Journal of Agromedicine
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wagr20

Characteristics of Evaluated Childhood Agricultural Safety Interventions

Susan S. Gallagher MPH [a]

[a] Department of Public Health and Community Medicine, Tufts University School of Medicine, Boston, Massachusetts, USA

Version of record first published: 10 Apr 2012.

To cite this article: Susan S. Gallagher MPH (2012): Characteristics of Evaluated Childhood Agricultural Safety Interventions, Journal of Agromedicine, 17:2, 109-126

To link to this article: http://dx.doi.org/10.1080/1059924X.2012.664033

Journal of Agromedicine, 17:109–126, 2012

ISSN: 1059-924X print/1545-0813 online
DOI: 10.1080/1059924X.2012.664033

Taylor & Francis
Taylor & Francis Group

Characteristics of Evaluated Childhood Agricultural Safety Interventions

Susan S. Gallagher, MPH

ABSTRACT. The goal of this paper was to examine interventions focused on childhood agricultural safety since the last general assessment conducted for the 2001 Summit on Childhood Agricultural Injury Prevention. The objectives were to identify the strengths and weaknesses of the knowledge base and identify challenges to and recommendations for improving programs, interventions, and policies. Published literature from 2001 to 2009 was identified and reviewed. We found 26 studies evaluating the effectiveness of interventions aimed at preventing farm-related injuries to children. There were mixed results in a number of studies, weak methods in many, and a lack of randomized controlled trials, in particular. Most interventions focused on the individual level of the socio ecological model and only on education as a strategy, with behavior change and knowledge acquisition as the objectives. Although more studies have been published in recent years, the quality of the research and intervention design has not necessarily improved. Based upon this review, key recommendations for future childhood agricultural safety interventions are proposed.

KEYWORDS. Children, youth, agriculture, safety interventions, injury prevention, evaluation

INTRODUCTION

There is a wealth of data indicating that children and adolescents continue to be injured while working, visiting, or living on a farm.[1,2] Many local, state, and national organizations as well as businesses sponsor programs related to protecting children in agricultural settings. Questions have been raised regarding the extent to which these programs are effective. Are programs based upon theoretical models and established frameworks? Are programs targeted to address risk factors for the most common fatal and nonfatal injuries? Have programs reduced the toll of fatal and nonfatal childhood injuries associated with agricultural settings?

There have been three systematic reviews of evaluated interventions to prevent injury in the agricultural sector.[3–5] Only one of these specifically focused on the child and adolescent population in agricultural settings.[4] The latter noted that the evaluated interventions focused on educational strategies and intermediate outcomes such as knowledge and behavior change.[4]

Susan S. Gallagher is affiliated with the Department of Public Health and Community Medicine, Tufts University School of Medicine, Boston, Massachusetts, USA.

This study was supported by a subcontract from the National Children's Center for Rural Agricultural Health and Safety funded by NIOSH grant 5U54OH009568. Appreciation is extended to Sana Shahram and Megan Coffman, graduate student research assistants on the project who helped with the literature review, developing the categories, and coding. Gratitude is also owed to Marcy Fitz-Randolph, then of the National Children's Center, for assistance with literature search and classification of variables.

Address correspondence to: Susan S. Gallagher, MPH, TUSM, 136 Harrison Avenue Boston, MA 02111, USA (E-mail: sue.gallagher@tufts.edu).

BOX 1. Four Types of Evaluation[11]

Formative for intervention program planning and designing materials, messages, equipment, and strategies before they are put into effect. It allows one to fine-tune an intervention that is tailored to the target audience. It often employs pretesting, pilot studies, readability assessments, and qualitative tools such as focus groups, surveys, interviews, and observations. Are the materials understood and culturally appropriate?

Process for monitoring and managing a program. Is the injury prevention program being implemented as planned? Is it reaching the target audience? What is the intervention participation rate? Is there implementation consistency across locations? What is the cost of the interventions?

Impact for determining whether an intervention is meeting intermediate goals. Has there been knowledge, attitude, and behavior, organizational or policy changes? Have the number of hazards been reduced on the farm? Have guidelines been applied?

Outcome for determining whether a longer-term change related to intervention goals has occurred. Has there been a change in the number and severity of injuries? Is the intervention sustainable after the program ends?

Notably absent were interventions to reduce fatalities in preschool-aged children, who constitute approximately one half of fatal farm injuries among children.[6,7] Randomized control trials and community-based trials were also rare.

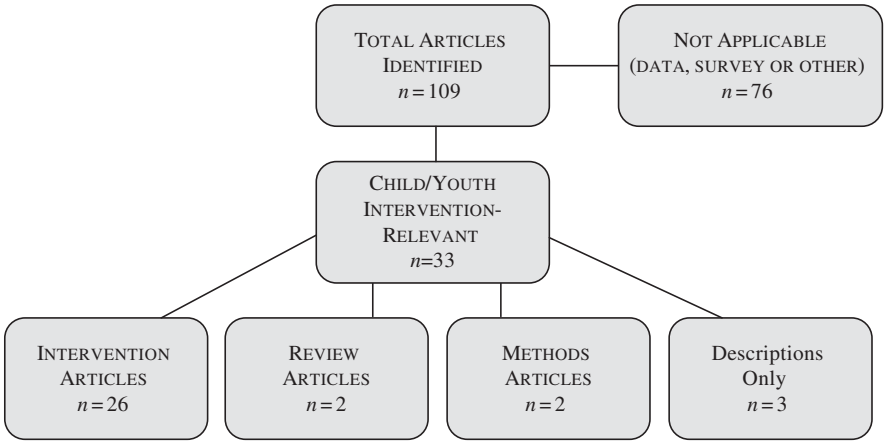
This paper is part of the Blueprint for Knowledge Translation initiative (Lee at al., "Developing the 2012 National Action Plan for Protecting Children in Agriculture"; this issue) to better focus current prevention efforts and move state-of-the-art intervention knowledge into practice. The goal of this paper is to examine what is currently being done to protect children and youth working, visiting or living on US farms since the last general assessment, conducted for the 2001 Summit on Childhood Agricultural Injury Prevention.[8] The specific objectives are to (1) identify strengths and weaknesses in the knowledge base for public health strategies and interventions designed to improve safety for children and youth on farms; and (2) identify challenges to and recommendations for improving child agricultural safety programs, interventions and policies.

