-based planning and evaluation show that this approach to enhance agricultural productivity while preventing pesticide-related injuries should be methodologically strong, culturally appropriate, and theoretically sound (DeRoo and Rautiainen, 2000; Goldenar and

Schulte, 1996; Arcury et al., 2010). Importantly, the literature suggests that culturally acceptable models of dissemination and adult learning principles (CDSL, 2000) can be used to improve agricultural practices among a needy population. This methodology provides a model for other agricultural injury prevention experts to intervene in culturally discrete populations where mortality and morbidity are high and strategies for prevention have not been effective or have not been adequately studied (Helitzer et al., 2009a, 2009b).

Theoretical Framework

A theoretical framework, the *Diffusion of Innovations* theory (Rogers, 1995), was chosen as a culturally appropriate foundation for the introduction of a new innovation (fig. 1). The theory was used originally to observe and evaluate the impact of development programs in agriculture, such as the diffusion of hybrid corn among farmers. For this reason, the theory considers factors that are relevant to agricultural practices in particular. In articulating the theory, Rogers (1995) observed that specific constructs determined the extent to which, and the pace at which, a farming community adopted an innovation. Originally conceived as a linear process, in which messages are communicated from one person to another, more recent understanding of diffusion suggests that it uses a "convergence" model in which "communication is essentially a social process in which subjectively perceived information about a new idea is created and shared by communication networks to reach a mutual understanding" (Rogers and Kincaid, 1981).

Elements of diffusion include the innovation itself, communication channels, time, and the social system. Classical diffusion theory suggests that there are two types of individuals who communicate about the innovation: those who have little or no experience using the innovation (adopters) and those who have experience using the innovation (opinion leaders and change agents). In addition to considering the elements of diffusion, Rogers (1995) discusses the process by which an innovation is diffused and accepted:

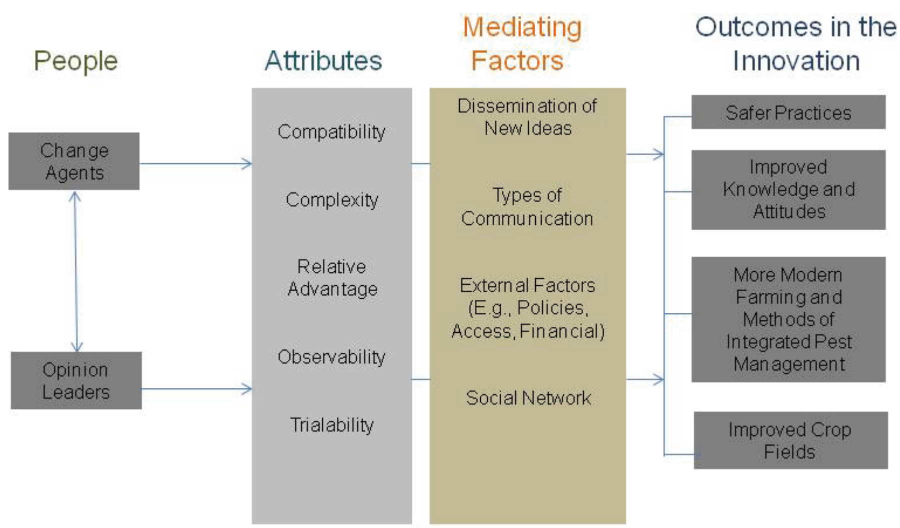


Figure 1. Theoretical framework of the intervention.

(1) knowledge, (2) attitudes, (3) decision, (4) behavior change, and (5) maintenance of the new behavior. The theory posits that when opinion leaders and change agents disseminate information, behaviors and health outcomes will improve and/or lead to other desired outcomes. Mediating factors are beliefs about the attributes of the innovation, types of communication and communication channels, and the breadth and depth of the social network and support systems.

Community-University Partnership

To design and implement an intervention to address agricultural risk for American Indian farm families, a university-community partnership, including the University of New Mexico (UNM), New Mexico State University (NMSU), the Shiprock Area Cooperative Extension Service, and a stakeholder group representing three Navajo Nation communities, came together to design and conduct a five-year agricultural intervention. The partnership was formed under a prior grant from the National Institute for Occupational Safety and Health (NIOSH). The intervention was conceived as a result of (1) a baseline survey that suggested that farm families learned to farm from their elders, neighbors, and other respected members of their communities; and (2) the concern that pesticide use, although not yet widespread, was expected to grow significantly due to its easy access to the Navajo Nation. Therefore, to prevent exposure hazards, our intervention was designed to introduce safe practices and familiarize participants with the safest pesticides available while focusing on compatibility with traditional farming methods, relative advantage to the farmers, and beneficial crop yields.

The *Diffusion of Innovations* theory was linked to the intervention design in the following ways: (1) the innovation was the safe use of pesticides, (2) the communication channels were primarily face-to-face communication, (3) the time period was a two-year training period and a two-year maintenance period, and (4) the social system was a group of farm families in a relatively contiguous geographical location. In these small farming communities, the farm families were often related to each other (social network), and families usually farmed the land together (social support network). The attributes of the innovation were those used in other diffusion studies: its trialability, observability, compatibility with current practices, relative advantage over current practices, and an acceptable level of complexity. The opinion leaders were two Agriculture Extension agents (Gary Hathorn from NMSU and Jeannie Benally from the Shiprock Extension Service), and the change agents were six farmers who lived and farmed in these communities and volunteered to be trained and employed during the grant period. We termed them "model farmers." The process of behavior change included knowledge about pesticide safety and administration, attitudes about the innovation (specifically about its attributes), the decision to use pesticides, behavior changes in pesticide storage and administration, and maintenance of the new behavior after the training period ended. Desired outcomes were safer practices, increased crop yields, improved knowledge and attitudes, and use of modern farming methods as well as methods that integrate pest management.

We predicted that we would observe significant improvements after training in knowledge, attitudes, and safe use and storage of pesticides. Furthermore, we predicted higher yields of corn and alfalfa with treatments of fertilizer and pesticides compared to controls.

Methods

Opinion Leaders and Change Agents

As defined by the *Diffusion of Innovations* theory, we identified two groups of individuals: opinion leaders and change agents. Opinion leaders are experts in agriculture and have influence over the behavior of the change agents. As guiding forces, Extension agents Gary Hathorn from NMSU and Jeannie Benally from the Shiprock Extension Service provided consulting experience and training while facilitating data collection throughout the five-year study. Some of the original stakeholder group members were also considered local opinion leaders in their roles as farming committee chairmen, San Juan Water Board representatives, or Farm Board representatives.

In the diffusion model, change agents are those who positively influence innovation decisions by mediating between the opinion leaders and the relevant social system. Six individuals with sufficient time and leadership qualities were employed and trained to participate in the study. We termed them "model farmers." These men and women were farmers who agreed to model the new behaviors on their own farms.

Training of Model Farmers

Through NMSU workshops and training, the six model farmers received extensive professional training on pesticide safety and the use of chemicals, as well as additional instruction in the following topics: environmental safety and regulatory components of crop production, integrated pest management, crop management, nutrient management, concepts of soil fertility, soil testing and plant analysis, nutrient sources and applications, soil pH and amendments, organic waste management, basic soil properties, irrigation management, soil erosion, water quality, weeds, insect management, disease management, pesticide regulations, organic farming, crop adaptation, cropping systems, planting factors, crop growth and development, and harvest factors. The New Mexico Core Curriculum for Vocational Agriculture Teachers (Harrison and Iverson, 1975) was used as a basis for training the model farmers. The curriculum includes standardized tests on each unit of instruction. The model farmers were required to attain a minimum pass rate on each test before continuing to the next unit. The literature on pesticide training showed that standardization of and fidelity to the curriculum was crucial for training the trainers. We chose this well-known and respected curriculum so that the intervention could be replicated, should the outcomes be positive.

The San Juan County Department of Geographic Information Systems (GIS) provided GIS and topographic maps showing roads and river/canal systems in the three irrigation canal areas. The model farmers surveyed the farms in their irrigation canal system area, identified the acres lying fallow and those in production, and described the crops being grown. In addition to familiarizing the model farmers with their catchment areas, this survey gave them the opportunity to develop a list of potential farmers for the study population. Equipment and reference materials enabled the model farmers to gain hands-on experience with the training content. These included four-wheelers with boomless nozzle sprayers for pesticide application, pesticide applicator manuals and tapes, Certified Crop Adviser Program training materials (ASA, 2006), crop protection handbooks, crop protection reference books, and pest identification books and guides, as well as crop-specific pest and production guides from many sources. The model farmers were required to pass curriculum competency exams with a passing grade of 70%. We trained six model farmers as crop managers in a formal training process during the first year of the study. Early in the training, one model farmer had to drop out, but we were able to recruit and train another individual who took over the catchment area of his predecessor.

After the model farmer training was complete, we implemented a treatment and delayed treatment crossover intervention with Navajo farm families to assess the effectiveness of best management practices and pesticide safety application procedures on farm yield, safety behaviors, and environmental effects.

