Farm Pesticides

Outcomes of a Randomized Controlled Intervention to Reduce Risks

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Background: In response to the multiple health risks that farm pesticide applicators experience and the need for controlled trials to evaluate prevention programs, this study tested the effects of a small-group educational intervention designed to increase personal protective equipment (PPE) use and to reduce direct pesticide exposure.

Design: A randomized controlled design was used with random selection of participants, random assignment to intervention and control groups, and baseline and postintervention assessments.

Setting/participants: Four hundred Wisconsin dairy farmers certified to apply pesticides to field crops were recruited to participate over a 1-year evaluation period.

Intervention: Three-hour educational sessions were conducted with approximately 100 randomly assigned participants. Sessions targeted four educational messages: (1) existing evidence of excess cancers among farmers, (2) simulation of pesticide exposure presented through slide show and description, (3) feedback of self-reported data collected from the farmers reporting on frequency of exposure and gear use, and (4) cognitive behavioral strategies that can be adopted to reduce pesticide hazards.

Main outcome measures: A change in use of required protective equipment use during application and self-reported dermal exposure were evaluated in the control and intervention groups postintervention.

Results: Six-month postintervention analyses showed that an educational intervention had significant effects on the use of gloves and gear during the most recent application and an actual reduction in the total number of pesticides used. However, the intervention did not have a significant impact on achieving full PPE compliance nor in reducing the amount of self-reported dermal pesticide exposure during the most recent application reported by applicators.

Conclusions: This one-time educational intervention successfully increased protective equipment use. However, more-intensive programs are needed to achieve greater reductions in personal pesticide exposure. (Am J Prev Med 2003;24(4):310–315) © 2003 American Journal of Preventive Medicine

Introduction

The acute health effects of occupational pesticide exposure have been well documented, and information on links between pesticide exposure and chronic diseases continues to emerge.[1] However, relatively little is known about the knowledge and health beliefs of applicators that influence precautionary pesticide handling or about how to develop preventive interventions that effectively reduce hazardous occupational exposures. In accordance with Environmental Protection Agency (EPA) guidelines, all states administer training and certification programs that limit the use of restricted pesticides to individuals who have successfully completed a certification course and written examination.[2] The effectiveness of certification programs and sales monitoring in preventing environmental contamination is evaluated in most states through periodic tests of groundwater and wells. Yet virtually no follow-up occurs regarding the safe handling practices taught during certification. For example, in many states re-certification is issued to private applicators every 5 years through completion of continuing education credits or through written re-examination. Since periodic monitoring or site visits remain infeasible, responsibility for safe handling is left to the applicator.

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Prior work with dairy farmers indicates that precautionary handling is not routinely practiced when applying pesticides in farm settings.[3,4] In one study, protective-gear use practices were compared to the specific personal protective equipment requirements listed on the label of each chemical to determine the percentages of full compliance (used all recommended gear during application), partial compliance (used some gear during application), and noncompliance (used no gear during application).[5] Of the three most common pesticides used (dicamba, atrazine, and cyanazine), the proportions of farmers who fully complied with the gear recommendations were 8.8%, 8.6%, and 2.5%, respectively. For those same pesticides, the proportions using none of the gear recommended were 56.9%, 38.6%, and 47.5%, respectively.

A prior study on the influence of pesticide safety knowledge, beliefs, and intentions found that knowledge levels were positively related to intentions, beliefs and self-efficacy to use personal protective gear, but not significantly related to risk perceptions and peer norms concerning pesticide safety.[6] Another study of psychosocial predictors and precautionary behavior found peer safety norms, behavioral intentions, risk perceptions of cancer and other health risks, and postsecondary education were each positively associated with glove use during application.[7] In this study, interactions between pesticide safety knowledge and postsecondary education, beliefs, and intentions were found for use of both glove and other protective gear.

