AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 40:145–152 (2001)

Evaluation of the Effectiveness of Educational Interventions in the Pennsylvania Central Region Farm Safety Pilot Project

Douglas P. Landsittel, PhD,[1]* Dennis J. Murphy, PhD,[2] Nancy Ellen Kiernan, PhD,[2] David L. Hard, PhD,[1] and Cathy Kassab, PhD[2]

Background *Evaluation of agricultural safety interventions has frequently been identified as an area requiring further research. This study prospectively evaluates the effectiveness of three specific educational safety interventions in reducing farm hazards.*
Methods *Farm characteristics and hazard conditions at 216 farms in Pennsylvania were assessed through a questionnaire and objective audit, respectively, at both pre- and post-intervention time points. Counties were assigned to one of the following interventions: youth education, community coalition, self-audit, pre/post control, or post-only control group. Changes in hazard were analyzed through linear regression.*
Results *Self-audit was the most effective intervention, leading to a 20% reduction in hazard scores. The community coalition and pre/post control group also showed reductions.*
Conclusions *Intervention effectiveness significantly differed depending on initial hazards, indicating the need to target specific interventions for more or less hazardous farms. Findings of this prospective evaluation differed from the initial cross-sectional results, thus underscoring the need for longitudinal investigations.* Am. J. Ind. Med. 40:145–152, 2001. *Published 2001 Wiley-Liss, Inc.*†

KEY WORDS: agriculture; educational intervention effectiveness; occupational; safety and health; farm hazards

INTRODUCTION

Previous literature on occupational safety and health research has discussed the need for conducting additional studies on intervention effectiveness [NIOSH, 1996; Rosenstock, 1996; Schulte et al., 1996; Rivara and Thompson, 2000]. Many studies conducted in this area did not incorporate appropriate methodology such as control groups or sufficient follow-up time [Goldenhar and Schulte, 1996; Rosenstock and Thacker, 2000]. Lack of questionnaire validity and adjustment for possible confounders also threaten the usefulness of study results. In addition, researchers are encouraged to interact more closely with industry groups, management, and workers to achieve results more effectively.

More specifically, evaluation of intervention effectiveness in agricultural settings has frequently been identified as an area requiring further research [NIOSH, 1991; Murphy et al., 1996; DeRoo and Rautiainen, 2000]. The Pennsylvania Central Region Farm Safety Pilot Project (PACRFSPP) is an agricultural safety and health study which attempts to better address these issues by implementing and evaluating three different educational interventions across four different counties of Central Pennsylvania with two other counties

[1]Division of Safety Research, Analysis and Field Evaluations Branch, National Institute for Occupational Safety and Health, Morgantown, West Virginia
[2]Penn State University, College of Agricultural Sciences, University Park, Pennsylvania
Douglas P. Landsittel's current address is Health Effects and Laboratory Division, Biostatistics Branch, National Institute for Occupational Safety and Health, Morgantown, WV.
*Correspondence to: Douglas P. Landsittel, Research Statistician, Health Effects and Laboratory Division, Biostatistics Branch, National Institute for Occupational Safety and Health, 1095 Willowdale Road, M/S L4020, Morgantown, WV 26505.
E-mail: del6@cdc.gov

Accepted 16 May 2001

serving as controls. Two of the four counties shared an extension agent, and therefore was treated as a single county with only one intervention being assigned to this two-county unit. Interventions were assigned to Central Pennsylvania counties agreeing to participate in the study. Using this quasi-experimental design [Cook and Campbell, 1979] hazard scores, recorded by a trained auditor, longitudinally assessed changes in hazard conditions for both experimental and control counties. Detailed descriptions of the interventions and project design are published elsewhere [Murphy et al., 1998].