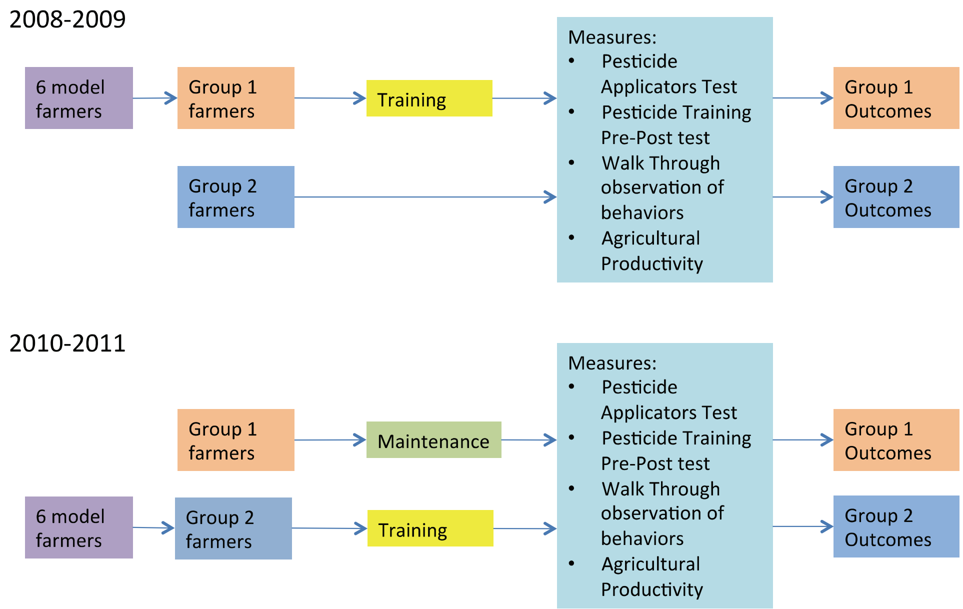
Study Design Overview

We used a longitudinal, randomized treatment and delayed treatment crossover design with repeated measures annually (up to five measures per farm family). Institutional human subject review boards (IRBs) from UNM and NMSU, as well as the Navajo Nation, approved the study. To conduct research on the Navajo Nation, in addition to the IRB approvals from UNM and NMSU, the Navajo Nation Human Research Review Board requires that each of the four chapters in which the study proposed to work must approve the research. We requested permission to be put on the meeting agendas of each chapter's monthly meeting, and then attended and presented the study in at least one meeting in each chapter. In each chapter, stakeholder group members from the local farming committee presented the study to the chapter leaders and members for their approval. After all four chapters had approved the study, the principal investigator prepared and presented a resolution for consideration by the Navajo Nation Health Board. After Health Board approval, the Navajo Nation Human Research Review Board entertained the application and approved the study. No participant recruitment was initiated until all approvals were granted.

In 2008, we recruited local farm families to participate in the study. Family groups work the farms, and family members came together to the recruitment meetings. Acknowledging that small family units shared the responsibilities for farming, we consciously included the entire family unit in the recruitment process. During the recruitment meetings, the participants were informed that there would be two groups of farm families: Group 1 was the intervention group, and Group 2 was the delayed intervention group. In order to ensure that all families understood the research design (Strong et al., 2008), we explained that both groups would receive the same intervention; the two groups would differ only in the timing of the intervention. We explained that Group 1 would receive the training in the first two years, and Group 2 would receive the training in the second two years. Initially, we considered administering a strict and controlled randomized experiment, but because the farming communities are closely knit extended family units, we recognized that there would be significant "contamination," which could undermine the original design. Therefore, while we trained Group 2, Group 1 was followed to learn if changes resulting from the intervention were maintained. There was evidence from prior interventions that trained individuals would not maintain behavior changes, and we decided to make this a formal research question (Strong et al., 2008) (fig. 2).

Study Populations and Locations

The farm families lived in four chapters of the Navajo Nation Shiprock Agency: Hogback, Cudei, Shiprock, and Upper Fruitland. These chapters have widely disbursed farms that are located near the San Juan River in northwestern New Mexico. The San Juan River irrigation canal system serves the population cohort for this study. These four chapters comprise the majority of Shiprock Agency farms, including approximately 800 farm fam-



ilies and 3,605 hectares (ha) (8,907 acres). The average farm has 6 ha (15 acres). The mapping process (described above) confirmed initial partnership statistics about the farms and acreage within the area of the three systems of irrigation canals (Fruitland, Hogback, and Cudei).

Due to the complexity of pests in the intervention sites, our goal was to improve the margin of safety and reduce exposure risk by providing enhanced training in pesticide use and safety behaviors to intervention farm families. Each of the six model farmers created a list of farms within the three-canal system and updated their GIS maps. The model farmers then recruited 120 participating farm families. Farm families were selected based on demonstrated interest in learning about pest management and pesticide application. Participants were told that they would be randomly assigned to either Group 1 (intervention) or Group 2 (delayed intervention). These families attended one of several meetings held in the four-chapter area where they were told about the study. Families who were interested in participating then attended a formal recruitment meeting where the study procedures were explained again. Although many intervention participants were part-time farmers, they were also exposed in day-to-day farming practices involving pesticides. In many cases, the participants were a husband and wife team; in some cases, grown children participated as well. Whether the intervention was implemented with a family or an individual farmer, the family agreed to identify one individual to complete all the pre/post tests.

All of the 120 farm families who attended the recruitment meeting agreed to participate in the study, and a member of the partnership research team (not the model farmer) administered informed consent. The individual who agreed to take the research tests signed the informed consent on behalf of his/her family.

Before randomization, each farm family participated in a complete inventory of their farm. The inventory assessed acreage, acreage productivity, farm boundaries, equipment, and crop types. The model farmers conducted this inventory of each of the farms in their irrigation canal system area, similar to what they had learned to do during their training. These data, including crop production data, were considered baseline data from which to judge intervention effectiveness. Once a farm family agreed to participate, we administered a baseline test of knowledge about pesticide practices. Subsequently, the 120 farm families were randomized into two groups. The farm families randomized into Group 1 were assigned to work with the model farmer in their irrigation canal system during 2008-2009, and one-on-one training by the model farmers ceased in 2010-2011. Farm families randomized into Group 2 became members of the delayed intervention group during 2008-2009; they worked with the model farmer in their irrigation canal system during 2010-2011. Group 1 was in a maintenance phase in 2010-2011, which allowed us to assess long-term behavior change.

Intervention

Farm Inventory

The model farmers completed a complete inventory of each farm that included crops grown, equipment, pesticides and storage, as well as pest problems. Soil samples were taken and sent off for analysis. From this inventory, the following information was found, which served as a basis for the project.

Crops

In these chapters, all crops were flood irrigated. The two primary field crops grown on these farms were alfalfa and Indian white corn. Alfalfa is grown as a hay crop to feed livestock in the area; for these farmers, it is mostly grown as a cash crop that is sold along the side of the highway or at the local flea market. In this area, alfalfa averages four cuts per season, with the first cut around the first of June and the last cut at the end of September. The average yield for San Juan County (the New Mexico county in which the study was implemented) is five tons per acre. Yields on small farms within the project area were less than the county average, largely due to the age of stands, lack of fertility, and weed infestation.

Indian white corn is planted in bunches about 91 cm (3 ft) apart in rows spaced from 91 to 102 cm (36 to 40 in.). The number of plants per bunch varies from 6 to 12, with very little consistency on each farm. Indian white corn is mostly grown for food and is consumed by steaming on the cob. Some is taken off the cob and packaged for mutton stew or used to make Navajo bread, called "kneel down" bread. Farmers in the area grow the corn for their own consumption as well as to sell fresh or steamed by the ear. From the farm survey, we also learned that most farmers plant vegetable gardens for their own consumption and to sell at the local farmers' markets, flea markets, and along the highway. In some instances, families have their own stands along the highway.

Pest Problems

Weeds were the most prevalent problem for farms. The only two insects identified consistently from the farm survey were squash bugs and corn earworms. These pest problems were used to determine the content of the integrated pest management program for the farms throughout the project area.

Soil Test Results

For the most part, soil test results showed low fertility in the fields that were sampled. This was not surprising, as very few Navajo farmers in this area used commercial fertilizer. This led to the decision to incorporate training in the use of commercial fertilizer on these farms. In addition, we added information to educate farmers in the use of crop rotation systems. Using demonstration plots, we showed that crop rotation could make use of nitrogen left by legume plants such as alfalfa, beans, and peas by planting nitrogen-using plants such as corn and other vegetable plants.

Visual assessment by the model farmers showed that most farms had a large amount of fallow land. Very few farms were fully cropped and in some cases had not been cropped at all during the previous year. Although farmers had intentions of cropping over the next several years, this did not always happen because of drought or other challenges.

Integrated Pest Management Plan

From the farm survey and visual observation, an integrated pest management plan was formulated for each farm for each year. This plan took into consideration cultural, biological, and chemical control opinions of the farm families and delineated their goals for the four years of the study, including crop yields and desired skills and knowledge. The model farmers reviewed each individual farm plan with Gary Hathorn; before plans were approved, they discussed the feasibility of implementation. The model farmers shared plans with one another in regular meetings to give feedback and support.

