A Systematic Review of Farm Safety Interventions

Lisa A. DeRoo, MPH, Risto H. Rautiainen, MS

Objective: The main objective of this study was to systematically review the existing evidence for the effectiveness of farm injury prevention interventions.

Search Strategy: We used a systematic approach to search the following electronic databases: MEDLINE, EMBASE, ERIC, PsycInfo, Sociofile, NTIS, Agricola, Expanded Academic Index, Dissertation Abstracts, and Occupational Safety and Health (NIOSHTIC). Proceedings and technical papers of the National Institute for Farm Safety were reviewed. We also checked the references of potentially eligible studies and consulted with experts in the field to identify other relevant information sources.

Selection Criteria: Papers had to involve a farm safety intervention to be included in the review. To best characterize the current state of farm safety research, all study designs were accepted, including those without comparison groups and those with absent or inadequate evaluation methods.

Results: We identified 25 studies for the review. Eleven of the studies involved farm safety education programs, five consisted of multifaceted interventions that included environmental revisions, a farm visit, or both; nine papers described farm safety interventions but did not report results from an evaluation. Farm safety education interventions included safety fairs, day camps; certification programs; workshops; and courses for farm families, youth, and agricultural workers. Multifaceted interventions were targeted to farm operators and generally involved farm safety audits, followed by environmental or equipment changes and/or safety education. Program evaluations assessed changes in safety attitudes, knowledge, and/or behaviors and generally involved pre- and post-test methodology. Only three studies examined changes in the incidence of farm injuries. Of the studies evaluated, most reported positive changes following the interventions. However, limitations in the design of evaluations make the results of many of the studies difficult to interpret.

Conclusions: There is a need for more rigorous evaluations of farm safety intervention programs. Suggested study design improvements include randomization of study subjects when appropriate, use of control groups and the objective measurement of outcomes such as behavior change and injury incidence.

Medical Subject Headings (MeSH): agriculture, accident prevention, safety management, intervention studies, occupational accidents/prevention and control, review literature
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Introduction

Farming has long been recognized as a hazardous occupation. Agricultural work has consistently ranked as one of the top three occupations with the highest incidence rates of injuries in the United States. Despite declines in reported agricultural injuries in recent years, in 1997 the agricultural injury mortality rate was 20.3 deaths per 100,000, second in rank to the mining industry.[1] Farmers are exposed to a variety of hazards including tractors, machinery, enclosed structures such as grain bins and silos, overhead power lines, tools, ponds, and animals. In addition, they often work long hours under severe time constraints and many use older model farm equipment that lack safety features.[2] Farm machinery is involved in approximately 50% of farm work-related deaths[3] and 18% of nonfatal injuries.[4] When not fatal, these injuries can cause serious, permanent disability. For example, tractor roll-overs can cause crushing, evisceration, and amputation of limbs; and entanglement in rotating shafts or drivelines can result in limb amputation or scalping. Other types of farm injury include suffocation from silo-gas and engulfment in grain, physical trauma from working with livestock, drowning, and electrocution. The spouses and children of farmers are also at risk for

From the Department of Epidemiology, School of Public Health and Community Medicine, University of Washington (DeRoo), Seattle, Washington; and The Great Plains Center for Agricultural Health, University of Iowa (Rautiainen), Iowa City, Iowa

Address correspondence to: Lisa A. DeRoo, MPH, University of Washington, Department of Epidemiology, Box 357236, Seattle, WA 98195; email: lderoo@u.washington.edu.

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injury because they come into contact with hazards on the farmstead, regardless of whether or not they are working.[5,6]

Agriculture has historically relied on voluntary safety education programs and injury prevention activities.[7] Earlier efforts used mass appeal methods, such as videos, fact sheets, exhibits, and public service announcements. Other efforts have involved education in small groups, such as courses and seminars and one-on-one education provided with occupational health service and farm hazard evaluations. Farm safety regulations, such as the requirement for roll-over protective structures (ROPS) for tractors, have been shown through ecologic assessment to be successful in reducing injuries in settings where they apply.[8] However, despite the hazards on family farms, operations with ten or fewer employees (over 95% of U.S. farms) are exempt from federal Occupational Safety and Health Act (OSHA) regulations. Therefore, most U.S. farm operators are not required to undergo farm safety inspections nor adhere to safety standards, such as the requirement for ROPS for tractors. Child safety on U.S. farms is largely the responsibility of parents and farm operators. Under the Fair Labor Standards Act of 1938, there are no age or hazard restrictions for children working on their parents' farms and children aged 12 years or older may work on other farms with parental permission.