Hazard audit and survey data were initially collected from 216 farms during 1995, and again during the first quarter of 1998. Data were also collected from an additional 40 farms (that had no experimental safety interventions implemented) at only the second time point. Previous publications from this study analyzed associations between the farm operators' approach-to-safety and hazard conditions, using a cross-sectional analysis of the initial data collected in 1995 [Landsittel et al., 1998]. Results indicated that the farms with more acres, full-time operators, presence of hired labor, greater farm income, and operators that do not work outside the farm, were all significantly associated with reduced farm hazards. Additionally, greater concern about missing safety features, and greater importance of safety practices were significantly associated with reduced farm hazards. These analyses provided important insight into the interaction between the farm operators' approach-to-safety and hazard conditions, as well as how this association was influenced by demographics. Such cross-sectional analyses, however, only identify associations at a given time point, as opposed to longitudinal effects.

Further analysis, as documented in this article, was conducted to investigate the effect of educational safety interventions in reducing farm hazards over time. Data collected from the initial survey were used to characterize demographics and the farm operators' approach-to-safety. The effect of these interventions was then quantified by the percent change in hazard scores between the first and second hazard audits. Results of this study represent a crucial step in assessing the effectiveness of educational safety interventions which are typically believed to be effective but rarely evaluated scientifically.

METHODS

Data Collection

Surveys were collected both before (1995) and after (first quarter of 1998) the implementation of study interventions. For the purposes of this prospective analysis, the initial survey was used to quantify the farm operators' approach-to-safety which was measured by three survey components: concern for absence of safety features and protective devices, recognition of the importance of safety practices, and knowledge of hazards and risks [Murphy et al., 1996]. Details concerning analyses on the survey questions used to identify appropriate components (such as factor analysis) are published elsewhere [Landsittel et al., 1998].

To assess concern for missing safety features and protective devices, farm operators rated their degree of concern using a six-point Likert scale (from ''not much'' to ''extreme''). Items in this component focused on safety features and protective devices for tractors (e.g., rollover protection), machinery (e.g., driveline shaft shield for PTO-powered machines), buildings and structures (e.g., availability of a multiclass fire extinguisher), and emergencies (e.g., posting emergency reporting guidelines near a phone). Farm operators also assessed the importance of safety practices using a six-point Likert scale (from ''not much'' to ''extreme''). Questions related to tractors (e.g., daytime headlights), machinery (e.g., walking around an unshielded PTO driveline shaft), and buildings and structures (e.g., clearing debris inside barns). To assess the knowledge of hazards and risks, farm operators rated the strength of their agreement with statements related to tractors, machinery, buildings and structures, and emergency procedures (using a five-point Likert scale that ranged from ''true'' to ''false''). A total score for each of the three components was calculated as the sum of all individual items in that component. These scores were then categorized as either low, medium, or high based on their frequency distributions and preliminary regression results.

Hazard audits were also conducted at each farm at both the beginning (time 1) and end of the study (time 2) by a trained auditor. Various conditions were inspected and assigned a score between one (least hazardous) and five (most hazardous). Inspected items included features of tractors (e.g., rollover protection), PTO machines (e.g., driveline shaft shield), farm shops (e.g., storage of fuels), silo unloading rooms/areas (e.g., electrical fuse box covers), two-story bank barns (e.g., hay/feed drop openings), pesticide storage (e.g., decontamination equipment), bottom unloading grain bins (e.g., grain suffocation warnings), manure handling and storage (e.g., restricted access), and emergency procedures (e.g., emergency reporting instructions). Inspected items for tractors and machines were also preassigned a number between one (least important) and 10 (most important) to represent the importance of that item. A weighted average of these individual hazard scores was then calculated for each farm so that the overall hazard score for a farm was a number between one and five. A detailed description of the statistical procedure and analysis of the initial hazard audit are published elsewhere [Landsittel et al., 1998].

Educational Interventions

Different educational safety interventions were assigned to each county. One county was assigned a self-audit intervention. Farm operators conducted two self-audits of their operations (approximately 6 months apart) and then returned them to the county agent who scored and summarized them. The agent then marked which audited items should be corrected immediately, which items should be corrected in the near future, and which items should be corrected as time permitted. Seventy-two farm operators participated in this intervention. Two counties that shared an extension agent, and were therefore treated as a single unit, were assigned the youth education intervention. For this intervention, 64 youths from 30 farm families participated in a wide variety of educational programs and activities. The youths ranged in age from 7 to 17. The other participating county was assigned a community coalition intervention. Cooperative extension agents worked with community leaders and businesses to promote farm safety among all farm operators in the county (41 farms). Programs and activities included a hazard reduction cost-share program, a youth farm safety day camp, and distribution of fact sheets and other safety literature.