Few studies to date have tested preventive interventions to reduce pesticide exposure hazards. A systematic review of the effectiveness of interventions in reducing pesticide overexposure and poisoning found that of the 17 studies identified, the majority were small field tests of protective equipment involving <20 workers, and most of the exposure techniques evaluated were not tested in actual worksite programs.[8] No studies were identified that described prevention programs on pesticide poisonings; most measured the effectiveness of protective equipment or handling methods on exposure to pesticides by measurements of pesticides penetrating protective equipment or entering the body. Results of a Minnesota countywide educational intervention that targeted individual applicators, county physicians, elementary school youth, and extension agents showed modest increases in glove and other protective equipment use in the intervention group.[9] Although the study was conducted a decade ago, few studies have followed in testing preventive educational approaches at the community level.

In response to the multiple health risks that farm pesticide applicators experience and the need for controlled trials to evaluate prevention programs, this study used a randomized controlled design to test the effects of a small-group educational intervention designed to increase personal protective equipment use and to decrease direct pesticide exposure.

Methods

Study Design

In winter 1997, a total of 540 private pesticide applicators were randomly selected for telephone screening to determine their current pesticide application status and their willingness to participate in a study on farm health and pesticide safety. Active applicators were randomly assigned to the intervention or control condition. They were administered a baseline assessment at the start of the application season to determine pesticide handling practices as well as knowledge and beliefs regarding safe application. During the subsequent winter season, the intervention group received a one-session intensive workshop on pesticide risk reduction, while the control group attended the standard re-certification meeting. At the beginning of the following pesticide application season, the intervention and control groups were administered a follow-up assessment to determine changes in handling practices.

Setting/Participants

Private dairy farmers residing in a geographic area composed of six adjacent counties in Wisconsin were contacted by telephone for interview. This geographic area was targeted due to its ranking as the agricultural district with the highest reported herbicide usage in the state. Respondents were randomly selected from a list of all certified pesticide applicators residing in the target area. The designated sampling unit was the individual farm owner, and respondents were selected randomly using a PC-based random number generator (SPSS Institute, Chicago IL, 1998).

Telephone screening. Eligibility criteria for interview were (1) being a dairy farmer (milked cows at least once in the prior year); (2) residence in the six-county study area; and (3) current certification to apply restricted use pesticides. Final status codes were completed for 540 applicators; 30 applicators had incorrect contact information; and 28 could not be reached after 10 attempts over a 2-week period. A total of 450 were eligible to participate in the interview; 400 completed the interview and 50 refused. Overall interview participation rate was 88.9%.

Eligible respondents were then invited to participate in a study of farm health and pesticide safety. The study involved completing a telephone interview after their first pesticide application of the season; attending the winter pesticide re-certification meeting, and completing a second telephone interview after their first season application of the following year. Respondents were offered $50 for their full participation in the two interviews and the re-certification meeting. All 400 respondents (100%) agreed to participate in the study at that time.

Baseline/follow-up assessments. Applicators were interviewed over the telephone within 1 week following their first pesticide application of the growing season in 1997 and again in 1998. A total of 385 participants completed the follow-up interview, with an overall response rate at follow-up of 96.3%.

Psychosocial risk assessment items were constructed to measure pesticide safety knowledge, intentions, beliefs, risk perceptions, peer norms, and self-efficacy. Scale items and psychometric characteristics have been reported previously.[6,7] Scale items were examined separately rather than as composite scores if the Cronbach's alpha for the scale was <0.70. Knowledge items were based on information included in the Wisconsin Pesticide Application Training Manual.[10] Eighteen true/false pesticide safety and risk items were used to construct the knowledge scale.

Six behavioral-intention items were asked concerning applicator intentions to follow precautions the next time they used a pesticide. The response option ranged from 1 (strongly disagree) to 4 (strongly agree). The sum of the six behavioral items was treated as a composite score representing behavioral intentions.

Four safety-belief items were asked concerning applicators' beliefs about pesticide hazards. The response option ranged from 1 (strongly disagree) to 4 (strongly agree). Each of the four items was treated as separate dimensions of pesticide safety beliefs.

Three risk-perception items measured applicators' perceived risk of health hazards associated with exposure. The response option ranged from 0 (very unlikely) to 10 (very likely), and the sum was treated as a composite score representing perception of health risks.

Five peer-norm items measured applicators' perceptions of pesticide safety among other known farmers. The response option ranged from 1 (strongly disagree) to 4 (strongly agree), and each of the individual items was treated as a separate dimension of peer norms.