In the early 1990s, concern about the continued high rates of farm injuries led to demands from the farming community and the public health infrastructure for an increase in farm injury prevention measures and accompanying research.[2,9–12] Subsequently, increased interest and funding from both the public and private sectors have led to the development and implementation of a variety of farm safety interventions throughout the United States. Despite the consensus to take action regarding farm safety, there have been few evaluations of interventions to determine what types of programs are most effective in reducing injuries. To achieve a reduction in farm injuries, there is a need for sound scientific evidence that farm safety education and risk-reduction programs have a beneficial effect on the knowledge and safety practices of farmers and their families. The results of well-conducted evaluations can increase our understanding of farm injury prevention by documenting what works and thereby help determine how public funds and resources for farm safety programs can best be used in the future. In this study, we intended to systematically review the existing evidence for the effectiveness of farm safety interventions for persons working or residing on family farms or small agricultural businesses, as well as identify potential methodologic improvements in their evaluations.

Methods

Search Strategy for the Identification of Studies

Relevant studies from peer-reviewed journals, technical and government reports, and unpublished reports were retrieved using a systematic approach to literature searching. Due to the multidisciplinary nature of the research question, the search was conducted across disciplines, and included many different databases and collections of literature. The following ten databases were included in the search:

- Biomedical—MEDLINE, EMBASE
- Social science—ERIC, PsycINFO, Sociofile
- Government—NTIS
- General—Expanded Academic Index, Dissertation Abstracts
- Occupational Health—Agricola, Occupational Safety and Health (NIOSHTIC)

A full description of the databases is included in the overview article on information retrieval.[13] In addition to database searching, we checked references and consulted with experts in the field to identify other relevant information sources. We also reviewed conference proceedings and technical papers of the National Institute for Farm Safety.

Selection Criteria

To be included, papers had to involve a farm injury–prevention intervention. Descriptive studies of farm injuries and risk factors were not included unless they involved a safety intervention component. Papers concerning the prevention of agricultural health problems other than injuries, such as respiratory disease or pesticide poisoning, were also excluded. To best characterize the current state of farm safety research, all study designs were accepted, including those without comparison groups and those with absent or inadequate evaluation methods. Most of the studies reviewed do not meet the usual methodologic criteria of systematic reviews, and thus their results require cautious interpretation.

Methods of the Review

We reviewed the titles and abstracts identified in the literature searches. A total of 118 studies that potentially met our inclusion criteria were then obtained for further review. Disagreements regarding study inclusion were resolved by consensus of both authors.

Information on the type of safety intervention, evaluation (if any), and results (if available) were abstracted from each of the selected studies. Meta-analysis or the pooling of study results was not attempted because studies differed in the types of interventions, target populations, study designs, outcome measures, and sample sizes. Furthermore, many papers provided only a description of the intervention, and therefore outcome data were not available.

Results

Included Studies

A total of 25 papers met our inclusion criteria. Eleven of the studies involved farm safety education programs (Table 1),[14–24] and five consisted of multifaceted inter-