Two additional counties were used as control groups for this project. In one county, called the pre/post control, county agents continued with a few traditionally scheduled safety activities comprised of pesticide education certification programs, a 1 day farm safety camp for children, and safety articles in commodity-oriented newsletters. For the second control county, the agricultural agent position with responsibility for safety education programming was vacant for most of the intervention period. The impact of this vacancy was that the only safety-related programs conducted during this time period were pesticide education certification and pesticide container recycling programs, conducted by agents who did not have primary responsibility for safety programming in that county. This county was referred to as the post-only control, since only post-intervention hazard audits and survey questionnaires were completed.

Statistical Analyses

For each farm the percent change in hazard was calculated using the following equation

$$\text{Percent change} = \left[\frac{[\text{hazard score at time 2} - \text{hazard score at time1}]}{[\text{hazard score at time 1}]}\right].$$

The mean percent change in hazard was then calculated for each intervention (and control) group in the study. The mean hazard scores at each time point were also described separately by intervention. Analysis of variance was used to determine whether any significant differences existed between the interventions. Linear regression analysis was used to quantify associations between change in hazard and possible predictor variables. Distributions were approximately normal.

RESULTS

Description of Demographic and Survey Variables, and Farm Hazards

The size of participating farms ranged between 40 and 2,000 acres with a mean of approximately 260 acres. Farm operators worked an average of 66 h per week on the farm, with only 24% working off the farm. Their average age was approximately 46 years with 35% attending (at least some) college. Just over 65% utilized child labor and 46% had employed hired labor within the last 3 months. Forty-one percent reported an annual income under 50,000 with 23% reporting under 20,000 per year. Nearly half of the farm operators, however, reported an annual income over $100,000.

The percent change in hazard score was approximately normally distributed. The mean change in hazard was −13.8%, with a median of −12.3%. Almost 77% of the farms experienced a decrease in hazard scores, with over 35% experiencing at least a 20% decrease. Less than 10% of the farms had over a 10% increase in hazard scores. Only three farms had over a 30% increase in hazard scores, while 43 farms had at least a 30% decrease. The maximum increases and decreases were almost 60 and 70%, respectively.

Associations between Educational Interventions and Hazard Scores

The mean hazard scores by intervention group are displayed in Table I. The community coalition intervention and the pre/post controls had the highest mean hazard (i.e., most hazardous conditions) at time 1, at 2.45 and 2.42, respectively. The self-audit intervention had the lowest mean hazard at time 1 (2.19), which was slightly lower (i.e., less hazardous) than mean scores for the youth education intervention (2.28). Using an analysis of variance test, a statistically significant difference was found between the four groups ($P = 0.02$), indicating that initial hazard conditions could not be ignored in comparing hazard scores at time 2.

For each group, the mean hazard score was then calculated using hazard audits taken at the end of the study. The self-audit intervention group had the lowest (safest) mean hazard score at 1.72, and, as might be expected, the

TABLE I. Mean Hazard Scores of 256 Central Pennsylvania Farms by Intervention

Intervention	Sample size	Mean hazard time 1	Mean hazard time 2	Change (%)
Youth education	30	2.28	2.20	−3.5
Community coalition	41	2.45	2.14	−12.7
Self-audit	73	2.19	1.72	−21.5
Pre/post control	72	2.42	2.04	−15.7
Post-only control	40	[a]	2.28	[a]
Total	256	2.33	2.02[b]	−13.8

[a]Data not collected.
[b]The mean hazard at time 2 was 2.02 including the post-only control (1.97 excluding).

post-only control had the highest mean hazard score at 2.28. The pre/post control, community coalition, and youth education intervention had similar scores at 2.04, 2.14, and 2.20, respectively.