Six self-efficacy items focused on applicators' confidence to avoid exposure and use required protective equipment during application. The response option ranged from 0 (not at all confident) to 10 (very confident), and the sum was treated as a composite score representing self-efficacy.

The structure of the pesticide-use questions was based on questionnaires from prior investigations of pesticide exposure and cancer among farmers.[11] The questionnaire employed a question series including 15 separate, restricted-use pesticide chemicals: atrazine, dicamba, cyanazine, metolachlor, alachlor, imazethapyr, trifluralin, pyrethoid, terbufos, fonofos, carbofuran, metribuzin, simazine, chlorpyrifos, and diazinon. Chemical and trade names were indicated for each pesticide. Information on the characteristics of first pesticide application of the growing season included date of application; number of acres applied to; type of crops applied to; types of application equipment used, including personal protective equipment (PPE); and whether personal exposure occurred. PPE use involved six types of protective gear (chemical-resistant gloves, goggles, boots, apron, coveralls, and respirator) during mixing, loading, and applying. The personal exposure item asked whether any dermal exposure, inhalation, or ingestion of pesticides occurred during the application.

Randomization

Active applicators were randomly assigned to the intervention or control condition by the principal investigator (MJP), using a computer-generated randomization list. Intervention sessions were scheduled in five separate locations chosen for their proximity to residents in the six counties. Individuals assigned to the intervention and control conditions were both sent a reminder letter from the principal investigator to participate in the upcoming re-certification meetings. Project interviewers then contacted participants by telephone to schedule their attendance at either the enhanced (intervention) or standard (control) re-certification meeting. Although the randomization to either the standard or enhanced re-certification meeting was an explained part of the study at the time of recruitment, participants were never told directly to which group they had been assigned. During the follow-up interview, interviewers were blind to the treatment assignment of the participant until the last question of the interview, which asked what re-certification meeting was attended.

Intervention Administration

In winter of 1997–1998, 3-hour educational sessions were conducted with 100 pesticide applicators in the Wisconsin six-county study area. Five individual sessions were conducted in separate sites, with attendance at each site ranging from 20 to 50 applicators. Sessions consisted of four educational messages: (1) existing evidence of excess cancers among farmers; (2) simulation of pesticide exposure presented through a slide show and description; (3) feedback of self-reported data collected from the farmers to date, reporting on frequency of exposure and gear use; and (4) cognitive behavioral strategies that could be adopted to reduce pesticide hazards and ultimately cancer risks.

Intervention Session Content

Knowledge of pesticide-associated cancer risks. The laboratory and epidemiologic evidence on the carcinogenic properties of pesticides were summarized in a presentation format for a lay audience. This presentation also highlighted epidemiologic data on cancer mortality rates among farmers as well as Wisconsin cancer mortality rates.

Susceptibility to pesticide exposure. Slides depicting pesticide exposure were used to illustrate how pesticides contact the body during the use of different levels of protective equipment. The importance of preventing pesticides from entering the body through inhalation, absorption, and ingestion was emphasized using information from prior biomonitoring studies.

Peer norms for safe pesticide handling. A respected farmer from the area, identified through nomination on the baseline assessment, was asked to speak to the group on how he had incorporated safe handling into his pesticide application routines. This component of the intervention proposed that using a well-regarded member of a peer group (i.e., farmers in a shared community) to endorse the desired behavior change (i.e., use of personal protective equipment during application) would exercise peer influence directly to encourage behavior change among the peer group.

Skills training to increase self-efficacy beliefs. During the intervention session, time was spent demonstrating the proper use of protective gear and safe handling practices. The demonstration paid particular attention to how applicators can make minor adjustments in their application routines to easily incorporate these practices. For example, the presenter suggested placing an extra set of disposable coveralls and rubber gloves in several places for easy access (e.g., in the barn, on the tractor, and in a storage box in the field).

In addition to the demonstration by a presenter, each of the applicators were given the opportunity to experiment with the protective equipment. This included trying on respirators, practicing a brief check to make sure that all parts of the body were covered, and timing each other to illustrate how one can gear up properly in only a few minutes. The objective of this component of the session was to give applicators time to acquire the skills necessary to practice safe handling procedures.