Table 1. Farm safety education programs

Reference	Intervention	Study design	Outcome(s)	Results	Comments
Harper et al. (1998)[14]	South Carolina Farm Leaders for Agricultural Safety and Health (FLASH) Program Trained farm leaders in injury prevention and community program development	Post-workshop focus groups and individual interviews	Safety knowledge and attitude changes following the educational workshops Implementation of community activities and programs within one year after the FLASH program	No significant change in participants' attitudes or knowledge of farm safety Several local community educational programs were carried out; educational materials were distributed to 100 local leaders and educators	• Atttendance at educational workshops was poor • No control group • Self-report of participant's knowledge and attitudes • No pre-test; attendees were asked to retrospectively estimate attitudes and knowledge before the workshops
Burgus (1997)[15]	Community Family Farm Seminars, Iowa, 1995, evening programs on farm safety	Post-seminar questionnaires	Process evaluation Intended behavior change	Participants expressed the intention to adopt behavior changes	• No pre-test or baseline measure of safety behaviors • No control group • Self-report of intended behavior change
Rodriguez et al. (1997)[16,a]	Safe Farm Public Information Campaign, Iowa, 1992	Baseline (1991) and follow-up (1993) telephone survey of 460 farm operators	Safety awareness, concern, behavior (100-point indices)	Awareness: mean score increased from 67.25 to 68.88, $p=0.035$	• Differences in measured outcomes were small, although statistically significant
	Disseminated safety messages through radio and newspapers and distributed farm safety publications, target was family farmers			Concern: mean score increased from 78.50 to 79.91, $p=0.011$ Behavior: mean score increased from 73.01 to 74.17, $p=0.020$	• Self-report of safety awareness, concern and behavior
Clarahan (1995)[17,a]	Cass Youth Safety Fair, Cass County Iowa, September 1991, ages 8–15	Pre- and post-tests administered on the day of event	Knowledge acquisition	27% increase in correct responses to farm safety questions	• No control group
Hawk et al. (1995)[18,a]	Farm Safety Walkabout, Iowa, 1990–1991	Pre-tests were incorporated into the ''walkabout" booklet	Process evaluation	Response rates were best in the community-run group	• Self-report of behavior and environmental changes implemented
	Farm safety booklets, including a self-guided farm ''walkabout'' to identify hazards and educate about safety practices, were distributed by Future Farmers of America (FFA) students to farm families	For group 1, post-tests were administered by the same FFA students who distributed the guidebooks; for groups 2 and 3, post-tests were mailed to families who had returned the pre-tests	Safety behavior and farm environment changes	The three groups each had a significant change in behavior based on total behavior change scores ($p<0.001$) There were no statistically significant differences in behavior change scores between the three comparison groups	• Did not have a comparison group that consisted of families that did not receive booklets

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Reference	Intervention	Study design	Outcome(s)	Results	Comments
	To test the hypothesis that follow-up by a community group would improve intervention efficacy, 3 groups were compared: (1) community group, (2) health professional group and (3) group without a structured follow-up program				
Reed (1994)[19]	The Farm-Church Partnership Project, Mercer County, Kentucky Farm safety health fair in rural church setting	Post-event questionnaires and informal interviews Farm walkabout checklist completed after returning home and turned in to local feed store for discount	Process evaluation Safety changes on farms based on checklist	Over 50% of participating families indicated that they incorporated safety changes on their farms	• Self-report of safety changes
Buchan (1993)[20,a]	Farm safety day camps, Fruita and Montrose, Colorado, summer 1992, ages 4–17 y	15-month post-intervention telephone survey of parents	Parental assessment of child's knowledge acquisition and behavior change	Increase in knowledge acquisition ranged from 45–100%; behavioral changes ranged from 31–84.5%	• Open-ended, non-specific questions (e.g. Did your child learn anything?) • No baseline measurement of safety knowledge; parents were asked to retrospectively recall child's knowledge and behavior before the intervention • No comparison group
Wilkinson (1993)[21,a]	Tractor and machinery certification programs, Wisconsin, ages 14–15 y Mandatory tractor and machinery training programs run by county extension, 4-H and school educators to provide certification for youth who wish to operate a tractor or other machinery on a farm owned by someone other than their parents	Pre- and post-training surveys of youth and their parents	For youth: Frequency of operating tractors without roll-over protective devices (ROPS), carrying extra riders and riding as an extra rider on a tractor, and conducting hazard inspections For parents: assessment of youth's increase in farm safety knowledge, tractor and equipment operation and maintenance knowledge, safer	For youth (comparing post-training to pre-training surveys): 15.1% increase in daily exposure to tractors without ROPS Carrying extra riders increased slightly whereas the youth riding as an extra rider decreased 9.2% increase in daily inspections of tractors and equipment	• Self-reported outcomes • No statistical tests were used to compare frequencies of behaviors before and after training

