A Systematic Review of Interventions to Prevent Childhood Farm Injuries

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ABSTRACT. Objective. The goal of the study was to systematically review the global body of evidence surrounding the effectiveness of interventions for the prevention of acute pediatric agricultural injuries. A specific focus was the effectiveness of the North American Guidelines for Children’s Agricultural Tasks.

Methods. Two reviewers independently screened studies and applied inclusion criteria on the basis of searches of 17 bibliographic databases (eg, Medline and Embase). We also screened reference lists of relevant studies and contacted experts in the area. Studies were included if they represented primary research, a comparison group was used, the study population included children or the intervention was directly applicable to children, and objective outcomes were reported. Two reviewers independently assessed the methodologic quality of included studies with the Downs and Black checklist. A qualitative analysis was performed because of extensive heterogeneity among studies.

Results. We included 23 controlled studies, ie, 4 randomized, controlled trials, 5 controlled trials, and 14 quasiiexperimental or observational studies. Only 8 of the relevant studies were published in peer-reviewed journals. School-based programs appeared to be effective at increasing short-term knowledge acquisition; outcomes were enhanced with active, hands-on participation, as opposed to passive activities. Safety day camps showed positive results for knowledge acquisition. Tractor training programs and community- and farm-based interventions showed mixed results. Studies examining the North American Guidelines for Children’s Agricultural Tasks suggested that uptake improves if dissemination is accompanied by a farm visit from a safety specialist or if information about child development principles is provided in conjunction with the guidelines.

Conclusions. There is a lack of randomized, controlled trials and community-based trials in this area. Studies primarily examined intermediate outcomes, such as knowledge acquisition; few studies evaluated changes in injury rates. The interventions targeted at children and youths that were evaluated focused on educational interventions. There is both the need and potential for the development and evaluation of injury control interventions for children, particularly programs addressing lethal injuries to young/preschool-aged children. Pediatrics 2004;114:e483–e496. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2003-1038-L; wounds and injuries, agriculture, systematic review.

ABBREVIATIONS. NAGCAT, North American Guidelines for Children’s Agricultural Tasks; ROPS, rollover protection structures; QI, quality index; RCT, randomized, controlled trial; IQR, interquartile range.

This review was conducted to gather evidence regarding methods to reduce the burden of injuries experienced by children on farms. The objective was to conduct a high-quality systematic review to synthesize the evidence on the effectiveness of interventions to prevent the occurrence of childhood injuries in agricultural settings.

The North American Guidelines for Children’s Agricultural Tasks (NAGCAT) provide a good example of an educational intervention that may hold promise but has not been subjected to rigorous evaluation. The NAGCAT are a set of consensus guidelines developed to assist farm parents in assigning appropriate and safe work to their children 7 to 16 years of age (www.nagcat.org).1 Since their introduction in 1999, the efficacy of NAGCAT has been the topic of considerable debate. Nonetheless, NAGCAT have been widely distributed and used by agricultural communities across North America and Europe. This review therefore also focused on evidence surrounding the efficacy of NAGCAT and their effective dissemination.

Childhood agricultural injuries represent an important public health problem. Farm children experience high rates of premature death,2•4 morbidity,5•6 and disability7 attributable to injury. Children account for ~19% of all agricultural injury fatalities and hospitalizations.8 The direct and indirect economic costs attributable to farm injuries are substantial. Leigh et al9 estimated the costs of agricultural occupational injuries in the United States in 1992 to be $4.57 billion annually, for all age groups combined. In Ontario, costs for children (0–14 years of age) represent 23.6% of all costs related to agricultural machinery injuries.10

Many pediatric farm injuries occur because children are exposed to specific occupational hazards.2•6 There are 3 main approaches to the protection of children from workplace injuries: (1) occupational health and safety regulations; (2) modifications of the work environment (eg, engineering controls); and (3) education about known hazards.

In nonagricultural industries, there are regulations and work standards that outline appropriate work
tasks for both adults and children. These are uncommon for childhood farm safety but have been shown to be efficacious in other occupational settings. Children from family farms are exempt from most regulatory policies aimed at occupational safety and child labor regulations. Much of the work performed by children on farms is therefore unregulated. In addition, there are few regulations regarding bringing children into the farm workplace, even if they are not involved in farm work.