Main Outcome Measures

Three dichotomous primary outcome measures were identified a priori and subsequently evaluated. The measures follow:

1. prevalence of protective gear use (defined as use of any gear other than gloves during the most recent application)
2. full compliance with the required PPE during the most recent application
3. prevalence of self-reported dermal exposure during the most recent application.

To define full compliance, use of long-sleeved shirts, long pants, and shoes plus socks were assumed for all applicators and were not counted as separate gear items. Depending on the chemical, other required gear may have included chemical-resistant gloves, footwear, and apron; protective eyewear; and/or an approved respirator. Gear use practices were compared to the specific PPE requirements for each chemical to construct a dichotomous variable of full compliance (used all recommended gear during application) versus noncompliance (used some or no required gear during application).

Data Analysis

The main objective of this study was to determine whether the educational intervention session increased safe pesticide handling and reduced pesticide exposure. It was hypothesized that the intervention would significantly increase any PPE use (other than gloves), including full compliance with all required gear, and would decrease dermal exposure as reported by participants 6 months postintervention.

Because there were no previous pesticide safety intervention studies to refer to in anticipating the effect size, specified a priori was what was defined as modest yet satisfactory increases in safety behaviors. Based on prior studies of PPE use, which showed that gloves are more frequently worn than other gear, it was anticipated that the prevalence of any protective gear use other than gloves would be 40% in the control group with a 18% increase in the intervention group. Based on 0.8 power to detect a significant difference (p=0.05) and using an allocation ratio of 1:3, a minimum of 91 participants was required for each study group for a two-sided test, and 71 participants were required for a one-sided test. For evaluating full compliance, it was believed that the prevalence of full compliance in the control group would be 9% in the control group (as found in a prior study) and there would be a 13% increase in the intervention group. Based on 0.8 power (p=0.05) and an allocation ratio of 1:3, a minimum of 86 participants were required for each study group for a two-sided test, and 67 participants were required for a one-sided test.

Exploratory data analyses and parametric statistics, including Wilcoxon-signed-rank tests and chi-square tests, were used to analyze the demographic data and assess the effects of the intervention on knowledge, risk perception, perceived peer norms, and self-efficacy beliefs postintervention. For assessing whether this study was effective in increasing use of protective gear and decreasing dermal exposure in the intervention applicators while adjusting for relevant covariates, estimates from multivariate logistic regression equations were calculated using the control group as the referent category. Due to power restrictions and the risk of multiplicity, separate logistic regression equations were calculated for each of the five outcomes: used gloves, used any other gear, full PPE compliance, reported dermal exposure, and decreased number or pesticides applied. The latter outcome (i.e., decrease in the number of pesticides applied) was not specified a priori and was considered an exploratory outcome.

Results

Figure 1 describes the flow of participants through each stage of the study. A follow-up rate of 96.3% (n=385) of study participants was achieved in the postintervention assessment, thus providing a sample size powerful enough to detect an intervention effect. Per protocol outcome analyses were performed; these were restricted to only participants who fulfilled the protocol in terms of eligibility, interventions, and follow-up assessment. Table 1 compares the baseline demographic and pesticide application practices in the two treatment groups, indicating there were no significant differences between the two groups at baseline. Similarly, analyses of the psychosocial variables of interest did not show significant differences between the two groups at baseline (data not shown). All of the applicators were male.

Table 2 summarizes postintervention bivariate differences on the primary intervention variables of knowledge, intentions, risk perceptions, and safe pesticide handling by intervention condition. Knowledge, intentions, risk perceptions, and other gear use were significantly increased postintervention in the intervention group, whereas glove use was not significantly affected.

Table 3 shows adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for safety behaviors by treatment, using the control group as the referent and adjusting for age, education, farm size, and farm years worked. Odds of glove use and any other gear use during the most recent application were significantly elevated for the intervention group. However, neither the increase in the odds of full PPE compliance nor the decrease in odds of dermal exposure at the most recent application were statistically significant in the adjusted models.