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Reference	Intervention	Study design	Outcome(s)	Results	Comments
	The programs consisted of reading and workbook assignments, viewing safety videos and some hands-on training with tractors and equipment; one-page tractor and farm hazard inspection checklists were distributed		operation of tractors and equipment, and improved safety behavior	95.1% and 89% of parents reported that their child's knowledge of farm safety and tractor and equipment increased, respectively; 62.6% reported improved safety behavior safer operation of tractors and machinery	
Pekkarinen et al. (1992)[22]	Reindeer husbandry safety, Finland, 1985–1987	Pre-/post-questionnaires	Adoption of 34 safety measures	Herders implemented an average of 5.8 measures per herder in 1987	• Self-report of safety behaviors • No control group
	In person and by letter, herders were instructed on 34 safety measures including the use of personal protective equipment and structural changes to animal separation and slaughtering areas		Injury incidence	Injury incidence decreased from 21 injuries/1000 work days in 1985 to 12/1000 work days in 1987	• Low response rate: 52% completed both questionnaires
Schmeising et al. (1991)[23,a]	The Kid's Farm Safety Day Camp, Colorado State University, December 6, 1991, 4th–6th grades	Pre-and post-tests administered in participants' schools	Knowledge acquisition	Correct responses to questions on farm safety topics increased, depending on topic, from 58 to 77% compared to pre-tests	• Low response rate, 58% • No control group
Jansson (1988)[24]	Safety education and training for farmer-loggers, Sweden 15 one-day courses with demonstrations over a 3-week period, took place in the forest	Post-intervention survey of participants and telephone survey of controls	Behavior change	71% reported a change in working methods Use of protective leg guards increased from 65% to 90%; 40% of controls used them Use of protective boots changed from 65% to 85%; 40% of controls used them	• No pre-test; participants were asked to retrospectively estimate work methods and use of protective safety equipment

[a]Paper not indexed in databases searched.

ventions that included environmental revisions and/or a farm visit (Table 2).[25–29] In addition, nine papers described farm safety interventions but did not include the results or data from a completed evaluation (Table 3). Some of these papers described completed programs that lacked evaluations.[30–32] Others described interventions with planned evaluation components, but because the studies were not yet complete at the time of publication, the results were not available.[33–38]

Farm safety education interventions. The farm safety education interventions were targeted mainly to farm families,[14–16,18,19] with some programs such as safety day camps,[20,23] a safety fair,[17] and a tractor certification program[21] aimed specifically at children and teenagers who live and/or work on farms. Only two of the interventions were for specialized agricultural workers such as herders[22] and loggers.[24] We found no papers on safety education interventions designed specifically for migrant and seasonal farmworkers and their families.

Participants' time commitment for the programs varied from a couple of hours at a fair[17] or evening program[15] to fifteen days attending a hands-on course in the field.[24] Most of the interventions involved the dissemination of farm safety information through lectures, written materials, testimonials, or demonstrations. Many of the programs covered general farm safety issues for a variety of activities such as riding a tractor, handling livestock, and working in grain silos. The exceptions were the youth tractor certification program and the interventions for loggers and herders that focused primarily on one activity.

Evaluations of the programs utilized mainly pre- and post-test methodology to examine changes in self-reported behaviors, attitudes or knowledge, or some combination of the three, as well as process evaluations to gain information on program implementation. Three studies used post-tests only, and subjects were asked to retrospectively estimate their or their children's attitudes, knowledge, or behaviors, or some combination of the three, prior to the intervention.[14,15,20] Only one educational intervention evaluation compared actual injury rates before and after the intervention. In their evaluation of a safety education program for reindeer herders in Finland, Pekkarinen et al.[22] found a reduction in injuries from 21 injuries/1000 work days to 12. Many of the studies reported increases in participants' correct responses to questions on farm safety, more appropriate attitudes about farm safety, and/or self-reported or intended changes in farm safety behaviors after the interventions (Table 1). However, for most of the studies, the validity and interpretation of the evaluation results are questionable due to limitations in design such as the lack of comparison groups and reliance on self-reported outcomes (see Discussion).