The self-audit intervention led to the greatest mean percent decrease in hazard scores (21.5%). The community coalition and pre/post control also showed significant decreases in hazard scores (12.7 and 15.7%, respectively). The youth education intervention led to almost no decrease (mean of 3.5%) in hazard scores. Since hazard scores were not measured at time 1 for the post-only controls, percent change in hazard scores could not be calculated for that group.

The post-only control, which did not have a cooperative extension agent responsible for safety in the county on staff during most of the intervention period, had generally greater hazard scores (at time 2) than did the pre/post control group or any of the intervention groups. The overall four most hazardous scores were from the post-only control group, and the minimum scores of the post-only controls were greater (more hazardous) than the minimum scores of any other groups. Strong caution, however, should be exercised in making any interpretations about the comparison of the post-only controls with other farms since, (1) initial hazard scores do not exist for the post-only controls, (2) results at time 2 were only moderately different, and (3) comparing hazards at time 2 only does not allow for assessing change over time.

Linear Regression Analysis

Bivariate analyses of time 1 and time 2 hazard scores indicated that the percent change in hazard depends on the score of the initial hazard audit. Higher (more hazardous) scores were more likely to decrease over the study, whereas initially lower scores were more likely to increase. Approximately 27% of the less hazardous farms (below-average hazard at time 1) had an increased hazard score, as opposed to only 18% of the farms with an above average hazard score at time 1. Almost 10% of the less hazardous farms (at time 1) suffered over a 20% increase in hazard, while none of the more hazardous farms increased this amount. This trend could be due to more hazardous farms simply having more opportunity to decrease hazards. Farms with generally safe conditions before the study would have less such opportunities.

Separate analyses were, therefore, run for farms with low and high hazard scores at time 1. Intervention effectiveness and other factors could then be assessed separately for less and more hazardous farms. Analyses were also conducted using the hazard score in a continuous scale and its interaction with each intervention as covariates. In addition, regression models were fit using different cut points for high/low hazard (with two or three levels). Since results were fairly similar, only analyses using the mean hazard (2.3) at time 1 as a cut point are presented.

Results in Table II indicate that most of the variables were not significant in predicting percent change in hazard. For farms with a high hazard at time 1, none of the demographic or approach-to-safety variables had a P-value of less than 0.17. For farms with a low initial hazard, age of farm operator, child labor, farm income, and importance of safety practices were all at least marginally significant ($P < 0.15$). The regression coefficient for each categorical variable represents the difference between, (1) the mean percent change (in hazard scores) for farms with the higher level of that variable, versus (2) the mean percent change for farms with the lower level of that variable. For continuous variables (size of farm and age of farm operator) the coefficient represents the difference for an increase of one unit in that variable (i.e., age $= 29$ vs. age $= 30$). Note that a negative percentage change in hazard corresponds to a better hazard score for that farm (since a higher hazard score corresponds to a more hazardous farm). A negative coefficient, therefore, means that farms with the higher level of that variable experienced more of a reduction in hazards than farms with the lower level of that variable. The greater

TABLE II. Linear Regression Model of Demographic and Approach-to-Safety Variables for 216 Farm Operators With Pre- and Post-Intervention Scores

		Low hazard at time 1		High hazard at time 1	
Variable	**Levels**	**Coefficient**	***P*-value**	**Coefficient**	***P*-value**
Size of farm	log(acres)	−0.80	0.80	−3.84	0.21
Age of operator	Years	−0.27	0.12	−0.09	0.57
Education	Any vs. no college	−5.00	0.23	−0.53	0.90
Hours on farm	40+ vs. ≤40/week	0.24	0.97	2.14	0.63
Hours off farm	Any vs. none	−8.11	0.32	−3.70	0.37
Child labor	Any vs. none	8.69	0.03	5.81	0.17
Hired labor	Any vs. none	1.67	0.68	−4.80	0.23
Farm income	$50K+ vs. ≤$50K	8.73	0.08	−0.32	0.94
Off farm income	$10K+ vs. ≤$10K	−5.28	0.32	−5.82	0.21
Concern for	Medium vs. low	−4.71	0.38	−3.71	0.41
missing features	High vs. low	−4.51	0.38	−3.06	0.56
Importance of	Medium vs. low	−5.75	0.56	−0.65	0.93
safety practices	High vs. low	−15.03	0.12	−0.77	0.91
Knowledge of	Medium vs. low	−0.07	0.99	4.04	0.34
hazards/risks	High vs. low	3.97	0.49	−1.91	0.76