As discussed recently, the historical reasons for the lack of work standards on farms are complex. In general, the lack of standards is related to the value placed on independence and self-sufficiency in rural societies. Consequently, there is a reliance on voluntary safety standards, which may or may not be effective. Farm groups have been known to resist actively the institution of rules and regulations. This has resulted in farm children being exempt from most health and safety legislation despite the fact that they live and work in an occupational environment with known hazards.

Engineering controls have great potential to be effective in preventing farm injuries, but only if they are voluntarily adopted by farmers. One of the most common forms of engineering control on farms is rollover protection structures (ROPS) on farm tractors; the use of ROPS in Scandinavia has historically reduced the tractor rollover-related death rate to 0. The American Society of Agricultural Engineers has introduced a voluntary standard for inclusion of ROPS as standard equipment on new tractors. However, substantial numbers of North American farm children are operating tractors that are not equipped with ROPS. This suggests that reliance on a voluntary system for engineering controls is insufficient to protect many farm children from known occupational hazards.

Educational initiatives are the most commonly used approaches in farm injury prevention. These are generally considered to be less effective than engineering and regulatory initiatives in preventing injuries. Educational approaches may be useful as a means to increase awareness of injury control issues and to change attitudes toward them. However, educational approaches are heterogeneous and may produce varied results. It is clear that not all farm parents embrace educational messages. Furthermore, even if these messages are embraced, the acquisition of knowledge may not lead to changes in safety practices. This finding is consistent with much of the summarized injury prevention literature on agricultural safety programs, not only those involving children.

METHODS
Identification of the Literature

Reference lists of the included studies and other related studies were checked for potentially relevant articles. Content experts and an author of each included study were contacted for information on additional studies. The conference proceedings of the American Public Health Association were searched for the years 2001 to 2003 (because this was expected to identify NAGCAT-related research). Finally, the listing of extramural research awards funded under the National Institute for Occupational Safety and Health Childhood Agricultural Injury Prevention Initiative was reviewed to identify other relevant projects (www.cdc.gov/niosh/childag/ChildAgExtramuralResearch.html).

Both published research and unpublished research were considered for inclusion. We identified completed as well as ongoing research. The search was not restricted according to language of publication.

Selection of Eligible Studies
The identification of relevant studies involved 2 steps. First, 2 reviewers independently screened the titles and (when available) abstracts from the search output. Second, we obtained the full text of potentially relevant studies, and the 2 reviewers assessed each study by using a standard form with predetermined inclusion criteria. We resolved discrepancies with discussion between the 2 reviewers and with a third reviewer if necessary.

Included studies met the following criteria: (1) primary research evaluating the efficacy or dissemination of NAGCAT or the efficacy of other interventions to prevent acute childhood farm injuries; (2) inclusion of a comparison group (eg, controlled trial, before/after, or cohort design); (3) study population involving any age group as long as the study was relevant to children; and (4) report of at least 1 objective quantified outcome (eg, occurrence of injuries, uptake of guidelines, changes in behavior or attitudes, or knowledge acquisition). Studies were excluded if they simply described a program, if they provided an evaluation with no comparison group, or if the intervention specifically targeted adults.

Quality Assessment
The methodologic quality of included studies was assessed with a partially validated checklist developed by Downs and Black. This tool measures quality in terms of reporting, external validity, internal validity (bias and confounding), and power, with a maximal quality index (QI) of 29. QI scores of 20 were considered good, 11 to 20 moderate, and <11 poor. Two reviewers assessed study quality independently and resolved discrepancies through discussion. Quality was assessed only for published reports, internal reports, and reports from conference proceedings. Abstracts, presentations, and Web sites were not assessed for quality, because they did not provide enough detail for accurate assessment.

Data Extraction and Synthesis
Data were extracted directly into Microsoft Excel (Microsoft, Redmond, WA) by 1 reviewer and were checked for completeness and accuracy by a second reviewer. The following information was recorded for each study: year of publication, country where the study was conducted, study design, objectives, intervention and comparison groups, characteristics of the study population, number of participants, outcomes, type of injury targeted, study setting, results, authors’ conclusions, and study limitations reported by the authors.

Our approach to analysis was qualitative rather than quantitative. A meta-analysis was not conducted because of extensive heterogeneity in terms of the interventions, study populations, and outcomes. Results were organized according to the 2 review questions.