Multifaceted interventions that included environmental revisions and/or a safety audit. In contrast to the educational interventions, all of the multifaceted farm safety interventions were targeted to farm operators because they were responsible primarily for making decisions regarding environmental changes and the use of safety equipment on the farm. These studies were characterized by farm audits conducted by safety specialists who provided specific safety recommendations to allow farm operators to make informed decisions on hazard corrections. Farmers then made environmental or equipment improvements either with[27,28] or without financial assistance,[25] or participated in farm safety education programs, or a combination of the two activities.[25–27,29] The outcomes assessed in the evaluations included injury incidence,[26,28] the number of worker compensation claims,[25] changes in safety behaviors[26,29] and productivity,[28] the number of training sessions provided to hired workers[25] and the effectiveness of cash incentives.[27]

Most of the studies utilized pre- and post-test surveys of an intervention group in their evaluations. However, Carstensen et al.[26] used a randomized intervention design and established ongoing injury surveillance and behavior checks to measure outcomes. Three of the five studies were conducted in European countries that provided comprehensive occupational health services.[26,28,29] For example, Husman et al.[29] evaluated the Finnish national model for farmer's occupational health services, which included clinical physical exams with follow-up every 2 years, as well as the farm hazard evaluation and education.

All of the multifaceted safety studies reported some positive changes in outcomes following the interventions (Table 2). Abend et al.[25] found a 27% decrease in the number of worker compensation claims filed after an intervention targeted to farm owners who employed outside workers. To obtain a rebate on worker compensation insurance, farm operators had to make at least five hazard corrections identified during a farm audit and provide safety training for their employees. Although the outcomes were self-reported, the researchers conducted random inspections of 25% of the farms and found that 95% of hazard corrections had been made as reported. However, the number of worker compensation claims for the intervention group was not compared to that of the control group to determine if factors other than the intervention were responsible for some or all of the decrease. Carstensen et al.[26] used a randomized study design to assign 200 farms to an intervention group that included a farm safety check and to two control groups. For the intervention group, injury rates dropped from 33.4 to 20.1 injuries per 100,000 work hours ($p<0.05$) and improvement in safety behaviors occurred for 66 working routines. No significant changes in these outcomes were observed in the control groups.

Table 2. Multifaceted farm safety interventions that included environmental revisions and/or farm visit

Reference	Intervention	Study design	Outcome(s)	Results	Comments
Abend et al. (1998)[25,a]	New York State Agricultural Hazard Abatement and Training (AHAT) Project, dairy farms, New York Farmers were asked to correct at least 5 hazards identified during an on-site safety audit of equipment guards and shields Two training sessions were provided to assist farmers in establishing on-going safety training programs for their employees Farmers received up to a 14% rebate of their 1996 worker compensation insurance premium for full participation in the program	Controls received on-site safety audit but not the rest of the intervention Pre- and post-training surveys Monthly training reports submitted by farmers	Numbers of training sessions conducted by the farmers Number of injuries as reported on workers compensation claims Farmers' attitudes and beliefs about providing safety training for their employees	A mean of 6.1 training sessions per farm were conducted by farmers during the 6-month study period 27% decrease in the number of workers compensation claims filed after the intervention There were significant changes in farmers' attitudes and beliefs about training after receiving the intervention	• A control group was used to compare attitudes and beliefs about training but worker compensation claims for the intervention group and controls were not compared • Self-report of number of training sessions and abatement activities; 25% of the farms were randomly visited to inspect changes and >95% of corrections were found as reported
Carstensen et al. (1998)[26,a]	The West-Jutland Study, Phase 3 Randomized intervention study of 200 randomly selected farms Intervention group had a farm inspection and safety check and a one-day safety course for all adults who worked on farm	Ongoing injury surveillance and behavior checks	Injury incidence rates Safety behaviors	For the intervention group: injury incidence dropped from 33.4 to 20.1 injuries per 100,000 work hours ($p<0.05$) improvement in safety behavior occurred for 66 working routines For control groups: no statistically significant reductions in injury incidence occurred; no improvement in safety behaviors was observed	• Randomized trial • Used two control groups in order to evaluate effects of study participation on awareness of hazards (Hawthorn effect) • Used appropriate statistical tests
Stone et al. (1998)[27,a]	Roll-over Protective structure (ROPS) Grant Campaign, Virginia Farm Bureau, 1997	Post-intervention survey	Effectiveness of cash incentive	Thirty-three incentives were provided for a total cost of $4950	• No evaluation of the impact of the new ROPS on injury incidence