Each farm plan took into consideration the family's management practices, availability of equipment, ability to purchase chemicals, and cultural beliefs. The literature showed that cultural beliefs play a large part in whether or not new practices are adopted, so we encouraged each model farmer to discuss these beliefs (Arcury et al., 2010). In many families, the oldest member was quite elderly (~75 years old) and had cultural beliefs different from those in which the oldest member was more middle-aged (~50 to 65 years old). For every farm, the plan included traditional methods that fit well with cultural beliefs, as well as mechanical and chemical methods.

When incorporating the use of chemicals into the plan, many obstacles were considered. The first was the use of restricted-use chemicals. In New Mexico, a farmer must have a private applicator license to purchase and apply restricted-use chemicals. One of the U.S. requirements for pesticide licensure is to allow pesticide inspections. Because the Navajo Nation is a sovereign nation, the New Mexico Department of Agriculture Pesticide Division is not able to conduct pesticide inspections on its farms. However, the Navajo Nation has no separate licensing program for its citizens. For this reason, only non-restricted chemicals were used in this study. There was one exception to this: 2,4D is not restricted in Colorado and can be obtained without a license. For the farmers in this study, Colorado is less than an hour's drive away; therefore, 2,4D was incorporated into the integrated pest management plan.

The plans included chemicals that were readily available and could be purchased easily in the area, as well as those that were the safest, most effective chemicals on the market. In the beginning of the study, Pursuit, Raptor, and Velpar were used for weed control in alfalfa; however, Raptor and Pursuit were dropped from the program due to their cost and concerns with behavior maintenance. The only chemical used for weed control in corn was 2,4D. Sevin was used to combat corn earworms. Glyphosate was used for weed control along ditch banks and irrigation canals to combat willows and Russian olive trees.

No herbicides were used in garden plots or vegetable gardens. Only Sevin was used on squash bugs.

Training

The model farmers trained each individual farm family on chemicals and their uses, sprayer calibration, pesticide safety, fertilizer application, and pesticide rates. Participants were also trained on integrated pest management; this approach was demonstrated on individual farms by using traditional, mechanical, and chemical control methods. Each group was invited to attend one of four training sessions held by NMSU Cooperative Extension each year throughout the study. These three-hour training sessions were scheduled at night and on Saturdays to accommodate study participants who were employed off the farm. The training content included pesticide safety, integrated pest management, weed identification, insect identification, and information about the program itself. Pesticide safety incorporated principles such as how pesticide exposure occurs, precautions to prevent exposure, toxicity type, symptoms of pesticide poisoning, procedures if exposure occurs, selection of safer over more toxic pesticides, and environmental safety. Based on the demonstration results, the farm families made pest management decisions. Chemicals, biological agents, fertilizers, and supplies were purchased to accommodate each individual's farm plan. The model farmers also set up demonstration plots on the farms for visual and yield analysis.

Measures

Three measures tested the intervention: walk-through analysis of safety storage and behaviors, test of knowledge and attitudes, and yield analysis. Table 1 shows the measures and the timing of their administration to each group during 2008 to 2011.

Walk-through Analysis

A structured observation instrument assessed safe pesticide storage and behaviors. The observer was guided to look for pesticides and, if present, examine how they were stored, prompted by a list of correct behaviors such as "locked up," "out of children's reach," and "in a ventilated room" and incorrect behaviors such as "in the house." Some questions required the observer to ask for information, such as "how is the clothing washed that is used for pesticide application?" Also included in the walk-through was identification of pesticide application equipment and pesticide safety equipment. The observer was trained to identify concerns, which would then immediately be addressed.

Test of Knowledge and Attitudes about Integrated Pest Management

This instrument was divided into two parts: a knowledge test and an attitude test. The

Table 1. Measures of intervention evaluation, 2008-2011.

	2008	2009	2010	2011
Group 1	Pre-training	Post-training	Maintenance	Maintenance
Walk-through analysis	√	√	√	√
Knowledge test and attitude survey	√	√	-	√
Agricultural yield (in Apr. and Sept.)	√	√	√	√
Group 2	Pre-training	-	Pre-training	Post-training
Walk-through analysis	√	-	√	√
Knowledge test and attitude survey	√	-	√	√
Agricultural yield (in Apr. and Sept.)	√	√	√	√

first part of this instrument assessed knowledge about integrated pest management. We adapted 36 questions from those used on the certified crop management application license assessment. Topics included exposure, safety precautions and personal protection, types of weeds and pests, environmental protection, proper use of pesticides and equipment, and calibration problems. The second part of the instrument included ten additional questions that assessed attitudes toward using integrated pest management. We linked these questions to the constructs in the *Diffusion of Innovations* theory, particularly related to communication, social support, and attributes of the innovation. These questions were not included in the knowledge score calculation. Perception of agreement was assessed with a six-point Likert scale, where 1 = strongly disagree and 6 = strongly agree.

Agricultural Yield

At the end of each growing season, we calculated agricultural yield. On intervention farms during 2010 and 2011, we set up demonstration plots of Indian white corn and alfalfa. For yield analysis, we randomly selected 11 farms for corn and 16 for alfalfa. One treatment plot and one control plot were established in the same field to demonstrate change in yield both visually and quantitatively. On corn treatment plots, corn was fertilized at the rate of 113.5 kg ha^{-1} (100 lbs $acre^{-1}$) of actual nitrogen. Weeds were controlled during the growing season with 2,4D. Prior to harvest, we measured both the control and treatment plots for yield by randomly selecting three bunches of corn in each plot; we counted the number of ears and measured the length of each ear. On alfalfa fields, a 0.4 ha (1 acre) plot was staked off and fertilized with 11-52-0 fertilizer at a rate of 170 kg ha^{-1} (150 lbs $acre^{-1}$). The plot was sprayed with a herbicide labeled for alfalfa. The rest of the field was left untreated as a control for comparison. We collected yield data on the third cut for the year. A 0.09 m^2 (1 ft^2) sample was clipped from both the control and treatment plots. Each sample was weighed for comparison. We predicted that there would be significant increases in crop yield for both corn and alfalfa in treated plots compared to control plots.

Data Analysis

We consolidated and cleaned, prepared for pair-wise analysis, and entered the data into Statistical Package for the Social Sciences (SPSS) for analysis. Kolmogorov-Smirnov tests determined the data distribution. Test scores among those who completed all three tests were normally distributed ($p > 0.05$); therefore, we used parametric tests to analyze the test scores. For all remaining data, which did not fit a normal distribution ($p < 0.05$), non-parametric statistical tests were used. For this study, among a population of 800 farmers, a sample size of 60 farmers per group was sufficient to detect a significant difference in agricultural yield, with a difference of 25% (confidence interval of 12.5 points) at a 95% confidence level. We hypothesized that we would observe differences of at least 25% within intervention groups on most indicators, given the intensive nature of the intervention and the low levels of existing knowledge, behaviors, and crop productivity.

Walk-through Analysis

We tested null hypotheses associated with the following predictions, stated as null hypotheses or alternative hypotheses:

$H_{A(1a)}$: Group 1 will show significant improvements in pesticide storage and safe use across years (2008-2011).

$H_{A(1b)}$: Group 1 will show significant improvement in pesticide storage and safe use between 2008 and 2009.

$H_{0(1)}$: Group 1 will maintain behaviors (no increases or decreases) regarding pesticide storage and safe use between 2010 and 2011.

$H_{A(2a)}$: Group 2 will show significant improvements in pesticide storage and safe use across years (2008-2011).

$H_{0(2)}$: Group 2 will show no significant differences in pesticide storage and safe use between 2008 and 2010.

$H_{A(2b)}$: Group 2 will show significant improvements in safety behaviors and pesticide storage between 2010 and 2011.

For the walk-through analyses, we used log-likelihood goodness-of-fit tests for contingency tables because many cells had an expected value of less than 5 and therefore did not fulfill the assumptions of the chi-squared goodness-of-fit test.

Pre/Post Tests of Knowledge about Safety Practices

We tested null hypotheses associated with the following predictions, stated as null hypotheses or alternative hypotheses:

$H_{A(3a)}$: Group 1 test scores will improve significantly across years (2008-2011).

$H_{A(3b)}$: Group 1 test scores will improve significantly between 2008 and 2009.

$H_{A(3c)}$: Group 1 test scores will improve significantly between 2008 and 2011.

$H_{0(3)}$: Group 1 test scores will not increase or decrease between 2009 and 2011.

$H_{A(4a)}$: Group 2 test scores will improve significantly across years (2008-2011).

$H_{0(4)}$: Group 2 test scores will not change between 2008 and 2010.

$H_{A(4b)}$: Group 2 test scores will improve significantly between 2010 and 2011.

$H_{A(4c)}$: Group 2 test scores will improve significantly between 2008 and 2011.

To determine if test scores improved across multiple years ($H_{A(3a)}$ and $H_{A(4a)}$), we used one-way repeated-measures ANOVA tests. These tests included only individuals who completed all three tests. The data in both groups met all assumptions of the repeated-measures ANOVA, including Mauchly's test of sphericity. We used paired-sample t-tests to compare test scores between two years ($H_{A(3b-c)}$, $H_{0(3)}$, $H_{A(4b-c)}$, and $H_{0(4)}$). To determine differences between Group 1 and Group 2 in mean test score differences (score on test in 2011 minus score in 2008 for each individual), we used an independent sample t-test.