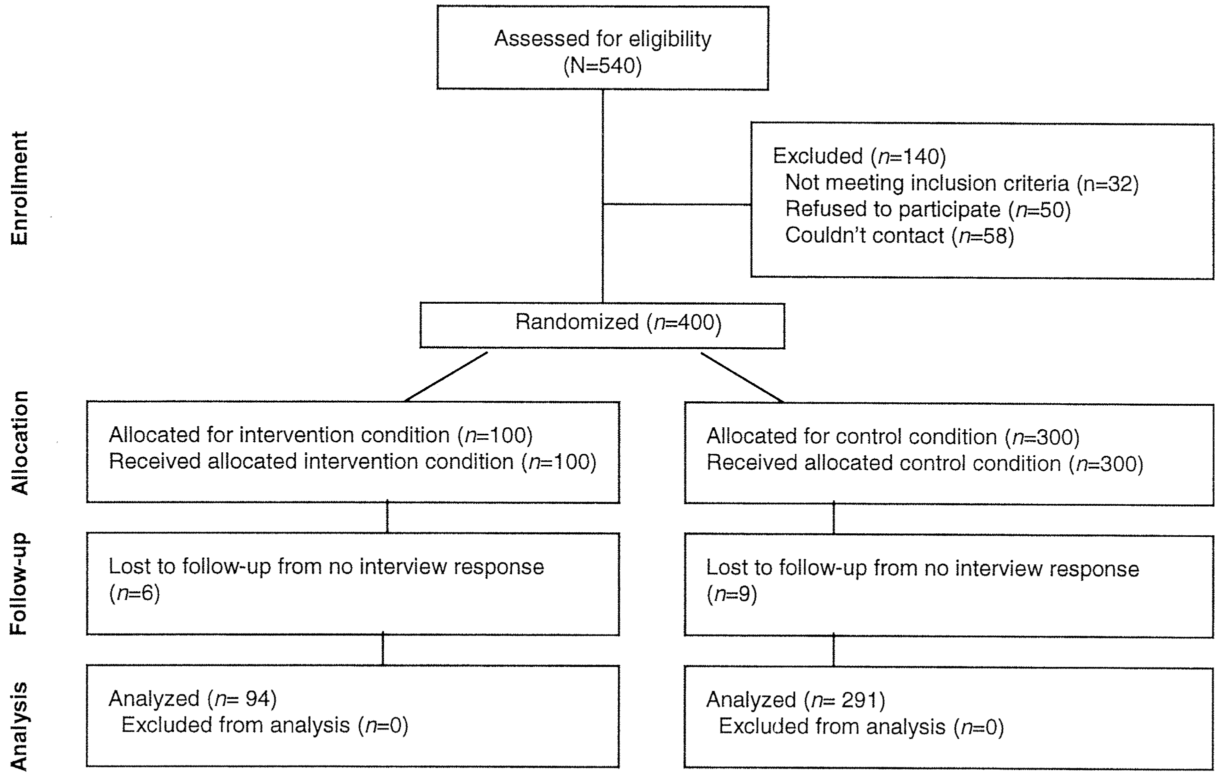

Figure 1. Flow of participants through each stage of the randomized trial.

Discussion

Reducing pesticide exposure in farm owners, workers, and farm family members remains a significant challenge to occupational health practitioners. Family farms are often isolated workplaces with only a few workers, which makes health and safety outreach, monitoring, and enforcement especially difficult. The approaches necessary to minimize hazardous exposures in farm settings require a departure from typical industry-based programs and must be recast to include more targeted community-level public health initiatives.

In this study, which tested an educational pesticide–safety intervention launched in community venues, 6-month postintervention analyses showed that the intervention had significant effects on use of gloves and gear during the most recent application and an actual reduction of the total number of pesticides used. However, the intervention did not have a significant

Table 1. Demographic characteristics of pesticide intervention and control groups[a]

Characteristic	Control (n=291)	Intervention (n=94)
Mean age	45.4	46.4
Mean years of education	12.8	12.6
Mean years worked in farming	40.7	40.0
Mean acres of land	429.7	403.1
Mean dairy cows	71.0	68.2
Percentage of pesticide applied in past year		
atrazine	20.3% (59)	28.7% (27)
dicamba	20.3% (59)	22.3% (21)
cyanazine	11.3% (33)	13.8% (13)
terbufos	13.4% (39)	9.6% (9)

[a]No significant differences detected between control and intervention groups using Wilcoxon-signed-rank tests for means and χ^2 tests for proportions.