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Table 2. Multifaceted farm safety interventions that included environmental revisions and/or farm visit

Reference	Intervention	Study design	Outcome(s)	Results	Comments
	$150 cash incentive to cover estimated costs of ROPS installation on older model tractors for Farm Bureau members Educational component cosisted of farm safety inspections and safety programs			61% of survey respondents said the incentive was the most important factor in their decision to purchase a ROPS 45% said they planned to purchase a ROPS prior to hearing about incentive; 14% said they had not been seriously considering a purchase; 41% they had not thought at all about purchasing a ROPS	
Lundqvist (1996)[28,a]	The Swedish Working Life Fund provided funding to farmers to make physical and technologic improvements in the farm environment	Post-intervention mail survey of all participants in one county	Injury incidence rates and productivity	84% response rate For dairy/beef farmers: 22% decrease in injury rate, 29% decrease in musculoskeletal disorders, 16% decrease in work time	• Self-reported outcomes • No baseline; participants were asked to retrospectively estimate previous injuries and productivity
Husman et al. (1990)[29]	National model for farmers' occupational health services, Finland, 1979–1988 Included farm visit or interview, safety critique, injury prevention education and recommendations, clinical physical exam, follow-up every two years	Pre/post intervention survey of participants and controls	Knowledge acquisition Proportion who purchased and used protective devices Changes in engineering and work practices	Compared to controls, intervention group farmers had an increased knowledge of hazard reduction, and a greater proportion purchased and used personal safety equipment No difference between cases and controls in improvement of working conditions, e.g. changes in engineering and work practices	• No statistical tests used • Self-reported outcomes

Programs without completed evaluations. Several of the identified interventions have not been evaluated (Table 3). Some of these studies had evaluations planned or in progress but others did not. All of the interventions were educational; only two study designs included the collection of data on injuries.[33,35]

Discussion

Effect of Interventions

Evidence for the effectiveness of farm safety education programs was weak due to inadequate study designs. The strongest evidence of a reduction in injury rates was for a program for reindeer herders,[22] but the study lacked a control group and had a low response rate.

Table 3. Descriptions of farm safety programs without completed evaluations

Reference	Intervention	Study design	Outcome(s)
Lee et al. (1999)[33,a]	Future Farmers of America chapters in pre-selected states were randomized to a standard educational intervention, an educational intervention including community involvement and a non-intervention control group	Three-group, randomized controlled trial with data collection conducted three times over a 2-year period	Safety and risk taking attitudes, safety practices, self-esteem, leadership traits and self-reported injuries
Murphy et al. (1998)[34]	Pennsylvania Central Region Farm Safety Pilot Project Farms were randomized to three educational interventions: (1) farm hazard audits and systematic follow-up with farmer operators (2) youth safety and health program (3) community farm injury prevention education, and a nonintervention control	Pre- and post-tests Farm hazard audits	Beliefs, attitudes and knowledge of farm safety Hazard audit scores
Reinhart et al. (1997)[35]	Tailgate Safety Training, Ohio Farm employees randomized to treatment or comparison group Treatment group participates in weekly safety sessions for one year	Controlled pre- and post- tests using four instruments: attitude (Likert scale items), knowledge (64 multiple choice questions), review of worker compensation files to ascertain injury history, on-farm inspections	Attitude change Knowledge acquisition Behavior change Changes in injury rates
NIOSH (1966)[36]	TRAC-SAFE, a community-based program aimed at reducing injuries from tractor roll-overs Educational programs on tractor risk abatement and control	Post-test	Process evaluation Knowledge acquisition
Gay et al. (1990)[37]	Iowa Agricultural Health and Safety Service Project Community-based comprehensive program including voluntary environmental health and safety evaluation and education	Questionnaire	Process evaluation Knowledge acquisition, Attitude change Behavior changes
Pratt (1990)[30]	The Bassett Farm Safety and Health Project, New York Educational component consisted of the development of a library of teaching films on farm dangers	None described	None described
Sandfort (1990)[31]	Workplace Health in Agriculture Program, Colorado State University Funded by the W. K. Kellogg Foundation Health education programs and resources targeted to rural health care providers, vocational-agricultural students and teachers, farm/ranch clubs and rural emergency services	None described	None described
Wilson (1990)[32]	Farmsafe Central West, Australia Farm safety field days, media programs (TV and radio), publications and workshops	None described	None described
McJilton et al. (1982)[38]	Self-contained instructional package designed to be used by Extension agents and vocational-agricultural workers who have regular contact with farmers, Minnesota	Pre- and post-tests, survey of participants	Knowledge acquisition Process evaluation