Pre/Post Tests of Attitudes about Integrated Pest Management

We tested null hypotheses associated with the following predictions, stated as null hypotheses or alternative hypotheses:

$H_{A(5a)}$: Group 1 attitudes will change significantly across years (2008-2011).

$H_{A(5b)}$: Group 1 attitudes will change significantly between 2008 and 2009.

$H_{A(5c)}$: Group 1 attitudes will change significantly between 2008 and 2011.

$H_{0(5)}$: Group 1 attitudes will not change between 2009 and 2011.

$H_{A(6a)}$: Group 2 attitudes will change significantly across years (2008-2011).

$H_{0(6)}$: Group 2 attitudes will not change significantly between 2008 and 2010.

$H_{A(6b)}$: Group 2 attitudes will change significantly between 2008 and 2011.

$H_{A(6c)}$: Group 2 attitudes will change significantly between 2010 and 2011.

In single-item analyses, we compared rank values of attitude questions across years ($H_{A(5a)}$ and $H_{A(6a)}$) with Kruskal-Wallis tests, corrected for ties. The test statistic is presented as the H value. To compare ranks between years ($H_{A(5b-c)}$, $H_{0(5)}$, $H_{A(6b-c)}$, and $H_{0(6)}$), we used Mann-Whitney U-tests, corrected for ties. The test statistic for Mann-Whitney

U-tests is presented as the U value. Only individuals who answered at least some of the questions were used in the analyses. However, sample size is not consistent among questions because not all questions were answered on a given survey.

Agricultural Yield

We tested the following null hypothesis: $H_{0(7)}$: Crop yields will be significantly greater in plots treated with fertilizer and herbicides than in untreated (control) plots.

We used Mann-Whitney U-tests, corrected for ties, to determine differences in number of ears of corn, corn ear length, and mean weight of alfalfa. For the corn data, we used the mean of three data points on each plot for the analysis to avoid pseudo-replication. Therefore, although the total number of data points consisted of 33 clusters of corn, the sample size was 11.

Results

Population Sample

We identified a total of 803 farms, 120 farm families, and six model farmers in the three irrigation canal systems (table 2).

Pesticide Safety Behavior, Storage, and Pesticide Application

The following results for the walk-through analyses of changes in safety, storage, and application of pesticides refer to table 3.

Group 1: Significant differences across years ($H_{A(1a)}$). The percent of farm families who owned pesticides increased significantly across years (G = 103.4, $p < 0.001$). Among those who owned pesticides, we observed significant improvement in keeping pesticides out of children's reach (G = 15.5, $p < 0.001$). We observed significant increases across all years in the percent of farm families who owned at least some standard pesticide safety equipment (G = 64.8, $p < 0.001$), in particular chemical-resistant gloves (G = 64.8, $p < 0.001$), sand (G = 31.2, $p < 0.001$), chemical-resistant boots (G = 49.2, $p < 0.001$), and protective clothing (G = 50.8, $p < 0.001$). There were significant differences in ownership of pesticide application equipment across years, initially increasing and then decreasing (G = 55.2, $p < 0.001$).

Group 1: Significant differences between 2008 and 2009 ($H_{A(1b)}$). The percent of farm families who owned pesticides increased significantly between 2008 and 2009 (G = 46.7, $p < 0.001$). Among the farm families who owned pesticides, we observed significant improvements in keeping pesticides locked up (G = 4.7, $p < 0.05$). The percent of farm families who owned at least some pesticide safety equipment increased (G = 32.4, $p < 0.001$), including chemical-resistant gloves (G = 32.4, $p < 0.001$), sand G = 4.3, ($p < 0.05$), chemical-resistant boots (G = 24.7, $p < 0.001$), and protective clothing (G = 11.1, $p < 0.001$). There was a significant increase in ownership of pesticide application equipment between 2008 and 2009 (G = 32.6, $p < 0.001$).

Table 2. Population sample.

Chapter Name	Farms	Model Farmers	Group 1	Group 2
Upper Fruitland	318	2	20	20
Hogback and Shiprock	438	3	30	30
Cudei	47	1	10	10
Total in the three irrigation canal systems	803	6	60	60

Table 3. Percent of individuals (number of positive observations and relevant sample size in parentheses) who owned pesticides, pesticide safety equipment, and pesticide application equipment.

	2008	2009	2010	2011
Group 1				
Have pesticides	14.3% (5/35)	93.3% (28/30)	100.0% (33/33)	100.0% (35/35)
Locked up	60.0% (3/5)	96.4% (27/28)	93.9% (31/33)	97.1% (34/35)
Out of children's reach	80.0% (4/5)	64.3% (18/28)	97.0% (32/33)	94.3% (33/35)
Ventilation	60.0% (3/5)	89.3% (25/28)	90.9% (30/33)	94.3% (33/35)
In house	0.0% (0/5)	0.0% (0/28)	0.0% (0/33)	0.0% (0/35)
Have safety equipment	42.9% (15/35)	100.0% (30/30)	100.0% (33/33)	100.0% (35/35)
Chemical-resistant gloves	42.9% (15/35)	100.0% (30/30)	100.0% (33/33)	100.0% (35/35)
Sand	34.3% (12/35)	60.0% (18/30)	66.7% (22/33)	94.3% (33/35)
Kitty litter	2.9% (1/35)	6.7% (2/30)	6.1% (2/33)	5.7% (2/35)
Chemical-resistant boots	37.1% (13/35)	93.3% (28/30)	93.9% (31/33)	97.1% (34/35)
Protective clothing	40.0% (14/35)	80.0% (24/30)	97.0% (32/33)	100.0% (35/35)
Washed separately[a]	93.0% (13/14)	100.0% (24/24)	94.0% (30/32)	62.09% (22/35)
Have application equipment	22.9% (8/35)	90.0% (27/30)	87.9% (29/33)	60.0% (21/35)
Group 2				
Have pesticides	4.4% (2/45)	No data	76.7% (33/43)	80.5% (33/41)
Locked up	100.0% (2/2)	-	97.0% (32/33)	100.0% (33/33)
Out of children's reach	50.0% (1/2)	-	100.0% (33/33)	100.0% (33/33)
Ventilation	0.0% (0/2)	-	97.0% (32/33)	97.0% (32/33)
In house	0.0% (0/2)	-	0.0% (0/33)	0.0% (0/33)
Have safety equipment	55.6% (25/45)	-	79.1% (34/43)	87.8% (36/41)
Chemical-resistant gloves	55.6% (25/45)	-	79.1% (34/43)	87.8% (36/41)
Sand	51.1% (23/45)	-	62.8% (27/43)	73.2% (30/41)
Kitty litter	2.2% (1/45)	-	2.3% (1/43)	2.4% (1/41)
Chemical-resistant boots	55.6% (25/45)	-	72.1% (31/43)	82.9% (34/41)
Protective clothing	55.6% (25/45)	-	74.4% (32/43)	85.4% (35/41)
Washed separately[a]	100.0% (25/25)	-	100.0% (32/32)	100.0% (35/35)
Have application equipment	11.91% (5/45)	-	76.7% (33/43)	85.4% (35/41)

[a] Of those who had protective clothing.

Group 1: Maintenance of practices between 2010 and 2011 ($H_{0(1)}$). By 2010, most farm families used pesticide safety and storage practices, and these behaviors were maintained between 2010 and 2011. Availability of sand or absorbent material continued to increase between 2010 and 2011 ($G = 9.0$, $p < 0.005$), but the practice of washing protective clothing separately declined between 2010 and 2011 ($G = 10.1$, $p < 0.001$). The percent of farm families who had pesticide application equipment declined between 2010 and 2011 ($G = 7.1$, $p < 0.01$).

Group 2: Significant differences across years ($H_{A(2a)}$). We observed a significant increase across years in the percent of farm families in Group 2 who owned pesticides ($G = 75.0$, $p < 0.001$). Among those who owned pesticides, we observed significant improvements in storage practices across years: out of children's reach ($G = 7.7$, $p < 0.05$), and in a ventilated room ($G = 12.5$, $p < 0.005$). However, the sample size of those owning pesticides in 2008 was only two. The percent of farm families who owned some form of standard pesticide safety equipment increased ($G = 12.5$, $p < 0.005$), particularly chemical-resistant gloves ($G = 12.5$, $p < 0.005$), chemical-resistant boots ($G = 7.9$, $p < 0.05$), and protective clothing ($G = 9.7$, $p < 0.01$). There was a significant increase in ownership of pesticide application equipment across years ($G = 64.4$, $p < 0.001$).

Group 2: Significant differences between 2008 and 2010 years ($H_{0(2)}$). Group 2 represented the delayed intervention group; therefore, we did not predict significant differences between 2008 and 2010. However, we found numerous improved practices between these years. Significantly more farm families in Group 2 owned pesticides in 2010 than in 2008 (G = 55.3, $p < 0.001$). Among those who owned pesticides, storage practices improved: out of children's reach (G = 6.3, $p < 0.05$), and in a ventilated room G = 11.5, ($p < 0.001$). Between 2008 and 2010, we observed significant increases in the percent of farm families who owned some kind of standard pesticide safety equipment (G = 5.6, $p < 0.05$), specifically chemical-resistant gloves (G = 5.6, $p < 0.05$). There was a significant increase in ownership of pesticide application equipment between 2008 and 2010 (G = 42.3, $p < 0.001$).