In addition to being a more recent review, this paper includes several study variables not included in systematic reviews. For example, it examines the types of evaluation employed in the study: formative, process, impact, outcome (see Box 1). It looks at the role of theory in the design of the intervention.[9] It examines interventions by the five-level socioecological model used in public health as a framework to develop interventions and better understand the effect of potential prevention strategies.[10] This model considers the interplay between the individual [child], interpersonal [parents, peers, teachers with potential to influence the child], institutional [schools, farms, workplaces], community [health organizations, churches, 4-H], and societal/policy [North American Guidelines for Children's Agricultural Tasks—NAGCAT, child labor laws] levels. Interventions are best implemented within and across levels to reduce individual and collective health risks.

METHODS

Published literature from 2001 to early 2009 was identified and reviewed using several terms singularly or in combination that related to children, agriculture, farming, safety, and injury prevention. Searches were conducted through the OVID MEDLINE databases as well as PubMed. The following search terms were used: (safety[tw] OR prevent*[tw] OR control*[tw] OR "prevention and control"[MeSH Subheading]) AND (injur*[tw] OR accident*[tw] OR "Wounds and Injuries"[MeSH] NOT radiat*) AND (agricultur*[tw] OR farm*[tw] OR Agriculture[MeSH]).

FIGURE 1. Literature search results for child agriculture safety interventions.



Titles were screened and abstracts from the search output reviewed. Criteria for study inclusion were the following: intervention involving the population less than 19 years of age, evaluation of some type reported, and carried out in the United States, Canada, or Australia. Using manual review, duplicates and articles that were published earlier than 2001 or in other countries were omitted. Description of a program and reports of injury data and survey results were excluded unless there was an evaluated intervention in the article. The remaining 109 articles included two intervention review articles and were sorted according to Figure 1.

Classification

The articles were classified according to 21 variables using a standardized classification scheme. The scheme was developed based on variables of interest for the Blueprint project (Lee at al., "Developing the 2012 National Action Plan for Protecting Children in Agriculture"; this issue) and through consensus by three researchers connected with the project.

Eligible literature was reviewed by the principal investigator and a research assistant, who was a graduate student in public health who received training regarding classification of articles. Each article was independently reviewed and coded according to the classification scheme. Coding accuracy was examined by comparing independent classifications of randomly selected articles by the research assistant and the principal investigator. Where there was disagreement and/or confusion, discrepancies were resolved through discussion and classification variables were updated and/or more precisely defined to accommodate the project's goals. In several instances, another researcher with a background in children and agriculture was asked to provide an additional opinion.

Preliminary data were presented to a scientific advisory committee of the National Children's Center for Rural and Agricultural Health and Safety. Intervention descriptions were not specific enough to adopt the scientific advisors' recommendations to use the Farm and Agricultural Injury Classification Code[12] or the Safety Hierarchy with its priorities to eliminate the hazard, guard the hazard, or reduce the severity of a hazard.[13] States where the intervention took place was added at the suggestion of the scientific advisors. Variables in the classification scheme included factors such as journal, population demographics, study characteristics, and the use of theoretical frameworks to design the interventions (see Table 1). The data were entered into an Excel file. Descriptive analyses were completed and standard summary statistics are presented.

TABLE 1. Classification Scheme Variables and Subcategories

Variable	Subcategories
Name of journal publication year *Year the article was published.*	• Variable (*Year Range: 2001 to 2009*)
First author	
Peer review status	• Yes, peer-reviewed journal • No, not a peer-reviewed journal • Other
Funder *Entity that provided support for the published research or intervention. May have multiple.*	• NIOSH • Other US Government Agency • Canadian Government Agency • Australian Government Agency • Private—University, Foundation, Corporate • Unknown
Geographic location *Site where intervention took place. May have multiple.*	• USA, State _____ • Canada • Australia • Unknown
Age range *Age of child for which injury prevention outcome is desired. May have multiple.*	• 5 years and under • 6–12 years • 13–19 years • Combination of age ranges
Gender	• Male • Female • Both • Unknown
Special/vulnerable population *Population for which injury prevention outcome is desired. May have multiple.*	• Latino • Hmong • Amish/Anabaptist/Mennonite • Other • Not applicable
Youth work status *Population for which injury prevention outcome is desired. May have multiple.*	• Working on own farm • Working on other farm • Not working on farm • Unknown
Target population *The group or entity in which the intervention was developed to create change. May have multiple.*	• Children • Clinical practitioners • Rural populations (includes parents) • Educators • Other
Type of intervention approach *In which of the three Es the intervention is based. May have multiple.*	• Education • Enforcement • Engineering • Combination of approaches
Socioecological level *Level under which the intervention falls. May have multiple.*	• Individual: *Targets child/young worker directly* • Interpersonal: *Targets population with which child interacts including parents, peers and teachers* • Organizational: *Targets institutions that impacts child's performance, including family farm and other employers, schools* • Community: *Targets groups within the community in which child lives/works including health providers and churches* • Society/Policy: *Targets policies that have potential to protect or affect all child/worker safety if fully implemented including child labor laws, NAGCAT*, tractor certification

(Continued)

TABLE 1. (Continued)

Variable	Subcategories
Study design *Type of design that provides scientific legitimacy to intervention.*	• Randomized control trial • Quasi-experimental design • Other
Evaluation type *May have multiple.*	• Formative • Process • Impact • Outcome
Source of data collection instrument	• Author developed • Adapted from another source • Unknown
Objective/scope *Goal of the intervention. May have multiple.*	• Knowledge change • Attitude change • Behavior change • Organizational change • Policy change • Injury reduction • Other
Use of theory in crafting intervention	• Yes, Type _____ • No
Use of set curriculum or program	• Yes, Specify _____ • No
Outcome *Results and recommendations—free text.*	
Notes *Questions and important issues raised based on the intervention or research.*	

RESULTS

Journal

In all, 26 intervention articles met the criteria for classification. The number of evaluated child agricultural safety intervention articles published from 2001 to early 2009 ranged from two to four in any given year. Overall, the number has been relatively stable for each 2-year period. The 26 articles were published in eight journals, primarily the *Journal of Agricultural Safety and Health* (12), followed by the *Journal of Agromedicine* (4) and the *American Journal of Public Health* (3). Other journals included the *Australian Journal of Public Health* (1), *Injury Prevention* (2), *Journal of Safety Research* (1), *Preventive Medicine* (2), and *Public Health Nursing* (1). Eight of the 26 articles were first authored by two researchers (Marlenga and Reed).