RESULTS
Results of Literature Searches
Figure 1 presents the selection process for including studies in the review. A total of 23 studies were included (22 were controlled studies) (Tables 1–4). A
list of excluded studies (and the reasons for exclusion) is available from the authors.

Effectiveness and Dissemination of NAGCAT

No studies evaluating the effectiveness of NAGCAT that met our inclusion criteria were found; specifically, there were no studies with comparison groups (ie, controlled, before/after, or cohort designs). However, 1 study evaluated the effectiveness of NAGCAT with a case-series design. The researchers applied the guidelines to a series of cases of pediatric farm injuries to determine whether the use of NAGCAT could have prevented the injury. As determined with expert review, approximately one-half of the cases for which a relevant guideline existed could have been prevented.

Two randomized, controlled trials (RCTs) examined the effects of different dissemination strategies for NAGCAT. One study evaluated parental use and knowledge of NAGCAT at 6 and 15 months after intervention, whereas the other study measured injury incidence during a 2-year surveillance period. One study was published in a peer-reviewed journal in 2002 and was of rigorous methodologic quality (QI: 29 of 29), and the other study is ongoing. The studies showed that enhanced or active dissemination of NAGCAT improved outcomes, compared with standard dissemination strategies.

An additional 2 ongoing studies involving NAGCAT were identified through the National Institute for Occupational Safety and Health list of extramural research. One study is exploring factors that might explain the discrepancy between the content of the guidelines and parents’ practices concerning assignment of tasks to children. The second study will evaluate the impact of adapting NAGCAT for ethnic communities.

Effectiveness of Other Interventions to Prevent Childhood Agricultural Injuries

We identified 20 studies that evaluated the effectiveness of interventions to prevent childhood agricultural injuries. The studies varied widely in the interventions and outcomes studied, the types of injury targeted by the interventions, and the study design and methodologic rigor (QI range: 11–20). Although all studies evaluated educational interventions, their focuses varied; 7 were designed for, or examined in, the school setting, 12 were community-based, and 1 was designed for use on the farm.

The most commonly assessed primary outcome was knowledge acquisition. The timing of this measure varied, ie, immediately after the intervention (n = 2), 1 day after the intervention (n = 1), 1 week after the intervention (n = 1), 4 weeks after the intervention (n = 1), 1 year after the intervention (n = 1), and not specified (n = 7). Ten studies measured changes in safety attitudes and/or behavior as 1 of their principal outcomes. Many of these studies evaluated short-term changes; 2 studies reported outcomes measured the year after training, and 1 study evaluated effects on behavior at 1 year after the intervention for a small subset of the original sample. One study measured recall of farm hazards at 1, 14, and 28 days and the extent to which children made comparisons with their own farms. Another...
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<tr>
<th>Authors/Year/Country</th>
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<tr>
<td>Gadomski,25 2003, United States (abstract)</td>
<td>“To evaluate the impact of active dissemination of the NAGCAT on the incidence of childhood agricultural injury”</td>
<td>RCT involving 845 farm households in central New York that had child residents or employed children</td>
<td>Intervention farms were visited by an educator who reviewed the NAGCAT guidelines with them; comparison group received a farm visit to complete baseline survey only</td>
<td>Injury incidence density: intervention group: mean decrease from 7.71 to 5.9 injuries/1000 full-time (40 h) equivalents; comparison group: 7.16 to 6.90 injuries/1000 full-time equivalents (difference not statistically significant)</td>
<td>Active dissemination of NAGCAT may decrease children’s farm injuries; results are based on partial follow-up results; study is ongoing; quality not assessed (abstract)</td>
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<td>Marlenga et al,24 2003, United States (abstract)</td>
<td>“To systematically apply NAGCAT to case descriptions of children’s farm injuries to determine whether their application would have prevented the injury”</td>
<td>An expert panel applied NAGCAT to a series of cases of pediatric farm injury (n = 382) from the United States and Canada for 1990–2000</td>
<td>NAGCAT were developed to assist farm parents in assigning developmentally appropriate and safe work to their children aged 7–16 y25</td>
<td>Use of NAGCAT could have prevented approximately one-half of work-related pediatric farm injuries</td>
<td>Study ongoing; at completion, authors will make recommendations for new guidelines not covered by NAGCAT; quality not assessed (abstract)</td>
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<td>Marlenga et al,26 2002, United States (published article)</td>
<td>“To compare the efficacy of the standard dissemination strategy with an enhanced, multiphased, dissemination approach in influencing parents to use/apply NAGCAT when assigning farm work to their children”</td>
<td>RCT involving parents operating a farm (n = 498) in western United States, midwestern United States, or Ontario</td>
<td>Enhanced dissemination activities (eg, video, personalized child development information, supportive telephone calls, copies of NAGCAT Parent Resource specific to commodity of participating farm, letters to encourage use, access to toll-free telephone number) versus standard approach (mailing copies of the guidelines, personalized to the farm and associated children, with a signed cover letter)</td>
<td>Proportions of parents actively using NAGCAT at 15 mo: intervention group: 108 of 218 (49.5%); comparison group: 83 of 224 (37.1%); difference between groups: 12.5% (95% CI: 3.4–21.7%; P = .002)</td>
<td>Farm parents who were exposed to the enhanced dissemination strategy were more likely to use NAGCAT QI: 29</td>
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NAGCAT targets hazards and injury priorities associated with 62 farm jobs that are common to children in North America. CI indicates confidence interval.