[a]Paper not indexed in databases searched.

The multi-faceted farm safety interventions provided greater evidence of efficacy and, in some cases, had more adequate designs such as randomization to intervention groups and the use of controls. These programs may offer the best prospect for farmers to reduce injury risk, but more sophisticated evaluations are needed to determine what aspects of the programs are important and if the programs can be effectively implemented in the U.S.

Methodologic Quality of Studies

Methodologic problems made it difficult to assess program efficacy of many of the farm safety interventions reviewed. Some of the evaluations had inadequate designs with no control group,[14,15,17,19,20,23] no pre-test or baseline measurements,[15,19] or asked participants to retrospectively recall their knowledge and attitudes before the intervention.[14,20,24,28] The post-tests of some of the evaluations were administered on the same day as the intervention so that only short-term retention of knowledge was assessed.[14,15,17] Some of the evaluations exclusively measured changes in participants' attitudes or knowledge,[14,15] or intended behavior change[23] with no attempt to determine if there was a reduction in injury risk. Although most of the researchers conducted process evaluations, few reported on program attendance. Harper and Poling[14] reported poor attendance at their educational workshops for farm community leaders but none of the papers compared the number of persons eligible to attend the programs to the number who actually attended. Knowledge of the percentages of invited farmers and their families who attended these programs would be helpful in determining if reasonable proportions of farm families were benefiting from these programs.

Although many of the papers on educational safety interventions reported some positive results, they are difficult to interpret. For example, in their evaluation of a farm safety media campaign, Rodriguez et al.[16] found statistically significant changes in farm safety awareness, concern, and behaviors but the changes were very small and may not have led to an actual reduction in injuries. In their study of tractor and machinery certification programs for 14 and 15 year olds, Wilkinson et al.[21] found that the program led to an increase in participants' knowledge of tractor safety and the importance of using ROPS. However, the post-intervention survey revealed that, after certification, the youth had a 15% increase in daily exposure to tractors without ROPS. Although the intervention led to an increase in safety awareness and knowledge, the youth probably lacked the authority to make decisions about the use of safety equipment. Some of the general safety interventions covered six or more farm safety topics in only a few hours or one day.[15,17,19,20,23] Although these studies reported an increase in knowledge of most of the topics covered, long-term retention of knowledge, especially for children, is questionable. As noted above, only one study found a reduction in injury rates after an educational program but the study lacked a control group and had other flaws.[22]

The evaluations of the multifaceted farm safety interventions had more promising results and fewer flaws in study design. However, it is difficult to determine which component(s) of these interventions led to the favorable outcomes. For example, it is not possible to determine if the farm safety audit, the educational program, or both were responsible for the decline in injury rates in the study by Carstensen and co-authors. Further evidence of the effectiveness of farm audits comes from the evaluations of two educational interventions. After the educational program, researchers encouraged participants to undergo self-guided farm tours by providing checklists and educational booklets to identify and correct hazards.[18,19] Although these studies relied on unverified self-reported outcomes, their results were suggestive that a farm "walkabout" was useful in helping some families recognize and modify environmental hazards, even without the assistance of an expert. This type of self-guided activity may be a more cost-effective and less intrusive intervention for U.S. farmers.