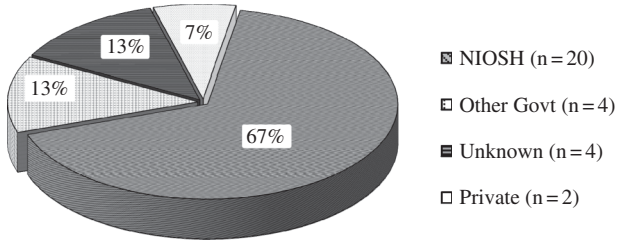
Funder

The National Institute for Occupational Safety and Health (NIOSH) was the funder most often acknowledged, followed by government sources in Canada and Australia and private foundations (see Figure 2). An external funding source was not indicated in four studies. Four of the 26 studies had more than one funder.

Geographic Location

Studies took place in the United States (23), Canada (6), and Australia (1). There was one study in which the location could not be determined. Five of the six Canadian studies were conducted jointly with US sites. The US studies specifically mentioned 24 states as a location, with the largest numbers in Iowa (8), Ohio (7), and Kentucky (7). Most locations were in the Midwest, with nine studies citing

FIGURE 2. Sources of funding for intervention studies (could have more than one).



states in the South (Alabama, Florida, Georgia, Mississippi, Texas), seven in the Northeast (New York, Pennsylvania, Vermont), and four in the West (California, Colorado). In a few studies the location was broadly cited as the West or Midwest.

Demographics

Many studies covered a broad age spectrum that included more than one age range. When multiple age ranges are included, older youth 13 to 19 years of age were most often the targets of the interventions, closely followed by the population 6 to 12 years of age. Few interventions were designed to address safety in the population 5 years of age and under. The majority of studies included both males and females or did not include information on gender. Just four studies focused on the Latino population and one on Anabaptist children. One of the Latino studies also included a small percentage of Hmong and other nationalities. Youth work status was not clearly stated in most studies. In 12 studies, the target population included all possibilities—working on own farm, working on other farm, and not working on a farm.

Target Population

A number of studies targeted more than one population directly for intervention (see Table 2). The majority of studies ($n = 21$) directly targeted children in the interventions. But other populations were also specifically targeted as intermediaries to reach children. Eight studies targeted rural populations such as parents for the intervention. In a few cases, educators ($n = 5$) or clinicians ($n = 1$) were also the focus of interventions.

Intervention Approach

The majority of studies used a solo approach in the intervention (see Figure 3). Education was the primary approach used in intervention studies, representing 18 of the studies for a solo approach, and 20 when there were multiple approaches that included the enforcement approach. Few studies included environmental/engineering or enforcement/regulatory approaches.

Socioecological Model

The number of studies employing more than one level of the socioecological model was equivalent to those employing a single level of the model. Whether one level or more than one level was employed, the individual level was predominant (17 studies) and the societal/policy level was least often the area of focus (5 studies) (see Figure 4).

Study Design

Randomized control trial was the method used in four studies. The others were primarily quasi-experimental design, with great variability in strength of evidence from quasi-experimental crossover design to one group posttest design. Three studies involved task simulations under laboratory conditions. Four studies were classified as retrospective case series. The majority of data collection instruments were developed by the author (24), and two were identified as being adapted from other studies. In many studies,

TABLE 2. Selected Intervention Study Characteristics

Intervention	Author	Target population	Approach (Es)	Eco model level	Evaluation type(s)	Objective/scope	Theory base
Act 455 (WI)	Marlenga et al., 2006[14]	Children 6–12, 13–19	Education Enforcement	Institutional Societal	Process Impact	Policy Injury	No
AgDARE	Reed et al., 2001[15]	Children 13–19	Education	Individual	Impact	Attitude Behavior	Transtheoretical Model of Behavior Learning Theory
	Kidd et al., 2003[16]	Children 13–19	Education	Individual	Impact	Attitude Behavior	Transtheoretical Model of Behavior
	Reed et al., 2003[17]	Children 13–19	Education	Individual	Process Impact	Behavior	Transtheoretical Model of Behavior
	Reed et al., 2004[18]	Children 13–19	Education	Individual	Formative Process Impact	Attitude Behavior	Transtheoretical Model of Behavior Participatory Action Research
Child labor laws	Marlenga et al., 2007[19]	Children 0–5, 6–12, 13–19	Enforcement/Regulation	Institutional Societal	Outcome	Policy Injury	No
ESL teen workers in agriculture	Teran et al., 2008[20]	Latino and Hmong children 13–19 Rural populations	Education	Individual Social	Formative Process Impact	Knowledge Attitude Behavior	English as a Second Language (ESL)
Farm safety day camps	Baker et al., 2001[21]	Educators Rural populations	Education	Community	Formative Process	Organizational	No
Farm Safety 4 Just Kids educational lesson	Burgus et al., 2007[22]	Anabaptist children 6–12, 13–19	Education	Individual Community	Formative Process Impact	Behavior	No
Farm Safety 4 Just Kids safety camp	Reed et al., 2009[23]	Children 6–12	Education	Individual	Formative Process Impact	Knowledge	No
Feed bin design	Allread and Waters, 2007[24*]	Children 6–12, 13–19	Engineering/Environment	Individual	Formative Process Impact Outcome	Injury Other	Ergonomics/Biomechanics
Feed level	Allread and Waters, 2007[24*]	Children 6–12, 13–19	Engineering/Environment	Individual	Formative Process Impact Outcome	Injury Other	Ergonomics/Biomechanics

(Continued)

TABLE 2. (Continued)