the magnitude of the coefficient, the greater the effect of that variable on decreasing/increasing hazards.

Table III displays the mean percentage changes in hazard scores by intervention group. The initially less hazardous (hazard score below the mean at time 1), and initially more hazardous farms were again analyzed separately since initially more hazardous farms tended to improve more during the study. Differences between the groups were statistically significant for farms with high time 1 hazards ($P < 0.01$ using analysis of variance) but not for those with low time 1 hazards ($P = 0.08$). In both cases, youth education showed, on average, very little effect on improving hazard conditions. The post-only intervention was not included in the remaining analyses since a percent change could not be calculated without the time 1 hazard score.

Multiple Regression Analysis

Table IV illustrates regression analysis of the interventions, after adjusting for demographic and approach-to-safety variables. The regression model was chosen as the most parsimonious model which accounted for possible confounding. The R^2 and adjusted R^2 of each possible model were also considered. None of the models explained a significant portion of the variability, as the R^2 of the regression models was only 0.23, and 0.11, for more, and less hazardous farms, respectively. None of the other models tested attained an R^2 above 0.3. The coefficient of the intercept predicts the mean percent change in hazard for farms in the lowest category for each variable in the model (i.e., minimum age, income $50,000, and pre/post control group).

Results in Table IV, as described below, are simultaneously adjusted for all terms in the model. Results indicate that none of these variables are statistically significant in predicting percent change in hazard for initially less hazardous farms. For initially more hazardous farms, older farm operators saw less of a reduction in hazard (positive coefficient) than younger farm operators after including educational interventions in the model. The youth education intervention, for initially more hazardous farms, was also significantly associated with less of a reduction in hazard conditions (positive coefficient), as compared to the pre/post control group. The self-audit intervention, however, was associated with a substantially greater decrease in hazards than the pre/post control. This effect was evident in both less, and more hazardous farms, although not statistically significant in farms with low hazards at time 1.

DISCUSSION

Associations Between Hazards and Demographic and Farm Characteristics

Results seem to suggest that farm producers' demographics and their approach-to-safety are not statistically associated with changes in hazard scores. This result was

TABLE III. Mean Percent Changes in Hazard Scores for 216 Central Pennsylvania Farms With Both Pre- and Post-Intervention Scores by Intervention

	Mean percent changes (Standard deviation)	
Intervention	**Low hazard at time 1**	**High hazard at time 1**
Pre/post control	−6.67 (19.77)	−18.50 (22.40)
Self-audit	−13.77 (17.08)	−30.60 (15.42)
Community coalition	−13.91 (21.22)	−11.47 (16.94)
Youth education	−0.32 (28.93)	−5.73 (7.88)
Overall	−9.89 (20.97)	−18.08 (19.04)

not evident in previous cross-sectional analyses [Landsittel et al., 1998] that only described associations with the hazard score at time one. Possible exceptions (see univariate results in Table II), although mostly not statistically significant, include the following: (1) Use of child labor and higher incomes were each associated with (about 9%) less of a reduction in hazards than farms without child labor, or with lower incomes, respectively. The association between hazard scores and child labor is likely due to the observed relationship between child labor and farm income, as a greater percentage of lower income farms in this study (who probably had less ability to actually make practical changes) also employed child labor, which could include family members. (2) High scores on one aspect of approach-to-safety, importance of safety practices, were associated with a 15% greater reduction in hazard, as compared to those with low scores. (3) Age of farm operator was associated with a slightly greater reduction in hazard (about 3% per 10 year increase in age). These associations only held for initially less hazardous farms in the single regression model (Table II).