Group 2: Significant differences between 2010 and 2011 years ($H_{A(2b)}$). We observed no significant differences between 2010 and 2011 in pesticide ownership and storage, pesticide safety equipment, or pesticide application equipment.

Pre/Post Tests of Knowledge about Safety Practices

Test scores improved significantly across years for both groups (table 4). Group 1 scores differed significantly between all years: 2008 and 2009 (t = 2.778, $p < 0.01$), 2008 and 2011 (t = 5.479, $p < 0.001$), and 2009 and 2011 (t = 2.531, $p < 0.05$). Group 2 scores differed significantly between 2008 and 2011 (t = 8.559, $p < 0.001$) but not between 2008 and 2010. The mean test score difference (calculated for each individual) was significantly higher in Group 2 (23.7 ±15.4, *n* = 31) than in Group 1 (15.2 ±16.1, *n* = 34, t = 2.183, $p < 0.5$).

Pre/Post Tests of Attitudes about Integrated Pest Management

Attitudes in Group 1 changed significantly across years for the statement of compatibility, both relative advantage statements, social network practices statement 2, and social communication statement 1. Table 5 shows the mean scores, and table 6 shows the statistical results; see the footnote in table 5 for the wording of the statements. Of the statements with significant changes, either across years or between years, only social network practices statement 2 scored consistently higher across years. The level of agreement declined significantly between 2009 and 2011 for all five statements, with statistically significant differences between 2009 and 2011.

The farm families in Group 2 expressed significant change, either across years or between years, in only four areas: compatibility, trialability, and both social network practice statements (tables 5 and 6). However, of the statements with significant changes, only social network practices statement 2 declined in level of agreement across years. Although only four statements were significantly different between and/or across years, contrary to Group 1, eight of the ten statements showed a general positive trend in the level of agreement.

Agricultural Yield

The yield of corn was significantly higher on treatment plots than on control plots for number of ears but not ear length (table 7). The yield of alfalfa was 41.2% greater on treatment plots than on control plots (table 7).

Table 4. Mean test scores across years for Group 1 (intervention) and Group 2 (delayed intervention).

	2008	2009	2010	2011	F[a]	p
Group 1 (*n* = 34)	57.3 ±17.2	64.9 ±18.0	-	72.4 ±11.0	14.342	<0.001
Group 2 (*n* = 31)	52.6 ±18.8	-	54.2 ±11.9	76.3 ±11.5	57.797	<0.001

[a] Repeated measures ANOVA.

Table 5. Changes in attitudes related to the theoretical framework. Values represent mean rankings on a Likert scale (±SD) for level of agreement with ten statements regarding integrated pest management.[a]

Statement of Attitude[b]	2008	2009	2010	2011
Group 1				
Compatibility	4.4 ±1.3, *n* = 29	4.9 ±1.1, *n* = 29	-	4.1 ±0.9, *n* = 31
Observability	4.2 ±1.4, *n* = 33	4.6 ±1.4, *n* = 29	-	4.5 ±1.3, *n* = 30
Trialability	3.6 ±1.3, *n* = 33	4.3 ±1.1, *n* = 29	-	3.7 ±1.0, *n* = 31
Complexity	3.2 ±1.3, *n* = 33	3.6 ±1.5, *n* = 29	-	3.6 ±1.2, *n* = 31
Relative advantage 1	4.0 ±1.4, *n* = 31	4.9 ±0.9, *n* = 29	-	4.1 ±1.0, *n* = 31
Relative advantage 2	4.9 ±1.0, *n* = 33	5.1 ±1.1, *n* = 29	-	4.4 ±0.8, *n* = 31
Social network practices 1	4.4 ±1.1, *n* = 32	4.8 ±1.0, *n* = 29	-	4.8 ±0.4, *n* = 31
Social network practices 2	3.4 ±1.5, *n* = 32	3.6 ±1.4, *n* = 29	-	4.3 ±1.0, *n* = 30
Social network commun. 1	3.7 ±1.6, *n* = 32	3.9 ±1.2, *n* = 29	-	2.5 ±1.0, *n* = 30
Social network commun. 2	4.5 ±1.4, *n* = 32	5.1 ±0.9, *n* = 29	-	4.0 ±0.9, *n* = 30
Group 2				
Compatibility	3.7 ±1.2, *n* = 41	-	3.9 ±1.5, *n* = 40	4.7 ±1.1, *n* = 31
Observability	4.5 ±1.3, *n* = 44	-	4.3 ±1.2, *n* = 41	4.7 ±1.1, *n* = 32
Trialability	3.1 ±1.2, *n* = 44	-	3.5 ±1.4, *n* = 41	3.6 ±1.3, *n* = 34
Complexity	3.6 ±1.3, *n* = 44	-	3.2 ±1.4, *n* = 41	3.4 ±1.1, *n* = 33
Relative advantage 1	3.4 ±1.4, *n* = 43	-	4.0 ±1.2, *n* = 41	4.0 ±1.1, *n* = 34
Relative advantage 2	4.4 ±1.0, *n* = 44	-	4.7 ±0.9, *n* = 41	4.8 ±0.9, *n* = 34
Social network practices 1	4.1 ±1.3, *n* = 44	-	4.8 ±0.9, *n* = 41	4.8 ±1.0, *n* = 33
Social network practices 2	4.2 ±1.3, *n* = 44	-	4.0 ±1.3, *n* = 41	3.6 ±1.1, *n* = 33
Social network commun. 1	3.0 ±1.3, *n* = 44	-	3.4 ±1.5, *n* = 41	3.4 ±1.5, *n* = 33
Social network commun. 2	4.7 ±1.3, *n* = 44	-	5.0 ±0.9, *n* = 41	5.1 ±0.6, *n* = 34

[a] Likert scale: 1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree.

[b] Compatibility (Q37): "Integrated pest management techniques work well with the other methods I use for farming."
Observability (Q38): "It is simple to watch others applying pesticides."
Trialability (Q39): "It is easy for me to try using pesticides."
Complexity (Q40): "Pesticide application is too complicated for me to learn to do it correctly."
Relative advantage 1 (Q41): "Pesticide application is better than other methods I have used to kill weeds, insects, and gophers."
Relative advantage 2 (Q45): "Using pesticides will make my farm more productive."
Social network practices 1 (Q42): "I know other farmers who agree that using pesticides is a good thing for our farms."
Social network practices 2 (Q43): "Other farmers think that using pesticides does not fit with the traditional ways of farming."
Social network communication 1 (Q44): "Farmers spend time talking about using pesticides with other farmers."
Social network communication 2 (Q46): "There is someone I can go to for help or to ask questions about using pesticides on my farm."

Conclusions

The model farmer program, based on a theory of dissemination that was culturally similar to the traditional ways of communicating about farming in these communities, was successful in changing knowledge and attitudes about pesticide use and in improving safety behaviors. A total of 120 farm families were exposed to the training, although not all farmers took all the tests or were available to have walk-through observations conducted on their farms at the appropriate times. Research results show that an intervention

Table 6. Significant differences in changes in attitudes related to the theoretical framework (see table 5).

	Across Years (2008-2011)		Between Years					
			2008 and 2009		2008 and 2011		2009 and 2011	
Statement of Attitude	H[a]	p	U[b]	p	U[b]	p	U[b]	p
Group 1								
Compatibility	12.611	<0.005	-	-	-	-	225.0	<0.001
Trialability	-	-	-	-	-	-	310.0	<0.05
Relative advantage 1	10.792	<0.005	280.5	< 0.05	-	-	247.5	<0.005
Relative advantage 2	15.542	<0.001	-	-	281.5	<0.001	225.5	<0.001
Social network practices 2	6.483	<0.05	-	-	314.5	<0.05	-	-
Social network commun.	15.392	<0.001	-	-	297.0	<0.005	179.0	<0.001
Group 2								
Compatibility	11.596	<0.005	-	-	338.5	<0.001	437.0	<0.05
Trialability	-	-	-	-	554.5	<0.05	-	-
Social network practices 1	6.525	<0.05	677.5	< 0.05	530.5	<0.05	-	-
Social network practices 2	6.712	<0.05	-	-	480.0	<0.01	-	-

[a] Kruskal-Wallis tests.
[b] Mann-Whitney U-tests.

Table 7. Yield of white corn (mean number of ears and mean ear length ±SD) and alfalfa (mean kg m^{-2} ±SD) with and without treatment (fertilizer plus herbicides), 2010-2011.

Crop	*n*	Treatment	Control	Increase	U[a]	p
Corn (mean number of ears)	11	7.5 ±2.5	4.8 ±1.4	56.3%	10.5	0.007
Corn (mean ear length)	11	12.5 ±1.2	11.9 ±2.1	5.0%	NS	-
Alfalfa (mean kg m^{-2})	16	2.4 ±1.0	1.7 ±1.3	41.2%	67.5	0.023

[a] Mann-Whitney U-tests (NS = not significant).

based on behavior change theory that is culturally appropriate can impact knowledge, attitudes, and behavior (Arcury et al., 2010; Flocks et al., 2007). Farmers on the Navajo Nation stated that the best way to learn farming practices was from their elders and neighbors.