Intervention	Author	Target population	Approach (Es)	Eco model level	Evaluation type(s)	Objective/scope	Theory base
Feed transport	Allread and Waters, 2007[24*]	Children 6–12, 13–19	Engineering/Environment	Individual	Formative Process Impact Outcome	Injury Other	Ergonomics/Biomechanics
Kids Count	Liller et al., 2002[25]	Latino children 6–12	Education	Individual Institutional	Formative Process Impact	Knowledge	No
Kids & Communities Count	Liller et al., 2005[26]	Rural populations Latino children 6–12	Education	Individual Social Community	Formative Process Impact	Knowledge Behavior	No
NAGCAT	Marlenga et al., 2002[27]	Rural populations Children 6–12, 13–19	Education	Societal	Formative Process Impact	Knowledge Behavior	Transtheoretical Model of Behavior Adult Learning Theory
	Marlenga et al., 2004[28]	Children 6–12, 13–19	Enforcement	Social Institutional Societal	Impact Outcome	Policy Injury	Child Development
	Gadomski et al., 2006[29]	Rural populations Children 0–5, 6–12, 13–19	Education	Institutional	Process Impact Outcome	Behavior Injury	Child Development.
NSTMOP	Garvey et al., 2008[30]	Educators Children 6–12, 13–19	Education	Individual Institutional Community	Formative Process Impact	Attitude Behavior	No
Ohio Tractor Certificate Program	Heaney et al., 2006[31]	Children 13–19	Education Enforcement	Individual Societal	Formative Process Impact	Policy	No
Partners Program (Future Farmers of America)	Lee et al., 2004[32]	Educators Clinical practitioners Children 13–19	Education	Individual Social Institutional Community	Process Impact Outcome	Knowledge Attitude Behavior Injury	No

Progressive Farmer Farm Safety Day	McCallum et al., 2005[33]	Children 6–12, 13–19	Education	Individual	Process Impact	Knowledge Behavior	No
	McCallum et al., 2006[34]	Educators Rural populations	Education	Social Institutional Community	Process Impact	Knowledge Attitude Behavior	No
Promotor de Salud Pesticide	Liebman et al., 2007[35]	Educators Latino rural populations Children 0–5	Education	Social Community	Process Impact	Knowledge Behavior	Adult Education
Shovel handle design	Kotowski et al., 2009[36]	Children 6–12, 13–19	Engineering/Environment	Individual	Formative Process Impact Outcome	Attitude Injury Other	Ergonomics/Biomechanics
Spot the Hazard	Page et al., 2001[37]	Children 6–12	Education	Individual	Impact	Knowledge Other	Psychology Learning Theory
Wheel barrow design	Kotowski et al., 2009[38]	Children 6–12, 13–19	Engineering/Environment	Individual	Formative Process Impact Outcome	Attitude Injury Other	Ergonomics/Biomechanics

*Allread and Waters appears three times because three different ergonomic modifications were included in one paper (feed bin design, feed level, feed transport method). An article by Day et al. (2008)[39] does not appear in the table because it evaluated different methods of intervention dissemination rather than an intervention per se.
NAGCAT = North American Guidelines for Children's Agricultural Tasks; NSTMOP = National Safe Tractor and Machinery Operation Program.

FIGURE 3. Types of intervention approaches.

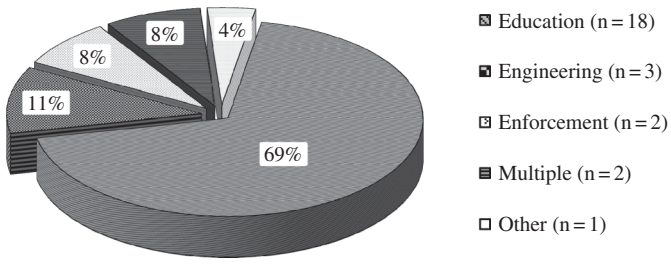
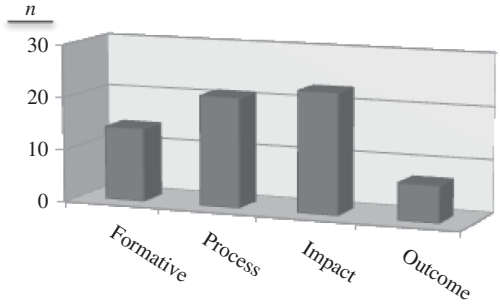


FIGURE 4. Socioecological model (based on Sallis and Owen[10]).

FIGURE 5. Types of evaluation employed (could have more than one).



the instruments had not been subject to validity testing.

Types of Evaluation

By definition for inclusion in this study, all studies had some form of evaluation (see Figure 5). Four studies reported only a single type of evaluation, typically impact evaluation. Seven studies included injury outcome in their evaluation. Most studies used impact evaluation or process evaluation. Just over one half of the studies used formative evaluation. Most studies assessing behavior change used self-report rather than direct observation through farm visits.

Objective/Scope of the Intervention

Most studies ($n = 17$) had two objectives. Only four studies had a single goal and these included evaluation of knowledge, behavior, and policy (see Table 2). Studies with more than one goal were most likely to describe a combination of knowledge, attitude, and behavior change. If single and combined goals are considered together, behavior change predominated (14 studies), followed by knowledge change (11 studies), attitude change (9 studies), and other (7 studies). "Other" goals and objectives included farm equipment design/ergonomic load changes related to reducing risks of injury to the lower back in youth. Eight studies specifically stated injury reduction as a measurable objective, all of which were combined with other goals. Only four studies evaluated policy change as a goal and one evaluated organizational change as a goal.

Use of Theory to Design Interventions

Theoretical principles were incorporated into the design of half of the interventions and four studies used more than one theoretical framework (see Table 2). Behavioral change theories were included in the design of five interventions with the Transtheoretical Model of Stages of Change predominating. Adult[40] and English as a Second Language[20] learning principles were incorporated into five studies and ergonomic principles into three studies. Other theoretical foundations included child development principles, participatory action research, and psychology.

Use of an Identifiable Curriculum or Program

Twenty studies included a specified curriculum, program, or equipment design for the intervention (see Table 2). The focus of noncurriculum evaluations included the North American Guidelines for Children's Agricultural Tasks (NAGCAT) ($n = 3$), equipment design ($n = 4$), Future Farmers of America (FFA) Partners for A Safer Community ($n = 1$), Promotoras de Salud ($n = 1$), and child labor laws ($n = 1$).