Evaluation of Educational Intervention Effectiveness

The effectiveness of the interventions was highly dependent upon the hazard conditions at time 1 for the given farm. Using percent change as the outcome of interest standardizes the outcome to the farm's initial hazard score. This approach does, therefore, slightly bias results, such that farms with more hazardous initial conditions will show a larger percent change for the same (absolute) change in hazard. This outcome, however, was chosen to provide a metric that is interpretable with respect to relative improvement given the initial conditions, and thus emphasize improvement of more hazardous farms.

The self-audit intervention was very effective in either case, but especially for more hazardous farms, with an average decrease of over 30% in hazard scores. The community coalition intervention was the most effective intervention (although very similar to results of the self-audit) when implemented in less hazardous farms. In (initially) more hazardous farms, however, these interventions led to less of a reduction than the overall mean (11 vs. 18%). For either case, the youth intervention showed little effect on farm hazard conditions. Such results, while not directly addressable in this study, are likely a function of the lack of monetary and decision-making control held by the youth. Since changes impacting the real hazard conditions must usually involve such factors, the ineffectiveness of youth intervention is not surprising.

For initially less hazardous farms, the pre/post control county showed less of a decrease than the overall average (6.7 vs. 9.9%). For more hazardous farms, however, the mean reduction in hazard was approximately equal to the overall average. This result may suggest that, for more hazardous farms, even an audit and survey at time 1

TABLE IV. Linear Regression Model of Educational Interventions and Other Factors for 216 Central Pennsylvania Farms With Both Pre- and Post-Intervention Scores

		Low hazard at time 1		High hazard at time 1	
Variable	**Level**	**Coefficient**	***P*-Value**	**Coefficient**	***P*-Value**
Intercept	—	2.04	0.87	−33.45	0.01
Age of operator	Years	−0.23	0.31	0.32	0.04
Income	\$50K+ vs. ≤\$50K	6.53	0.20	0.78	0.83
Intervention	Self-audit vs. pre/post control	−8.94	0.13	−13.82	0.01
	Community coalition vs. pre/post control	−7.30	0.33	5.62	0.22
	Youth education vs. pre/post/control	1.79	0.79	14.4	0.01

(accompanied by some pesticide workshops, newsletter articles, and a safety day camp) was sufficient to substantially reduce farm hazards (by nearly 20%).

An additional level of comparison was incorporated into the study using a second control county in which, for most of the study period, the agricultural agent position responsible for safety education programming was vacant due to a retirement. This control group allowed for limited comparison of the two control counties to assess possible effects that might result from either (1) not having an identified cooperative extension agent on staff or (2) not conducting an initial hazard audit and survey. While a comparison of the pre/post control to a post-only control was not an original intent of the researchers, it was done on a limited basis by comparing the time 2 hazard scores. The number of safety programs in the post-only control group was the lowest of all the counties studied. In addition, the post-only control group had the most hazardous scores on the time 2 hazard audits. This would tend to suggest that not having a county extension agent with responsibility for safety education programming in the county was associated with more hazardous conditions. However, the study design is limited by the lack of randomized interventions, and by an inability to determine whether the two control counties were initially equivalent. Strong caution should thus be made in making such interpretations, as results were only moderately different, and examination of hazards at time 2 only does not allow for studying longitudinal change. This issue is certainly deserving of further study and will only be validated through additional research.

Study Design Issues

The substantial differences between results of this study and previous cross-sectional analyses (on these data) underscore the need for more longitudinal studies of agricultural safety interventions. The longitudinal design of this project helps establish the temporal nature of associations, which is an important step in determining causality (especially in nonrandomized or observational studies). Caution should be exercised in evaluating intervention effectiveness from cross-sectional studies which generally cannot identify the temporal order of events. Results of this study also imply that more extensive data collection is needed for conducting agricultural safety research studies. Although investigators in this study collected data on demographics, specific farm data, and various aspects of the farm operators' approach-to-safety, the regression models still explained a low percentage of the variability of the data.