We saw significant changes in pesticide use, storage behaviors, and safety and pesticide application ownership. We saw these changes in both Group 1 and Group 2, and Group 1 maintained changes in the non-intervention years. We also saw significant changes in knowledge in both groups. Changes remained in Group 1 in the maintenance phase of the intervention. Attitudes about social network communication and support were significantly changed during the study for both groups. Group 2 showed more improvement in attitudes, with the exception of attitudes about social network practices: fewer farmers felt that pesticides were compatible with traditional ways of farming in 2011 than at the beginning of the intervention.

Since the Worker Protection Standard (WPS) was enacted in 1992 to reduce the risk of pesticide exposure (USEPA, 1992), pesticide safety training has been mandated on farms. Since that time, specific recommendations have been made to improve WPS enforcement and compliance, and ensure that materials are language-appropriate regardless of work site or worker status (Arcury et al., 1999). It has been stated that WPS training increases pesticide knowledge among farmworkers, but the extent to which this knowledge is put into practice has not been reported (McCauley et al., 2004b).

Researchers have found that oral training, or training using very simple printed materials, is more effective than written materials because of language barriers (Samples et al., 2009; Arcury et al., 2009). In a recent review, Arcury et al. (2010) discussed the challenges of training farmers whose language, literacy, financial limitations, work beliefs, and health beliefs impact their willingness to engage in training programs. They advocate for the development of safety programs that are conceptually within contemporary health education theory and practice and that include agricultural workers on the teams developing the training programs. The intervention described here meets all of these criteria.

There is evidence that one of the motivators for behavior change is risk perception. Cabrera and Leckie (2009) measured perceived risk of pesticide exposure among farmworkers in California's Salinas Valley and found that the farmworkers considered pesticide exposure to be the second most risky behavior after drinking and driving. These participants received training in how to minimize the risk, but the training did not impact their behavior. Our study used a culturally relevant theory that had as one of its tenets the relevance of the intervention for the farm families. We did not measure perceived risk, but we did measure change in the behaviors that reduce risk.

Vela-Acosta et al. (2002, 2005) conducted one of the most extensive studies among Latino farmworkers. A flip chart was used, and all instruction was given in Spanish. In their study, evidence suggested that the attitudes, beliefs, and pesticide knowledge of farmworkers influenced their safety-related behavior changes, such as wearing protective clothing or safe pesticide storage. Our training was primarily face-to-face with innovative training methods, such as the use of demonstration plots, which made the training very interactive and engaging. We found that our training sessions were not well attended; however, an analysis (not reported here) suggested that farmers who attended the training sessions and received training from a model farmer did not fare differently from those who only were trained by a model farmer.

Many researchers advocate for training content and delivery that is culturally appropriate (Farquhar et al., 2009; Kreuter et al., 2002; Perry et al., 1999). For some cases where no changes are seen, these researchers suggest that adoption of safety behaviors may have been inconsistent with traditional behaviors and may not have been well matched to cultural beliefs. We believe that our program was successful because it was culturally appropriate, it was developed with community partners, and it included locally influential farmers as trainers.

The literature on pesticide training programs suggests that many educational interventions produce inconsistent improvements in knowledge and behavior, such as safe storage practices or wearing protective clothing (Liebman et al., 2007; Arcury et al., 2009; Vela-Acosta et al., 2005; Quandt et al., 2013). Interventions that show positive effects use local trainers such as local *promotoras* or lay health promoters to educate the farm workers. Using these locally respected individuals to deliver the education (Eng et al., 1997; Kegler et al., 2003) is similar to our model farmer concept.

However, the three most recently published studies of pesticide training using lay health workers met with limited success. One reason was fidelity to the intervention. Liebman et al. (2007) developed a six-hour curriculum for *promotoras* who made home visits to talk about pesticide safety. For the families visited by one *promotora*, the researchers found increases in knowledge about the use of pesticides, routes of exposure, why children are vulnerable, symptoms of pesticide poisoning, and storing pesticides out of the reach of children. But there were problems of standardization of the educational curriculum among the *promotoras* in the study and concerns about the dual role of the *promotoras* as teachers and data collectors. Their findings could not be replicated. In our study, we adopted a very structured curriculum for the model farmers, and other research team members collected the data. The model farmers were only involved in training.

Arcury et al. (2009) also evaluated the effectiveness of a *promotora*-based program for teaching women in Latino farmworker families about pesticide safety. A randomized controlled study assessed a pesticide safety program as compared with a nutrition education program in the control group. Participants in the intervention group reported having received the pesticide education and had greater recognition of the key messages. However, their knowledge, pesticide exposure behaviors, and integrated pest management behaviors did not change. Using the experience and educational content from the Liebman et al. (2007) and Arcury et al. (2009) interventions, Quandt et al. (2013) developed an educational program, *La Familia Sana*, comprising six lessons that were delivered in five home visits. Significant changes in knowledge and exposure behaviors were observed. Even though these studies showed limited success, the researchers concluded, as we have, that lay health promoters with limited training and supervision can implement education programs that lead to changes in pesticide safety knowledge and practices.

Prior research has shown that community participation in the development and implementation of training programs has a higher success rate (Arcury et al., 2009; Bradman et al., 2009; Arcury et al., 2001; O'Fallon and Dearry 2002), although researchers have documented challenges in implementing and maintaining interventions that are developed and delivered through a community-university partnership. Our intervention, which was developed, implemented and evaluated in this manner, faced many challenges, including withdrawals from the program, drought, inconsistent attendance, participation by multiple family members, and contamination. Community interventions suffer from lower than optimal exposure to the training sessions. In our study, we had hoped that the farmers would sustain their gains in knowledge and positive attitudes during the maintenance period. However, while they generally maintained their safety behaviors, there are indications that there was regression in attitudes during Group 1's maintenance period. At the end of their intervention period, these farmers agreed that pesticide use was compatible with and more advantageous than current methods of farming. However, over the maintenance period, the level of agreement declined significantly. This may indicate a need for booster training or continued support from the model farmers, even if not at the same level of intensity as the original training.

The project team received requests from farmers for intermittent training, so pesticide training has been included in the Shiprock Ag Days in the spring and fall of each year since 2011. Further, during the same period, fewer families owned pesticide equipment in 2011 than in 2009. We are unable to discern whether the families who dispensed with their pesticide application equipment were those who saw less benefit in using pesticides. In addition, some of the farmers, living at the end of the ditches, experienced severe drought during several years and were not able to farm their fields. Vela-Acosta et al. (2009) concluded that there is a need for long-term, sustained intervention programs to support safe use of pesticides, and our study supports these conclusions.

This intervention was developed through the collaboration of a stakeholder group of community farmers and ranchers with university researchers and cooperative extension agents. Members of the stakeholder group agreed that the traditional ways of learning about farming could be a foundation for an intervention that would teach farmers new skills. At the time that the study began, there was very little use of pesticides on the Navajo Nation. The goal of the stakeholder group was to develop a training intervention that would ensure that the anticipated increased use of pesticides would be accompanied by safe practices and adequate knowledge. Stakeholder group members also understood that the cost of pesticides would be a deterrent for farmers unless they could be shown that the crop yields would increase through the use of safe practices. The stakeholder group used demonstration plots on neighborhood farms as part of the intervention.

The farmers and ranchers are now disseminating the results of this intervention throughout the Shiprock area at local gatherings and fairs, Ag Day events, and chapter meetings. The 120 farmers who participated in this intervention are now qualified to train other farmers to use pesticides safely and in a way that will help to increase the yields of the farms in their communities.

Limitations

As with any community-based research study, there are limitations that could have implications for the success of the intervention. They include contamination between groups, lack of information about who administered the pesticides, and the unlikelihood that this intervention can be replicated exactly as it has been designed.

Some unexpected findings suggested that the tight family groupings led to some contamination between the groups. For example, in Group 2, significantly more farm families owned pesticides in 2010 than in 2008, even though their knowledge base did not change during the same period. We were unable to divide the groups in a manner that eliminated the possibility that relatives were in different groups.

As we noted, we were working with farm families, rather than individuals. Because of this, we have no information about who actually applied the pesticides and which family members participated in the intervention on a regular basis at their farms. However, because farming is a family business in these communities, we believe that educating the entire family is very important.

Because this study was conducted in one Native American nation within relatively homogenous communities, it is unlikely that an exact replication could be implemented. We believe it would not be appropriate to do so (Burhansstipanov, 2000). However, the lessons we learned about using locally respected farmers (model farmers) to teach others can be applied to other populations, and these lessons are consistent with other studies that have used local health workers (Eng et al., 1997; Kegler et al., 2003). The importance of using a culturally appropriate theory has been validated; choosing the applicable theory is a local endeavor. The evidence of this study suggests that, in using a very structured training program for the model farmers, we overcame problems with fidelity that were found in other pesticide training interventions.

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References

Arcury, T. A., Austin, C. K., Quandt, S. A., & Saavedra, R. (199). Enhancing community participation in intervention research: Farmworkers and agricultural chemicals in North Carolina. *Health Educ. Behav., 26*(4), 563-578.

Arcury, T. A., McCauley, L., & Quandt, S. A. (2000). Farmworkers and pesticides: Community-based research. *Environ. Health Perspect., 108*(8), 787-792. http://dx.doi.org/10.1289/ehp.00108787.