Shortcomings of Evaluated Studies

Although many of the studies reported positive changes following the interventions, there were problematic design issues and evaluation deficiencies that should not be overlooked because they have significant implications for predicting long-term injury prevention outcomes. Major concerns with the evaluated interventions in this review were the following:

1. Self-reported behaviors and intentions to change behavior were used to measure success.
2. There often was a low response rate in data collection and intervention participation.
3. Baseline measures were often lacking.
4. There was a focus on short-term retention of knowledge and behavior.
5. Studies were limited in their use of randomization and control groups.
6. Few interventions attempted to assess injury risk reduction.
7. Several interventions were broadly targeted on general farm safety issues rather than on high-risk activities.
8. The majority of evaluated interventions addressed the individual level of the socioecologic model, which tends to be the least successful intervention especially when used in isolation.

Such shortcomings result in weak intervention design, create biases, reflect on validity of study results, and make it difficult to interpret the findings.

DISCUSSION

There are a number of important insights gleaned from this review that warrant discussion. We identified 26 studies evaluating the effectiveness of interventions aimed at preventing farm-related injuries to children less than 19 years of age in the period 2001 to early 2009. Of these, four were identified as published in peer-reviewed journals and five were identified as presentation or extramural research abstracts in Hartling et al.'s review of interventions to prevent injuries to children on farms during the period 1980–2002.[4] All of these latter abstracts became peer-reviewed publications that were subsequently identified in our study. Like Hartling, we found mixed results in a number of studies, weak methods in many, and a lack of randomized controlled trials, in particular. Although this review is 5 years later and had different criteria for inclusion, we also found that most interventions focused only on education as a strategy and behavior change and knowledge acquisition as the objective. Our review indicates that although more studies have been published in recent years, the quality of the research and the intervention design has not necessarily improved.

Funding Sources

It is somewhat disheartening that there are so few funders other than NIOSH supporting

the evaluation of child agricultural safety initiatives. Although the Canadian government has partnered with NIOSH on a few occasions, there is a great need for more research collaborations that foster multiple sources of support. These include other government agencies, such as the Department of Agriculture (USDA), other centers within the Centers for Disease Control and Prevention (CDC), Maternal and Child Health Bureau within Health Resource Services Agency (HRSA), and the National Institute of Child Health and Human Development; as well as nongovernmental sources such as foundations. Given that there were limited reported interventions focused on special populations at higher risk of fatal and nonfatal injuries, these deserve attention and may offer some unique possibilities for funding related to disparities. For example, the Paso del Norte Health Foundation provided resources to evaluate an intervention that used Promotoras de Salud to address pesticide poisoning among the young children of Latino farmworkers.[35]

Target Population of Intervention

The majority of interventions targeted children 13 to 19 and 6 to 12 years of age, indicating a mismatch between intervention targets and current mortality data[6,7] where there is a great need for interventions for children 5 years of age and under. The number of studies that cover a spectrum of age ranges within one intervention suggests that basic child development principles (physical, cognitive, and emotional capacity) and principles of learning are not being applied.

Youth work status was not clearly stated in most studies. In 12 studies, the target population included all possibilities—working on own farm, working on other farm, and not working on a farm. Unfortunately, a one-size-fits-all approach minimizes potential impact. Audience segmentation of those with shared or selected characteristics is a tenet of social marketing and health communication principles.[41] The importance of segmenting the target audience by work status and by ages that more closely align with child development will improve effectiveness of messaging for interventions. Along the same vein, strategies employing social media and other new communication technologies did not appear in this review, but these are timely approaches that should be integrated within intervention research and its dissemination to the different audiences (Gualtieri, "The Potential for Social Media to Educate Farm Families about Health and Safety for Children"; this issue).

Socioecological Level of Approach

The public health model emphasizes the importance of reducing risks for injury that are targeted for a specific population using interaction across a continuum of strategies and the socioecological model draws attention to these. At the interpersonal level, peers, parents, and teachers can promote positive behavior change and reduction in risks through their actions and in their choices that affect and support the child. The institutional level speaks to the impact on farm safety by an organization, school, or workplace. Interventions at the community level make use of how community organizations interact with each other to influence the culture of health and safety. This is an important level because the more support one has, the stronger the intervention will be, whether it is in terms of financial support, policy support, or community resources and collaboration. An example of this is involving health care providers or 4-H organizations in educational and policy efforts. Finally, the societal level represents guidelines, standards, and policies that influence and instruct agricultural safety from a broader standpoint. This includes voluntary work guidelines such as NAGCAT and child labor regulations that are less dependent solely on voluntary behavior change. In the socioecological framework education, engineering and enforcement approaches are cross cutting and may be included in different ways in each level of the model.

Our review revealed that the individual child was the focus in most single-level prevention interventions and, according to the socioecological model, these would have the weakest long-term results. With much of the current emphasis on educating youth as individuals, serious thought needs to be given to expanding

the intervention focus to parents, the community, and the larger societal level via policy and guidelines such as NAGCAT. Since parents bear the responsibility and accountability for assignment of many of the farm tasks,[42] the question is how to shift the intervention focus from the individual to the interpersonal level of the socioecological model. But it is not just about changing parental perceptions of risks[43] and underlying adult decisions. The approach taken by the Sustainable Farm Families Project in Australia is one that is focused on changing attitudes of farm families and fostering a community culture of safety.[44] This Australian approach should be carefully followed for applicable results. In short, more interventions should consider a continuum of activities that address multiple levels of the socioecological model and address cultural norms. Such strategy has been recommended and noted as a promising approach in the area of tobacco control[45,46] where smoking has been reduced in some states that systematically apply multiple levels of intervention while focusing on changing cultural norms.

Theoretical Framework

Behavioral change theories have been successfully employed in addressing other public health issues.[47] A particular concern is that half of the identified studies did not have a theoretical framework for the intervention. The Transtheoretical Model (TM), or Stages of Change Theory,[48] seems the most relevant for the development and evaluation of child agricultural safety interventions[16] and was cited in five studies. It allows interventions to do more than focus on knowledge and attitude change followed by a leap to behavior change. Each TM stage is a milestone in achieving behavior change, as five stages lead to continued performance of a desired behavior: (1) Pre-contemplation; (2) Contemplation; (3) Preparation; (4) Action; and (5) Maintenance.