A limitation in interpreting the effectiveness of these interventions, common to many observational research studies and linked to the issue of insufficient data collection, is that the interventions are possibly confounded, or modified by any unobserved county-specific effects. The possibility of a strong independent effect of some unobserved county-specific factor driving these associations, however, seems implausible in a study where safety and health activities were monitored over the study period. A more controlled trial, which might help reduce the variability in the data, would be very difficult to conduct in this setting.

In general, farms experienced significant reductions in farm hazards, with an average reduction of over 13%. On average, farm hazards decreased in all four groups, even after stratifying by initial hazard scores. Effectiveness of specific educational safety interventions was however, dependent on initial hazard conditions. Effective interventions for reducing hazards at initially more hazardous farms did not necessarily translate into the most effective interventions for less hazardous farms. This result demonstrates that specific educational safety programming should be separately targeted toward low hazard and high hazard farms. Dependence of results on initial conditions may reflect modifying effects of other variables not observed in this study. For instance, farms with greater productivity and revenue may be more effectively influenced by one intervention, whereas farms with less revenue may be better influenced by other interventions. Since these data were not directly collected in this study, such hypotheses cannot be tested here.

The community coalition intervention was more effective in initially less hazardous farms, as compared to the more hazardous farms. Despite different effects under different initial conditions, the self-audit was overall the most effective intervention. The self-audit performed very similar to the community coalition intervention in less hazardous farms, but over 12% better than any other intervention under more hazardous initial conditions. Overall, hazard scores were reduced by over 20% in the self-audit group. This improvement was especially impressive since farms in this county had the lowest initial hazard scores. These results should provide valuable guidance for researchers by indicating which interventions were most effective for more (or less) hazardous farms, and which demographic and approach-to-safety variables were associated with changes in hazard.

REFERENCES

Cook TD, Campbell DT. 1979. Quasi-experimentation. Design and analysis issues for field settings. Boston, MA: Houghton Mifflin Company.

DeRoo LA, Rautiainen RH. 2000. A systematic review of farm safety interventions. Am J Prev Med 18(4S):51–61.

Goldenhar LM, Schulte PA. 1996. Methodological issues for intervention research in occupational safety and health. Am J Ind Med. 29:289–294.

Landsittel D, Hard D, Murphy D, Kiernan NE. 1998. The Pennsylvania central region farm safety pilot project: part II-baseline data associations between approach-to-safety and hazard conditions. J Ag Saf Health. Special Issue (1):21–28.

Murphy DJ, Kiernan NE, Chapman LJ. 1996. An occupational health and safety intervention research agenda for production agriculture: does safety education work? Am J Ind Med. 29:392–396.

Murphy DJ, Kiernan NE, Hard DL, Landsittel D. 1998. The Pennsylvania central region farm safety pilot project: part I-rationale and baseline results. J Ag Saf Health. 4(1):25–41.

NIOSH (National Institute for Occupational Safety and Health). 1991. DHHS (NIOSH) Publication No. 92–105. Intervention—safe behaviors among adults and children. Paper and Proceedings of the Surgeon General's Conference on Agricultural Safety and Health. Cincinnati, OH, p 462–465.

NIOSH (National Institute for Occupational Safety and Health). 1996. DHHS (NIOSH) Publication No. 96–115. National Occupational Research Agenda. Intervention effectiveness research. p 46–47.

Rivara FP, Thompson DC. 2000. Systematic review of injury prevention strategies for occupational injuries. Am J Prev Med 18(4S):1–3.

Rosenstock L. 1996. The future of intervention research at NIOSH. Am J Ind Med. 29:295–297.

Rosenstock L, Thacker DC. 2000. Toward a safe workplace. Am J Prev Med 18(4S):4–5.

Schulte PA, Goldenhar LM, Connally LB. 1996. Intervention research: science, skills, and strategies. Am J Ind Med. 29:285–288.