* Results of primary outcome(s), first outcome(s) reported if primary outcome was not indicated, or outcome(s) most relevant to review questions.
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<td>Cole et al, 29 2001 (report) (project description in Britt et al, 56 1999)</td>
<td>To compare “the KDD print version, KDD multimedia version, and a no-treatment control group when administered to youths enrolled in rural secondary school programs”</td>
<td>Controlled trial with 287 junior- and senior-level youths enrolled in secondary school programs in Kentucky (intervention groups: n = 156; control group: n = 131)</td>
<td>“The Kayle’s Difficult Decision (KDD) is a simulation exercise intended to train individuals to recognize the economic benefits associated with prevention of costly injury”$^{56}$; intervention focused on tractor rollovers and the appropriate use of ROPS and seatbelts; control group received regular instruction</td>
<td>Percentage of correct responses on attitude and knowledge scale, mean (SD): print version: 82.9% (9.7%); CD-ROM version: 85.2% (6.6%); control group: 76.0% (8.5%) ($P \leq .0001$)</td>
<td>The intervention groups showed improved attitude and knowledge; there was no difference between the print and CD-ROM versions of the intervention; QI: 20</td>
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<td>Fleming and Rinehart, 30 1994 (abstract)</td>
<td>Not stated</td>
<td>Pretest/posttest involving fifth grade students from 3 school districts in Delaware county</td>
<td>“Kids Safety Scene is an all-day instructional program provided for Delaware county fifth graders; the program is multidisciplinary, with presenters representing community agencies’; 5 of the educational presentations focused on first aid and 6 on farm injury prevention (injury patterns not specified)</td>
<td>1993 posttests showed increases in knowledge at all but 1 station (gun safety); 1994 results showed “measurable learning”</td>
<td>No specific conclusions made; quality not assessed (abstract)</td>
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<td>Hansen and Baker, 31 1994 (abstract)</td>
<td>The objective of the intervention is “to increase youth awareness of safety and health hazards . . . to reduce injuries”</td>
<td>Pre/post design with &gt;1300 people from 6 rural schools and one urban community in Missouri</td>
<td>Multifaceted programs designed to “increase awareness of safety and health hazards associated with farm, home, and recreational activities”; activities can include day camps, in-school workshops, health fairs; school programming component was evaluated. Topics included “fire, electrical, tractor/power-take-off, grain suffocation, large animal, small animal, home chemicals, agricultural chemicals, lawn and garden, ATV, bicycle, water, and First on the Scene”</td>
<td>80% net gain in knowledge</td>
<td>Knowledge gains were seen in all topic areas; the authors observed greater gains when hands-on activities or role-playing was used; quality not assessed (abstract)</td>
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<td>Liller et al, 32 2002 United States (published article)</td>
<td>To develop and evaluate the Kids Count farm safety lesson designed for children in grade 5</td>
<td>Pretest/posttest design with 1742 students from 15 elementary schools in rural/farm areas of Hillsborough County, Florida (480 students measured pretest, 1262 students measured posttest)</td>
<td>45-min lesson to instruct “how farm-related injuries can be prevented and to be able to compare farm-related behaviors that are safe with those that are risky or harmful”; lesson was based on concepts from NAGCAT; student involvement during lesson was key, as well as use of visual aids and props; additional materials before and after the lesson helped to reinforce concepts; intervention targeted “safety around machines, animals, and water; diseases and hygiene issues; sun exposure and weather conditions; pesticides; appropriate picking and lifting techniques; and related protective gear”</td>
<td>Knowledge acquisition mean test score (SD): pretest: 6.04 (0.48); posttest: 8.13 (0.34) ($P &lt; .001$)</td>
<td>The results showed an improvement in farm safety knowledge; the “curriculum was effective in reaching both migrant and nonmigrant children . . . this may be one of the only elementary school farm safety lessons that used the NAGCAT as a major curriculum component”; QI: 19</td>
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TABLE 2. Continued