TM can demonstrate movement toward a desired behavior in concrete increments, and it fills a gray area between knowledge/attitude and behavior and behavior and injury risk. For example, it does not necessarily make sense to model safe protective behaviors for adolescent farmworkers who do not consider themselves at risk for injury; one would first want to raise awareness (or knowledge) by introducing the idea of workplace safety. Once convinced of the risk and farmworker safety is contemplated, the next goal is to get them to *intend* to practice safe work habits (positive attitude), by sharing strategies and the benefits of adopting safe practices. When the intention has developed, they are ready to prepare for safe work practices, at which point behaviors might be modeled. After this, the adolescent farmworker is ready to put all they have learned into action. Once proper behavior has been demonstrated, it is hoped they will stay in the maintenance stage. TM also provides guidance on how to proceed if a target audience moves backward. For example, if an adolescent farmworkers stops performing a certain safety behavior, a refresher intervention may be needed at the preparation level.

Safety Hierarchy

The industrial safety and health approach often refers to the "Three Es" of engineering, education, and enforcement. Although there are variations of what should be included in a safety hierarchy, almost all are in agreement that education, awareness, training, and warnings, which rely on the behavior of an individual, are a less desirable approach to safety. Elimination of the hazard, typically through engineering design changes or separation from the hazard through removal of children from the workplace, are deemed the more effective strategies to prevent injuries.[49] Although these latter approaches may not be widely popular, each strategy has an important role to play in preventing injuries to children and youth in farm settings. New on the intervention horizon for children are studies relevant to ergonomic loads on children performing farm tasks. Although promising, the equipment design changes in the reported studies had mixed results. Some of the farm tasks in these studies used tasks outlined in NAGCAT and would seem to be an important new direction for research related to reducing injuries in youth. The modification of current farm tools

and equipment so as to make them more compatible with the physical characteristics of youth will require engagement of researchers with backgrounds in biomechanics and ergonomics. The authors also note that this will require a shifting of attitudes and habits so as to gain compliance by youth.[24,36,38] Caution must be taken that modification of tools and equipment for youth does not make it more acceptable for youth to perform hazardous work.

Evaluation Approach

A number of studies restricted evaluation methods to impact and process measures. Formative research is essential to understand the characteristics and needs of a specific population being targeted and then to tailor interventions to their current level of knowledge, attitudes, and behavior. Formative evaluation also assures that there is consistency between the injury problem we are trying to prevent and the content of the intervention.[14] Without formative evaluation prior to designing and implementing an intervention, the chances of developing an effective strategy with appropriate communication channels for influencing behavior change are slim. The results of the FFA's Partners for a Safer Community Program also points out the importance of testing an initiative for efficacy before rolling it out on a national scale.[32]

Fewer than 30% of studies included an outcome evaluation to examine longer-term changes with injury occurrence as the measurement. Outcome evaluations are frequently more costly and involve an extended period of time and commitment. Yet, if we are serious about addressing injuries to children in agriculture, there must be increased efforts to include outcome evaluation so that scarce resources may be used more wisely. Return on investment is an additional approach used in health services research that may prove helpful in evaluating interventions.[50,51]

LIMITATIONS

It is possible that some evaluated intervention articles on child agricultural safety were not identified during the time period of our review. Additionally, we did not report studies currently underway and identifiable through conference proceedings and abstracts, funded grant abstracts, unpublished dissertations, and government reports. Misclassification of study variables may have occurred despite discussion and resolution of discrepancies between two independent and sometimes a third researcher. Further, there could be interventions underway that are not being subjected to systematic evaluation, yet may be experiencing positive outcomes. Finally, there may be underrepresentation of formative evaluation studies that precede the reported study because pilot studies are not necessarily submitted or accepted for publication.

Researchers sometimes failed to provide clear descriptions to be able to differentiate between children's ages and work status. Variables were coded based on what was explicitly written in the publication rather than on assumptions that could be made. As a result, generalizability to specific populations is not possible. The socioecological model, study goals, and target population were categorized from the intervention plan. In a few cases, the authors did not report results because of poor response rate or other methodological issues. Despite these limitations, this review still provides an indication of some of the strengths and weaknesses of current interventions and the challenges to reducing agriculture-related injuries to children.

CONCLUSION

It has long been established in the field of injury prevention that it is important to combine a range of efforts and maintain a diversity of injury prevention strategies to alter unsafe behaviors and change social norms; make the physical environment, products, and equipment less hazardous through engineering and design changes; convince policy makers to take action through education, and establish safety standards, regulations, and guidelines, and apply enforcement tools to motivate compliance with same.[52] Providing effective protection for children and adolescents on the farm requires a mix of these strategies. These include farm equipment design and other passive safety features,

job training by the employer, adequate supervision, matching required job tasks with adolescent development, informing parental attitudes about children working on the farm, training youth about hazards and risk avoidance on the farm site, and better public information and education about aspects of hazardous orders and their enforcement, among others. In addition, it may be advantageous to consider who is in the best position to reach more vulnerable populations, for example, community health workers[35,53] or English as a Second Language instructors.[20]

There are a very limited number of empirically sound intervention evaluation studies demonstrating successful strategies for reducing childhood agricultural injuries. Although we know that education of children alone is an insufficient method for keeping children safe and preventing injuries, for the most part, the field still seems to be "stuck" in that mode and has not matured and expanded to encompass a broader range of efforts that may be more effective. At the same time, there seems to be an increasing number of stakeholders involved in the development of programs and curricula for elementary and high school–aged youth.

Guidance and training on the elements of developing an intervention, proper channels of communication, and evaluation are much needed. Topics for such guidance and training would include (a) how to ensure that scientific data are used in development of interventions; (b) how to improve the targeting and design of interventions; (c) how to expand focus beyond the individual child; (d) how to engage additional partners in intervention programs and research; e) how to develop and use evaluation tools; (f) how to more widely replicate and disseminate successful interventions; and (g) how to demonstrate effectiveness of these interventions in real world settings.