Arcury, T. A., Cravey, A. J., Elmore, R. C., Quandt, S. A., & Russell, G. B. (2001). Farmworker reports of pesticide safety and sanitation in the work environment. *American J. Ind. Med., 39*(5), 487-498. http://dx.doi.org/10.1002/ajim.1042.

Arcury, T. A., Quandt, S. A., & Russell, G. B. (2002). Pesticide safety among farmworkers: Perceived risk and perceived control as factors reflecting environmental justice. *Environ. Health Perspect., 110*(supp. 2), 233-240.

Arcury, T. A., Marín, A., Snively, B. M., Hernández-Pelletier, M., & Quandt, S. A. (2009). Reducing farmworker residential pesticide exposure: Evaluation of a lay health advisor intervention. *Health Promot. Practice, 10*(3), 447-455. http://dx.doi.org/10.1177/1524839907301409.

Arcury, T. A., Estrada, J. M., & Quandt, S. A. (2010). Overcoming language and literacy barriers in safety and health training of agricultural workers. *J. Agromed., 15*(3), 236-248. http://dx.doi.org/10.1080/1059924X.2010.486958.

ASA. (2006). Certified crop advisory certification. Madison, Wisc.: American Society of Agronomy. Retrieved from https://www.certifiedcropadviser.org.

Austin, C., Arcury, T. A., Cabrera, L. F., Preisser, J. S., Quandt, S. A., & Saavedra, R. M. (2001). Training farmworkers about pesticide safety: Issues of control. *J. Health Care Poor Underserved, 12*(2), 236-249. http://dx.doi.org/10.1353/hpu.2010.0744.

Bradman, A., Salvatore, A. L., Boeniger, M., Castorina, R., Snyder, J., Barr, D. B., Jewell, N. P., Kavanagh-Baird, G., Striley, C., & Eskenazi, B. (2009). Community-based intervention to reduce pesticide exposure to farmworkers and potential take-home exposure to their families. *J. Expo. Sci. Environ. Epidemiol., 19*(1), 79-89.

Burhansstipanov, L. (2000). Native American health issues: Lessons learned from community-based interventions, and overview of Native cancer projects. Presentation 06-12. Retrieved from www.minority.unc.edu/institute/2000/materials/slides/LindaBurhansstipanov-2000.

Cabrera, N. L., & Leckie, J. O. (2009). Pesticide risk communication, risk perception, and self-protective behaviors among farmworkers in California's Salinas Valley. *Hispanic J. Behav. Sci., 31*(2), 258-272. http://dx.doi.org/10.1177/0739986309331877.

CDSL. (2000). *How People Learn: Brain, Mind, Experience, and School* (expanded ed.). Committee on Developments in the Science of Learning. Washington, D. C.: National Academies Press.

Cornwall, A., & Jewkes, R. (1995). What is participatory research? *Soc. Sci. Med., 41*(12), 1667-1676. http://dx.doi.org/10.1016/0277-9536(95)00127-S.

Crandall, C. S., Fullerton, L., Olson, L., Sklar, D. P., & Zumwalt, R. (1997). Farm-related injury mortality in New Mexico 1980-1991. *Accid. Anal. Prev., 29*(2), 257-261. http://dx.doi.org/10.1016/S0001-4575(96)00066-8.

DeRoo, L. A., & Rautiainen, M. S. (2000). A systematic review of farm safety interventions. *American J. Prev. Med., 18*(4 supp.), 51-62.

Dosemeci, M., Hoover, R. N., Blair, A., Figgs, L. W., Devesa, S., Grauman, D., & Fraumeni Jr., J. F. (1994). Farming and prostate cancer among African-Americans in the southeastern United States. *J. Natl. Cancer Inst., 86*(22), 1718-1719. http://dx.doi.org/10.1093/jnci/86.22.1718.

Duran, B. M., & Duran, E. F. (1999). Assessing needs, planning, and implementation of health promotion, disease prevention among American Indian and Alaska Native population groups: Towards a postcolonial approach. In R. Kline, & R. Huff (Eds.), *Promoting Health in Multicultural Populations* (pp. 291-312).Thousand Oaks, Cal.: Sage Publications.

Eng, E., Parker, E., & Harlan, C. (1997). Lay health advisor intervention strategies: A continuum from natural helping to paraprofessional helping. *Health Educ. Behav., 24*(4), 413-417.

http://dx.doi.org/10.1177/109019819702400402.
Farquhar, S. A., Samples, J., Davis, S., Abernathy, M., McCauley, L., Cuilwik, N., & Shadbeth, N. (2008). Promoting the occupational health of indigenous farmworkers. *J. Immigr. Minority Health, 10*(3), 269-280.
Farquhar, S. A., Goff, N. M., Shadbeh, N., Samples, J., Ventura, S., Sanchez, V., Rao, P., & Davis, S. (2009). Occupational health and safety status of indigenous and Latino farmworkers in Oregon. *J. Agric. Safety Health, 15*(1), 89-102.
Flannery, D., Adame, J., & Portis, M. (2003). Outreach to migrant farm workers through a pesticide safety initiative. *California J. Health Promot., 1*(2), 13-35.
Flocks, J., Clarke, L., Albrecht, S., Bryant, C., Monaghan, P., & Baker, H. (2001). Implementing a community-based social marketing project to improve agricultural worker health. *Environ. Health Perspect., 109*(supp. 3), 461-468.
Flocks, J., Monaghan, P., Albrecht, S., & Bahena, A. (2007). Florida farmworkers' perceptions and lay knowledge of occupational pesticides. *J. Comm. Health, 32*(3), 181-194. http://dx.doi.org/10.1007/s10900-006-9040-6.
Fullerton, L., Crandall, C., Olson, L., Sklar, D., & Zumwalt, R. (1995). Occupational injury mortality in New Mexico. *Ann. Emergency Med., 26*(4), 447-454. http://dx.doi.org/10.1016/S0196-0644(95)70113-3.
Garcia, J. G., Metheny Dresser, K. S., & Zerr, A. D. (1996). Respiratory health of Hispanic migrant farm workers in Indiana. *American J. Ind. Med., 29*(1), 23-32. http://dx.doi.org/10.1002/(SICI)1097-0274(199601)29:1<23::AID-AJIM4>3.0.CO;2-#.
Goldenar, L. M., & Schulte, P. A. (1996). Methodological issues for intervention research in occupational health and safety. *American J. Ind. Med., 29*(4), 289-294. http://dx.doi.org/10.1002/(SICI)1097-0274(199604)29:4<289::AID-AJIM2>3.0.CO;2-K.
Goodman, R. M., McLeroy, K., Speers, M. A., Fawcett, S., Kegler, M. Parker, E., Smith, S. R., Sterling, T. D., & Wallerstein, N. (1998). Identifying and defining the dimensions of community capacity to provide a basis for measurement. *Health Educ. Behav., 25*(3), 258-278. http://dx.doi.org/10.1177/109019819802500303.
Green, L. W., & Mercer, S. L. (2001). Can public health researchers and agencies reconcile the push from funding bodies and the pull from communities? *American J. Public Health, 91*(12), 1926-1929. http://dx.doi.org/10.2105/AJPH.91.12.1926.
Green, L. W., George, M. A., Daniel, M., Frankish, C. J., Herbert, C. P., Bowie, W. R., & O'Neil, M. (1997). Background on participatory research. In D. Murphy, M. Scammell, & R. Sclove (Eds.), *Doing Community-Based Research: A Reader* (pp. 53-66). Amherst, Mass.: The Loka Institute.
Green, L. W., George, M., Daniel, M., Frankish, C., Herbert, C., Bowie, W., & O'Neill, M. (2003). Guidelines for participatory research in health promotion. In M. Minkler, & N. Wallerstein (Eds.), *Community-Based Participatory Research for Health* (pp. 419-428). San Francisco, Cal.: Jossey-Bass.
Harrison, K. M., & Iverson, M. J. (1975). Agricultural pesticides: An instructional unit for teachers of adult vocational education in agriculture. Frankfort, Ky.: Kentucky State Department of Education. Retrieved from http://files.eric.ed.gov/fulltext/ED112253.pdf.
Helitzer, D., Willging, C., Hathorn, G., & Benally, J. (2009a). Building community capacity for agricultural injury prevention in a Navajo community. *J. Agric. Safety Health, 15*(1), 19-35. http://dx.doi.org/10.13031/2013.25413.
Helitzer, D., Willging, C., Hathorn, G., & Benally, J. (2009b). Using logic models in a community-based agricultural injury prevention project. *Public Health Reports, 124*(supp. 1), 63-73.
Israel, B. A., Schulz, A. J., Parker, E. A., & Becker, A. B. (1998). Review of community-based research: Assessing partnership approaches to improve public health. *Ann. Rev. Public Health, 19*, 173-202. http://dx.doi.org/10.1146/annurev.publhealth.19.1.173.
Kegler, M. C., Stern, R., Whitecrow-Ollis, S., & Malcoe, L. H. (2003). Assessing lay health advisor activity in an intervention to prevent lead poisoning in Native American children. *Health Promot. Practice, 4*(2), 189-196. http://dx.doi.org/10.1177/1524839902250774.