Limitations of Literature Search

Despite an extensive literature search, we may have missed some papers on farm injury interventions. Farm safety research is reported in a variety of media including peer-reviewed occupational health, engineering, agricultural, and epidemiology journals, as well as conference proceedings, unpublished theses and dissertations, and reports by health departments and agricultural extension services. Unfortunately, a large proportion of this literature is not indexed in bibliographic databases, making a comprehensive search difficult.[39] Although we may not have found every relevant study, those included are probably representative of farm safety research and program evaluations conducted in the last two decades.

Recommendations for Future Research

Although we found numerous published papers on farm safety interventions, a greater emphasis needs to be placed on conducting evaluations that will provide meaningful evidence of a reduction in injury risk for farmers and their families. To achieve this, we recommend the following methodological improvements in the evaluations of farm safety interventions:

- When appropriate, use a control group(s) to account for the effects of extraneous variables such as the effect of taking the pre-test alone, external events other than the intervention that occur between pre- and post-tests, and the maturation of subjects

- To avoid selection bias, randomize study subjects to intervention and control groups
- When possible, focus on outcomes such as behavior change and injury incidence, rather than measuring only knowledge, attitudes, or intended behavior change
- When possible, objectively measure outcomes or verify self-reported outcomes
- When possible, evaluate lasting changes in outcomes by conducting post-tests weeks or months following the intervention
- Use appropriate statistical tests to compare changes in pre- and post- tests for the intervention groups and controls

After determining which types of interventions work, research should focus on the best ways to implement the programs in the farm community. Finally, farm safety programs and evaluations for hired farm workers should be considered due to the lack of published studies pertaining to this group.

Conclusions

The articles reviewed were divided into two categories that reflect the main approaches safety specialists have taken in injury prevention. Educational approaches, traditionally the mainstay of public health prevention, work on the assumption that inadequate awareness, knowledge, and attitudes result in behaviors that cause injuries. The strategy is to increase knowledge, awareness, and appropriate attitudes so that people will engage in safer behaviors. In contrast, the focus of environmental and equipment modifications is to make behavior change unnecessary by providing automatic or passive protections or removing hazards completely.[40] In recent years, many safety specialists have argued that passive protections afforded by environmental modifications and legislation are more effective than educational programs in reducing injuries. Some agricultural specialists contend that farmers are already aware of the hazards involved in farming, lack the time and inclination to change their behavior, and are reluctant to attend educational programs.[41] The results of epidemiologic studies of farm injury risk factors provide additional evidence of the lack of effectiveness of farm safety educational programs. Although they did not focus on a particular intervention, researchers found no statistically significant difference in the incidence of injuries among farmers who had ever participated in any type of safety training program compared to those who did not.[42–44]

Regardless of the efficacy of farm hazard modification programs, there may be barriers to implementing these interventions in the U.S. Although common in some European countries, farm safety inspections are time-consuming and may not be acceptable to some U.S. farmers who value independence and privacy. Because most U.S. farm owners are exempt from the federal safety regulations, they are under no obligation to correct farm hazards once they have been identified. The cost, difficulty, and inconvenience of the indicated changes as well as the farmer's assessment of injury probability, may influence whether hazards are corrected.[45]

In this systematic review, we found numerous papers on farm safety interventions with absent or inadequate evaluations that made it difficult to determine their success. There are many potential barriers to conducting appropriate farm safety program evaluations. These include the lack of awareness of the need to conduct evaluations, unclear program objectives, lack of expertise in evaluation design, inadequate funding and staff, and the lack of resources such as computers for data collection and analysis.[40] Furthermore, it has been difficult to monitor trends in injury rates because farmers generally lack workers compensation or other consistent existing farm injury surveillance systems. Although it is beyond the scope of this paper to determine the specific reasons why appropriate evaluations have often not been planned and carried out as part of farm safety interventions, the obstacles need to be addressed by researchers. In some cases, programs have become long established without evidence that they are working. For example, in their article on tractor and machinery certification programs in Wisconsin, Wilkinson and co-authors noted that, prior to their study, the programs had been in place over 20 years with little or no evaluation to determine their effectiveness.[21] Without the results from well-conducted evaluations, farm communities have little evidence that the time, effort, and money spent on programs are making a difference in reducing injuries among farmers and their families.

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