Recommendations for the Future

1. Develop a strategy to improve collaborations and broaden the array of funders for intervention development, implementation, and evaluation.
   - Publication of child agricultural safety intervention research in journals that cover broader health topics should help bring attention to potential stakeholders.
2. Include theoretical frameworks and formative research in the conceptualization of interventions before implementation occurs.
   - Funders should ensure that these components have been included in the design of all interventions prior to awarding funds and that these be published, otherwise referenced, or clarified by interviewing the lead researcher for an intervention evaluation.
3. Create more partnerships between researchers and intervention programs to provide rigorous evaluation of existing and new interventions.
   - Enhanced collaboration among researchers and those carrying out interventions should improve the quality of research designs for evaluating child agriculture injury prevention and related public health initiatives. Future evaluations should consider return on investment as a method.
4. Develop comprehensive intervention strategies that incorporate several levels of the ecological model, various segments of the population, include elements beyond educational strategies in their approach, and use currently available data to target leading injury risks.
   - More engineering, policy development, and regulatory solutions must be utilized in order to produce substantial (or sustainable) safety benefits for children working in agriculture.
5. Provide guidelines, training, or technical assistance to all stakeholders engaged in the development, implementation, evaluation, and/or funding of child agriculture safety interventions.
   - Effective planning and delivery of child agriculture safety interventions should be enhanced by conducting a needs assessment to determine current knowledge of interventions, barriers, and facilitators to employing best

practice, and tools and training needed to improve effectiveness and use of resources.

6. Improve dissemination of effective interventions so that parents, farm owners, agricultural safety organizations, intervention implementers, funders, and other policy makers are fully aware of what works, what shows promise and what does not work in creating safe environments for children and youth in agriculture.
   - Building a system of resources and compendiums of knowledge such as a clearinghouse to support implementation of evidence-based interventions and research that addresses knowledge gaps will be necessary to achieve this recommendation. Social media applications will provide increased opportunities for collecting and sharing these tools and the experiences of those who use them.
7. Engage the medical establishment, clinicians, and community health workers in addressing the problem of injuries and deaths in rural farm populations.
   - Given the respect allocated to the medical community and the acceptance of community health workers by many populations, ways must be identified to utilize health and emergency medical professionals in promoting agricultural safety with the families and communities they serve. Better acquaintance of these professionals with the state of the art in child agricultural safety should promote participation in activities such as identification of injury risk factors with farm parents of patients, counseling with patients and parents to reinforce safe practices on the farm, and becoming a source of information to influence public opinion and public policy.
8. Expand the number of academic centers that focus on and train undergraduates, graduates, and professionals in the use of comprehensive, theoretically based safety intervention strategies and evaluation methods.
   - Develop a core set of competencies for professionals that addresses the roles they may play and the skills they need as practitioners and researchers working on increasing safety and reducing hazards to children in agricultural settings.

REFERENCES

1. Hard DL, Myers JR. Fatal work-related injuries in the agriculture production sector among youth in the United States, 1992–2002. *J Agromedicine*. 2006;11: 57–65.

2. Centers for Disease Control and Prevention, NIOSH. *Trends in Childhood Agricultural Nonfatal Injury Rates, 1998–2009.* Internal analysis of the Childhood Agricultural Injury Survey (CAIS) surveillance system. Morgantown, WV: National Institute for Occupational Safety and Health; 2010. Available at: http://www.cdc.gov/niosh/docs/2011-129/. Accessed March 13, 2012.

3. DeRoo LA, Rautiainen RH. A systematic review of farm safety interventions. *Am J Prev Med*. 2000;18:51–62.

4. Hartling L, Brison RJ, Crumley ET, Klassen TP, Pickett W. A systematic review of interventions to prevent childhood farm injuries. *Pediatrics*. 2004;114: e483–e496.

5. Rautiainen RH, Lehtola MM, Day LM, et al. Interventions for preventing injuries in the agriculture industry. *Cochrane Database Syst Rev*. 2008;(1).CD006398

6. Brison RJ, Pickett W, Berg RL, Linneman J, Zentner J, Marlenga B. Fatal agricultural injuries in preschool children: risks, injury patterns and strategies for prevention. *CMAJ*. 2006;174:1723–1726.

7. Pickett W, Brison RJ, Berg RL, Zentner J, Linneman J, Marlenga B. Pediatric farm injuries involving non-working children injured by a farm work hazard: five priorities for primary prevention. *Inj Prev*. 2005;11:6–11.

8. Lee B, Gallagher S, Marlenga B, Hard D, eds. *Childhood Agricultural Injury Prevention: Progress Report and Updated National Action Plan from the 2001 Summit*. Marshfield, WI: Marshfield Clinic; 2002.

9. Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. *Am J Health Promot.* 1997;12:38–48.

10. Sallis JF, Owen N. Ecological models of health behavior. In: Glanz K, Lewis FM, Rimer BK, eds. *Health Behavior and Health Education: Theory, Research, and Practice*. San Francisco, CA; Jossey-Bass; 2002:462–484.

11. Christoffel T, Gallagher SS. *Injury Prevention and Public Health: Practical Knowledge, Skills and Strategies*. Sudbury, MA; Jones and Bartlett; 2006:382–387.

12. Murphy DJ, Purschwitz M, Mahoney BS, Hoskin AF. A proposed classification code for farm and agricultural injuries. *Am J Public Health*. 1993;83:736–738.

13. Barnett RL, Brickman DB. Safety hierarchy. *J Safety Res.* 1996;17:49–55.

14. Marlenga B, Doty BC, Berg RL, Linneman JG. Evaluation of a policy to reduce youth tractor crashes on public roads. *Inj Prev.* 2006;12:46–51.

15. Reed DB, Kidd PS, Westneat S, Rayens KM. Agricultural Disability Awareness and Risk Education (AgDARE) for high school students. *Inj Prev.* 2001;7: 59–63.

16. Kidd P, Reed D, Weaver L, Westneat S, Rayens MK. The transtheoretical model of change in adolescents: implications for injury prevention. *J Saf Res.* 2003;34: 281–288.

17. Reed DB, Westneat SC, Kidd P. Observation study of students who completed a high school agricultural safety education program. *J Agric Saf Health.* 2003;9:275–283.

18. Reed DB, Kidd PS. Collaboration between nurses and agricultural teachers to prevent adolescent agricultural injuries: the Agricultural Disability Awareness and Risk Education Model. *Public Health Nurs*. 2004;21: 323–330.

19. Marlenga B, Berg RL, Linneman JG, Brison RJ, Pickett W. Changing the child labor laws for agriculture: impact on injury. *Am J Public Health.* 2007;97:276–282.

20. Teran S, Strochlic R, Bush D, Baker R, Meyers J. Reaching teen farm workers with health and safety information: an evaluation of a high school ESL curriculum. *J Agric Saf Health*. 2008;14:147–162.

21. Baker AE, Esser NM, Lee BC. A qualitative assessment of children's farm safety day camp programs. *J Agric Saf Health.* 2001;7:89–99.