Kent, R., Belitz, K., Altmann, A. J., Wright, M. T., & Mendez, G. O. (2005). Occurrence and distribution of pesticide compounds in surface waters of the Santa Ana basin, California, 1998-2001. USGS Scientific Investigations Report 2005-5203. Reston, Va.: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/sir/2005/5203/sir2005-5203.pdf.

Kreuter, M. W., Lukwago, S. N., Bucholtz, D. C., Clark, E. M., & Sanders-Thompson, V. (2002). Achieving cultural appropriateness in health promotion programs: Targeted and tailored approaches. *Health Educ. Behav., 30*(2), 133-146. http://dx.doi.org/10.1177/1090198102251021.

Liebman, A. K., Juárez, P. M., Leyva, C., & Corona, A. (2007). A pilot program using *promotoras de salud* to educate farmworker families about the risk from pesticide exposure. *J. Agromed., 12*(2), 33-43. http://dx.doi.org/10.1300/J096v12n02_04.

MacFarlane, E., Chapman, A., Benke, G., Meaklim, J., Sim, M., & McNeil, J. (2008). Training and other predictors of personal protective equipment use in Australian grain farmers using pesticides. *Occup. Environ. Med., 65*(2), 141-146. http://dx.doi.org/10.1136/oem.2007.034843.

McCauley, L. A., Ebbert, C., Higgins, G., Lasarev, M. R., Muniz, J., Phillips, J., & Rothlein, J. (2001). Work characteristics and pesticide exposures among migrant agricultural families: A community-based research approach. *Environ. Health Perspect., 109*(5), 533-553. http://dx.doi.org/10.1289/ehp.01109533.

McCauley, L. A., Lasarev, M. R., Scherer, A., & Shapiro, S. E. (2004). Assessing pesticide safety knowledge among Hispanic migrant farmworkers in Oregon. *J. Agric. Safety Health, 10*(3), 177-186. http://dx.doi.org/10.13031/2013.16474

McGwin Jr., G., Enochs, R., & Roseman, J. (2000). Increased risk of agricultural injury among African-American farm workers form Alabama and Mississippi. *American J. Epidemiol., 152*(7), 640-650. http://dx.doi.org/10.1093/aje/152.7.640.

Mills, P. K., & Yang, R. (2005). Breast cancer risk in Hispanic agricultural workers in California. *Intl. J. Occup. Environ. Health, 11*(2), 123-131. http://dx.doi.org/10.1179/oeh.2005.11.2.123.

Minkler, M., & Wallerstein, N. (2010). *Community-Based Participatory Research for Health: From Process to Outcomes.* San Francisco, Cal.: Jossey-Bass.

NASD. (2014). National Agriculture Safety Database. Cincinnati, Ohio: NIOSH. Retrieved from http://nasdonline.org/browse/178/chemicals-pesticides.html.

O'Fallon, L. R., & Dearry, A. (2002). Community-based participatory research as a tool to advance environmental health sciences. *Environ. Health Perspect., 110*(supp. 2), 155-159. http://dx.doi.org/10.1289/ehp.02110s2155.

Omishakin, M. A. (1994). A survey of pesticides containers management among African-American agricultural workers in mid-delta of Mississippi, USA. *J. Royal Soc. Health, 114*(2), 81-82. http://dx.doi.org/10.1177/146642409411400207.

Palis, F. G., Flor, R. J., Hossain, M., & Warburon, H. (2006). Our farmers at risk: Behavior and belief system in pesticide safety. *J. Public Health, 28*(1), 43-48. http://dx.doi.org/10.1093/pubmed/fdi066.

Parker, E. A., Eng, E., Laraia, B., Ammerman, A., Dodds, J., Margolis, L., & Cross, A. (1998). Coalition building for prevention: Lessons learned from the North Carolina community-based public health initiative. *J. Public Health Mgmt. Practices, 4*(2), 25-36.

Perry, M. J., Marbella, A., & Layde, P. M. (1999). Association of pesticide safety beliefs and intentions with behaviors among farm pesticide applicators. *American J. Health Promot., 14*(1), 18-21. http://dx.doi.org/10.4278/0890-1171-14.1.18.

Perry, M. J., Layde, P. M., & Marbella, A. (2000). Association of pesticide safety knowledge with beliefs and intentions among farm pesticide applicators. *J. Occup. Environ. Med., 42*(2), 187-193. http://dx.doi.org/10.1097/00043764-200002000-00017.

Quandt, S. A., Arcury, T. A., Austin, C. K., & Cabrera, L. F. (2001a). Preventing occupational exposure to pesticides: Using participatory research with Latino farmworkers to develop an intervention. *J. Immigr. Health, 3*(2), 85-96. http://dx.doi.org/10.1023/A:1009513916713.

Quandt, S. A., Arcury, T. A., & Pell, A. I. (2001b). Something for everyone? A community and academic partnership to address farmworker pesticide exposure in North Carolina. *Environ. Health*

Perspect., 109(supp. 3), 435-441. http://dx.doi.org/10.1289/ehp.01109s3435.
Quandt, S. A., Grzywacz, J. C., Talton, J. W., Trejo, F., Tapia, J., D'Agostino Jr., R. B., Mirabelli, M. C., & Arcury, T. A. (2013). Evaluating the effectiveness of a lay health promoter-led, community-based participatory pesticide safety intervention with farmworker families. *Health Promot. Practice, 14*(3), 425-432. http://dx.doi.org/10.1177/1524839912459652.
Rao, P., Gentry, A. L., Quandt, S. A., Davis, S., Sniverly, B. M. & Arcury, T. A. (2006). Pesticide safety behaviors in Latino farmworker family households. *American J. Ind. Med., 49*(), 271-280. http://dx.doi.org/10.1002/ajim.20277.
Robson, M., Schneider, D., Marentes, C., & Villanueva, E. (2001). Field conditions for agricultural workers in the El Paso, Texas, region. *J. Environ. Occup. Health Policy, 11*(2), 141-148.
Rogers, E. M. (1995). *Diffusion of Innovations* (5th ed.). New York, N.Y.: Free Press.
Rogers, E. M., & Kincaid, D. L. (1981). *Communication Networks: Toward a New Paradigm for Research.* New York, N.Y.: Free Press.
Rosskam, E. (2001). Participatory/problem-based methods and techniques for training in health and safety. *J. Environ. Occup. Health Policy, 11*(3), 215-227.
Salazar, N. K., McCauley, L. A., Napolitano, M., & Scherer, J. A. (2004). Hispanic adolescent farmworkers' perceptions associated with pesticide exposure. *Western J. Nurs. Res., 26*(2), 146-166. http://dx.doi.org/10.1177/0193945903259579.
Samples, J., Bergstad, E. A., Ventura, S., Sanchez, V., Farquhar, S. A., & Shadbeh, N. (2009). Pesticide exposure and occupational safety training of indigenous farmworkers in Oregon. *American J. Public Health, 99*(supp. 3), 581-584.
Schenker, M. B., Orenstein, M. R., & Samuels, S. J. (2002). Use of protective equipment among California farmers. *American J. Ind. Med., 42*(5), 455-464. http://dx.doi.org/10.1002/ajim.10134.
Stallones, L., & Sweitzer, K. (1999). Fatal head injuries among Hispanic farm workers and farmers in Colorado, 1983-1992. *J. Agric. Safety Health, 5*(2), 155-169. http://dx.doi.org/10.13031/2013.5680.
Strong, L. L., Koepsell, T. D., Meischke, H., & Thompson, B. (2008). Factors associated with pesticide safety practices in farmworkers. *American J. Ind. Med., 51*(1), 69-81. http://dx.doi.org/10.1002/ajim.20519.
USEPA. (1992). 40 CFR, Part 170: Worker protection standard. Washington, D.C.: U.S. Environmental Protection Agency.
Vela-Acosta, M. S., Bigelow, P., & Buchan, R. (2002). Assessment of occupational health and safety risks of farmworkers in Colorado. *American J. Ind. Med. 42*(supp. 2), 19-27. http://dx.doi.org/10.1002/ajim.10064.
Vela-Acosta, M. S., Chapman, P., Begelow, P. L., Kennedy, C., & Buchan, R. M. (2005). Measuring success in a pesticide risk reduction program among migrant farmworkers in Colorado. *American J. Ind. Med., 47*(3), 237-245. http://dx.doi.org/10.1002/ajim.20136.
Vela-Acosta, M. S., Sechrest, L., & Chen, M. K. (2009). Farmworkers at the border: A bilingual initiative for occupational health and safety. *Public Health Rep., 124*(supp. 1), 143-151.
Wallerstein, N. M., & Bernstein, E. (1994). Introduction to community empowerment, participatory education, and health. *Health Educ. Behav., 21*(2), 141-268. http://dx.doi.org/10.1177/109019819402100202.
Warwick, L., Meister, J., Wood, A., & de Zapien, J. (1992). Evaluation of a peer health worker prenatal outreach and education program for Hispanic farm worker families. *J. Comm. Health, 17*(1), 13-26. http://dx.doi.org/10.1007/BF01321721.
Weber, J. (2002). Training trainers to protect America's tribal communities against pesticide illnesses and injuries. *Western Center for Agricultural Health and Safety News, 12*(1), 1-3. Davis, Cal.: WCAHS. Retrieved from http://nasdonline.org/newsletters/WCAHS/AHSFall02Rev.pdf.