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<td>Page and Frager,33 2001, Australia (published article)</td>
<td>To evaluate a “resource that aims to develop rudimentary risk assessment skills in children through an observational learning task employing a combination of verbal and nonverbal strategies”</td>
<td>Controlled trial involving 79 primary school students from 3 schools</td>
<td>‘Spot the Hazard’ “consists of a model farm in which a range of farm toys display a number of common farm hazards” (eg; chemical drums near dam, riding in crane attached to barn, working near overhead power lines, tractor without ROPS, animal feeding, unguarded machinery, vehicle improperly jacked, using portable ladder to climb silo); 2 intervention groups: model farm present versus not present at posttests; comparison group participated in farm safety discussions but farm model was not used</td>
<td>Number of items recalled from farm model, mean (SD): intervention group 1: day 1, 9.63 (1.30); day 14, 9.26 (1.33); day 28, 9.26 (1.10); intervention group 2: day 1, 6.80 (1.52); day 14, 5.33 (1.07); day 28, 5.56 (1.48); control group: day 1, 2.05 (1.13); day 14, 1.95 (0.95); day 28, 1.59 (1.10)</td>
<td>“Modes that employ both visual and verbal stimuli in imparting farm safety knowledge to children are more effective than purely verbal approaches”; QI: 18</td>
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<td>Reed et al,35 2001, United States (published article)</td>
<td>To “develop and test a farm health and injury prevention educational intervention for high school agriculture students”</td>
<td>Quasiexperimental crossover (schools randomized to study groups) involving 790 high school agriculture students in 21 high schools in Kentucky, Iowa, and Mississippi</td>
<td>Agriculture Disability Awareness and Risk Education (AgDARE) “is an experiential learning curriculum for high school agriculture classes” involving “narrative simulations based on farm work stories and simulations of farm work while students pretended to have a disability”; focus of intervention was prevention of amputation, spinal cord injury, hypersensitivity pneumonitis, and noise-induced hearing loss; there were 2 treatment groups that received the narrative and physical simulations in reverse order; the control group received nothing</td>
<td>Attitude, least-squares mean (SE): intervention groups: 32.1 (0.3); control group: 31.3 (0.2) (*P &lt; .001); stages of change, least-squares mean (SE): intervention groups: 31.1 (0.6); control group: 21.4 (0.5) (*P &lt; .001)</td>
<td>Students in AgDARE showed greater gains in safety attitude and behavior; the authors commented that “AgDARE fits nicely into existing curriculum, time constraints, and budget”; QI: 20</td>
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<td>TASK,24 2000, United States (Web site)</td>
<td>“To assess the impact of TASK presentations on the agricultural knowledge and comprehension of younger elementary age students”</td>
<td>Quasiexperimental separate-sample pretest-posttest control group with students from 13 schools (n = 2919 for 1998–2000; n = 2859 for 2001)</td>
<td>Teaching Agricultural Safety to Kids (TASK) involves high school students teaching topics in agricultural safety and health to elementary school children; TASK content units include heavy farm equipment, mechanical factors; lawn mower safety, human factors, handling emergencies, hand and power tools, safety around animals, signs and symbols, storage facilities, rural recreation, chemical and pesticide safety, personal protective equipment, babysitting safety, violence prevention, alcohol safety, pedestrian safety, burn prevention, firearm safety, water safety, bicycle safety, and pickup truck safety; control group received no instruction</td>
<td>Quiz scores: no difference between pretest and posttest groups; percent correct scores on open-ended questions: experimental group: 78–91%; control group: 58–83%</td>
<td>There were no differences between groups on quiz scores (1998–2000); Researchers commented that lack of significance could be attributable to no difference in knowledge or questions were not discriminating enough or questions cued the students to correct responses; in 2001, researchers used an alternate test with open-ended questions; data indicated that those in the intervention group were acquiring knowledge specific to the TASK presentations; QI: 13</td>
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ATV indicates all-terrain vehicle.