22. Burgus S, Rademaker A. Testing a novel child farm safety intervention for Anabaptist audiences. *J Agromedicine*. 2007;12:63–70.

23. Reed DB, Claunch DT, Rayens MK. FS4JK farm safety day camps: who learns the most? *J Agric Saf Health.* 2009;15:5–17.

24. Allread WG, Waters TR. Interventions to reduce low-back injury risk among youth who perform feed handling and scooping tasks on farms. *J Agric Saf Health.* 2007;13:375–393.

25. Liller KD, Noland V, Rijal P, Pesce K, Gonzalez R. Development and evaluation of the kids count farm safety lesson. *J Agric Saf Health.* 2002;8:411–421.

26. Liller KD, Pintado I. Kids and communities count: Reaching migrant children and families with the North American Guidelines for Children's Agricultural Tasks (NAGCAT). *J Agric Saf Health.* 2005; 11: 365–372.

27. Marlenga B, Pickett W, Berg RL. Evaluation of an enhanced approach to the dissemination of the North American Guidelines for Children's Agricultural Tasks: a randomized controlled trial. *Prev Med.* 2002;35: 150–159.

28. Marlenga B, Brison RJ, Berg RL, Zentner J, Linneman J, Pickett W. Evaluation of the North American Guidelines for Children's Agricultural Tasks using a case series of injuries. *Inj Prev.* 2004;10:350–357.

29. Gadomski A, Ackerman S, Burdick P, Jenkins P. Efficacy of the North American Guidelines for Children's Agricultural Tasks. *Am J Public Health*. 2006;96: 722–727.

30. Garvey PM, Murphy DJ, Yoder AM, Hilton JW. National safe tractor and machinery operation program: development and content evaluation. *J Agric Saf Health.* 2008;14:333–349.

31. Heaney CA, Wilkins JR 3rd, Dellinger W, et al. Protecting young workers in agriculture: participation in tractor certification training. *J Agric Saf Health.* 2006;12:181–190.

32. Lee BC, Westaby JD, Berg RL. Impact of a national rural youth health and safety initiative: results from a randomized controlled trial. *Am J Public Health*. 2004;94:1743–1749.

33. McCallum DM, Conaway MB, Drury S, Braune J, Reynolds SJ. Safety-related knowledge and behavior changes in participants of farm safety day camps. *J Agric Saf Health*. 2005;11:35–50.

34. McCallum DM, Reynolds SJ, Kelley SC, Conaway MB, Braune J. The community benefits of farm safety day camps. *J Agric Saf Health*. 2006;12:335–348.

35. Liebman AK, Juarez PM, Leyva C, Corona A. A pilot program using Promotoras de Salud to educate farmworker families about the risks from pesticide exposure. *J Agromedicine*. 2007;12:33–43.

36. Kotowski SE, Davis KG, Waters TR. Investigation of select ergonomic interventions for farm youth. Part 1: shovels. *J Agromedicine.* 2009;14:33–43.

37. Page AN, Fragar LJ. Recall of farm hazards in Australian primary school age children using a 3-D visual cue test. *Aust J Rural Health.* 2001;9:216–221.

38. Kotowski SE, Davis KG, Waters TR. Investigation of select ergonomic interventions for farm youth. Part 2: wheelbarrows. *J Agromedicine*. 2009; 14:44–57.

39. Day L, Dosman J, Hagel L, et al. Application of novel communication technologies to the study of farm families: a randomized controlled trial. *Prev Med.* 2008;46:364–369.

40. Knowles MS. *Andragogy in Action: Applying Modern Principles of Adult Learning*. San Francisco, CA: Jossey-Bass; 1984.

41. Parvanta C, Nelson DE, Parvanta SA, Harner RN. *Essentials of Public Health Communication*. Sudbury, MA: Jones & Bartlett; 2011.

42. Pickett W, Marlenga B, Berg RL. Parental knowledge of child development and the assignment of tractor work to children. *Pediatrics.* 2003;112:e11–e16.

43. Zentner J, Berg RL, Pickett W, Marlenga B. Do parents' perceptions of risks protect children engaged in farm work? *Prev Med*. 2005;40:860–866.

44. Brumby SA, Willder SJ, Martin J. The sustainable farm families project: changing attitudes to health. *Rural Remote Health*. 2009;9:1012. Available at: http://www.ncbi.hlm.nih.gov/pubmed/19292570. Accessed March 13, 2012.

45. Lantz PM, Jacobson PD, Warner KE, et al. Investing in youth tobacco control: a review of smoking prevention and control strategies. *Tob Control*. 2000;9:47–63.

46. Centers for Disease Control and Prevention. *Best Practices for Comprehensive Tobacco Control Programs—2007*. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; October 2007.

47. Gielen AC, Sleet D. Application of behavior change theories and methods to injury prevention. *Epidemiol Rev*. 2003;25:65–76.

48. Prochaska JO, Redding CA, Evers KE. The transtheoretical model and stages of change. In: Glanz K, Rimer BK, Lewis FM, eds. *Health Behavior and Health Education: Theory, Research, and Practice*. San Francisco, CA: Jossey-Bass; 2002;99–120.

49. Murphy DJ. *Safety and Health for Production Agriculture. American Society of Agricultural Engineers Textbook No. 5*. St. Joseph, MI: ASAE; 1992.

50. Shiel A, Di Ruggiero E. Assessing the return on Canada's public investment in population and public health research methods and metrics. In *Return Investment in Health Research.* Ottowa: Canadian Academy of Sciences; 2009; A42–74.

51. Canadian Academy of Health Sciences. *Making an Impact: A Preferred Framework and Indicators to Measure Returns on Investment in Health Research.* Report of the Panel on Return on Investment in Health Research. Ontario: Canadian Academy of Health Sciences 2009. Available at: http://www.cahs-acss.ca/wp-content/uploads/2011/09/ROI_FullReport.pdf. Accessed March 13, 2012.

52. Haddon W, Baker SP. Injury control. In: Clark D, MacMahon B, eds. *Preventive and Community Medicine*, pp. 109–140. Boston, MA: Little Brown; 1981.

53. Forst L, Lacey S, Chen HY, et al. Effectiveness of community health workers for promoting use of safety eyewear by Latino farm workers. *Am J Ind Med*. 2004;46:607–613.