Table 2. Comparison of cancer and pesticide risk knowledge, attitudes, and behaviors, 6 months post-intervention by intervention condition (n=385)

Knowledge, attitudes, and behaviors items	Control (n=291)	Intervention (n=94)
Pesticide safety knowledge mean score	13.0	16.0*
Pesticide safety intentions mean score	8.2	11.5*
Risk perception mean score	6.5	9.3*
Percentage of use of gloves during most recent application	62.5%	70.0%
Percentage of use of any other gear during most recent application	40.0%	64.0**

*$p<0.05$ Wilcoxon-signed-rank test; **$p<0.05$ χ^2 test.

Table 3. Adjusted odds ratios and 95% CIs of pesticide safety behaviors by treatment, 6 months post-intervention[a]

Safety behaviors	Intervention OR (95% CI)
Used gloves	1.23 (1.13–1.34)
Used any other gear	1.53 (1.05–2.11)
Full PPE compliance	1.10 (0.80–1.59)
Reported dermal exposure	0.86 (0.78–1.05)
Decreased number of pesticides applied	2.04 (1.52–2.75)

[a]Adjusted for age, education, farm size, and farm years worked.
CI, confidence interval; OR, odds ratio; PPE, personal protective equipment.

impact on achieving full PPE compliance or on reducing the amount of dermal pesticide exposure during the most recent application reported by applicators.

Several limitations in the design of the study should be noted. A pesticide-exposure biomarker measured on a subsample of applicators was originally included in the design as an exploratory outcome. However, a large enough sample of applicators applying only one chemical was not available for analysis, thus precluding the corroboration of self-report with biomarker data. Although these findings relied on self-report data, differential rather than global improvements in outcomes suggest that intervention participants were not likely influenced by demand characteristics or biases in reporting. Also, the follow-up assessment was performed separately from the intervention, and interviewers were blind to the treatment assignment of the participants. Finally, as with most experimental studies, other unmeasured sources of error could have influenced the results. Although this study used randomization to equalize the presence of other factors that could influence the effects of the intervention—and no significant differences were found between the treatment conditions on baseline demographic, psychosocial, and behavioral variables—it remains possible that residual confounding from unidentified sources could have occurred.

Potential threats to external validity were reduced by random selection of participants from a large sample of farmers and by high participation and completion rates. The findings from this intervention trial would be most generalizable to similar family farm communities where personal pesticide application to field crops is common; this could include dairy as well as crop farmers. No adverse effects from the intervention or control conditions were observed during the full period of observation. The follow-up period of the study was a long-enough time from the intervention to determine short-term effects. However, a second follow-up assessment would have been optimal for determining maintenance effects.

The findings of this study suggest that it is possible to have at least a short-term effect on pesticide application practices and pesticide safety behavior by increasing safety knowledge, intentions, and cancer risk perceptions. However, the educational/behavioral skills approach tested here did not have a significant effect on self-reported dermal pesticide exposure or on achieving consistent full PPE compliance. It is unclear whether actual pesticide exposure was affected by the intervention due to the lack of sufficient biomonitoring data available for analysis.

Owing to the lack of prior studies designed to achieve pesticide safety–behavior change, knowledge of what works in increasing pesticide-safety awareness and behaviors is anecdotal at best. These findings suggest that a more powerful intervention program and evaluation design is needed. The program format included both cognitive targets, such as knowledge and risk perception, and behavioral targets, such as PPE-use skills. The results shown here suggest that both types of targets are important for effectiveness. One educational session should be considered as inadequate exposure to the intervention messages, and greater exposure may have been more effective. Ideally, farm pesticide–safety interventions should be designed to include multiple sessions, with periodic boosters to ensure maintenance of behavioral changes over time. Density-sampling strategies targeting specific pesticide use may be necessary to recruit adequate samples for biomonitoring assessments pre- and post-intervention.

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