* Results of primary outcome(s), first outcome(s) reported if primary outcome was not indicated, or outcome(s) most relevant to review questions.
### TABLE 3. Characteristics of Studies Evaluating Community-Based Interventions to Prevent Acute Childhood Agricultural Injuries

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<td><strong>Theater</strong></td>
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<td>Elkind et al.²⁰, 2002, United States (published article)</td>
<td>To determine whether knowledge of farm health and safety increases through theater</td>
<td>Pre/post with Hispanic “farm workers and their families living in a 3-county region of eastern Washington” (number of spectators varied by play)</td>
<td>Four 1-act Spanish plays were developed on various health and safety topics and performed by a community players’ group; the plays dealt with prevention of hepatitis A, tuberculosis awareness, and alcohol education; pesticide safety; pregnancy/prenatal concerns and drowning prevention; proper bending, lifting, and ladder safety</td>
<td>“13 of 17 questions showed a significant degree of positive knowledge change (P ≤ .10); mean positive change in knowledge was 13.6% for the whole sample on all questions” (range 4–44%)</td>
<td>“Appropriate farm health and safety knowledge increases as a result of attendance at a 1-act Spanish play”; QE 12</td>
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<td><strong>Camps</strong></td>
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<td>Hughes and Hartley,²⁷ 1999, United States (published article)</td>
<td>To evaluate the impact of camp attendance on farm safety knowledge</td>
<td>Pre/post involving 8- to 13-y-olds from 61 of Georgia’s 159 counties; 417 pretests and 380 posttests, including 253 matched sets</td>
<td>Georgia Healthy Farmers Farm Safety Camp; target age group was 10–13 y (1-day camp in 1992, 4-day residential camp in 1993, 3-day residential camp after 1993); “core courses included ATV safety, combine and harvesting equipment, first-on-the-scene, pesticide safety, sun sense, and water safety, in addition to first aid and introduction to CPR”</td>
<td>Immediate farm safety knowledge (range of mean scores): pretest: 61.1–84.6; posttest: 73.5–89.4 (P ≤ .001; for all tests for 4 of 5 y studied; for matched tests, results significant for 3 of 5 y); long-term impact on farm safety knowledge: pretest scores for previous attendees: 69.4–83.0, posttest scores for first-time attendees: 58.7–85.1 (significant only for 1 of 3 y at P ≤ .05)</td>
<td>Children showed an increase in knowledge after attending the camp; “respondents who had attended camp the year before had a higher level of farm safety knowledge entering their second year of camp than did respondents who had not attended camp previously”; QE 17</td>
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<td>Schmeising and Buchan,³⁸ 1991, United States (internal report)</td>
<td>To evaluate the effectiveness of a day camp in improving children’s farm safety knowledge</td>
<td>Pre/post with 160 children from 4th, 5th, and 6th grades, including 92 matched pretests and posttests (58%)</td>
<td>Kid’s Farm Safety Day Camp: 1-day camp designed to increase farm safety knowledge; day camp activities included “model tractor rollover demonstration, grain cart entrapment demonstration, tractor PTO entanglement demonstration, first aid, ATV safety demonstration, chemical safety/protective equipment demonstration, farm safety for kids video and handouts, farm accident rescue, and horse safety”</td>
<td>Hazard identification: “students listed an average of 1 more hazard on the posttest”; farm safety knowledge: for each activity area (except 1), students showed increased knowledge about the hazard (increase: 58–77%)</td>
<td>The day camp “should be considered a successful and innovative effort”; QE 19</td>
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<td>Tractor safety initiatives</td>
<td>Carrabba et al.³⁹ 2000, United States (published article)</td>
<td>To determine “the effectiveness of the Indiana, 4-H Tractor Program at instilling safe tractor operating behaviors and attitudes”</td>
<td>Cohort study involving 4-H Tractor Program members (n = 104) and “students enrolled in high school agricultural education programs (age: 14–19 y) who had not participated in the 4-H program but who reported they regularly operated tractors” (n = 108)</td>
<td>4-H Tractor Program is “designed to train youth in safe operation of tractors and machinery; participants attend informal instructional meetings, complete student manuals, and demonstrate their knowledge on a written test and their skills through optional operating contests”; program focused on fundamentals of safe tractor operation</td>
<td>Safe tractor operation (low score = safer operation): intervention group: score = 600; comparison group: score = 1067; difference statistically significant but no values reported</td>
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<tr>
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<td>Heaney,40 2001, United States (abstract)</td>
<td>To evaluate the effectiveness of a tractor certification program in terms of knowledge, attitudes, and behavior</td>
<td>Quasiexperimental (pretest and posttest evaluations) involving 384 youths</td>
<td>“The Ohio Tractor and Machinery Certification Program (OTMCP) is a training program for 14- and 15-year-olds who operate tractors”; “Youth who participated in the OTMCP were compared with youth who operate tractors but did not participate in the program”</td>
<td>Intervention group showed a greater increase in “self-reported safety behavior, scores on safety knowledge test, belief in potential severity of tractor-related injury, self-efficacy for safety behaviors, belief in benefits of performing safe behaviors” (no numbers provided)</td>
<td>The tractor certification program “is having a positive effect on participants, but the magnitude of the program’s effects is modest”; quality not assessed (abstract)</td>
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<td>Lehtola,41 1993, United States (conference proceedings)</td>
<td>“To reduce tractor-related fatalities and injuries”</td>
<td>Controlled trial involving farmers in 4 counties in Iowa (2 counties received intervention; 2 counties received nothing)</td>
<td>FARM-TRAC (Tractor Risk Abatement and Control) program included “a variety of educational activities for farmers and school children, including a farm safety day, tractor operator training course, displays, and distribution of written materials”; the focus of the program was tractor safety, with specific emphasis on use of ROPS</td>
<td>Tractor fatalities: intervention group: decrease by 12.4 fatalities/100 000 tractors; comparison group: decrease by 4.4 fatalities/100 000 tractors</td>
<td>Results from the first 2 y of the project showed a positive effect; QI: 15</td>
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<td>Schuler et al,42 1994, United States (conference proceedings)</td>
<td>To evaluate the effect of tractor certification programs in Wisconsin on youth behavior</td>
<td>Pre/post study of ~750 youth attending tractor certification training in 1993 (201 pretraining surveys returned; 68% response rate for posttraining surveys)</td>
<td>Youth training and tractor machinery certification program involves 10 or 20 h with reading and written assignments, written examination, class meetings, practical training, and driving evaluation; program provided instruction on safe handling and operation of tractors and machinery.</td>
<td>Operated tractor during preceding year (pretest versus posttest): 103.0 vs 144.9 h; rode as extra rider during preceding year: 46.1 vs 20.9 h; operated ROPS-equipped tractor: 63.3 vs 73.4 h; wore seatbelt on ROPS tractor: 25.9 vs 24.4 h</td>
<td>“The youth participating in the country and local programs demonstrated very little improvement in behavior resulting from the training”; QI: 11</td>
</tr>
<tr>
<td>Wilkinson et al,43 1993, United States (conference proceedings)</td>
<td>To evaluate the Wisconsin Tractor and Machinery Certification Training Programs in terms of youth behavior change</td>
<td>Pre/post study of 280 youths attending tractor certification training in 1992; &gt;500 pretraining surveys initially sent out; 283 (~37%) completed; 185 of 280 (66%) posttraining surveys completed</td>
<td>Youth training and tractor machinery certification program involves 10 or 20 h with reading and written assignments, written examination, class meetings, practical training, and driving evaluation; program provided instruction on safe handling and operation of tractors and machinery</td>
<td>Operate tractor with ROPS (pre versus post): daily, 4.3% vs 12.4%; weekly, 11.9% vs 22.2%; monthly, 8.1% vs 9.7%; few times, 22.7% vs 20.0%; never, 38.9% vs 25.9%; operate tractor without ROPS (pre versus post): daily, 15.7% vs 30.8%; weekly, 24.3% vs 28.1%; monthly, 9.7% vs 9.7%; few times, 26.5% vs 22.2%; never, 10.8% vs 4.9%</td>
<td>Pre/post evaluations showed little change in youth safety behavior; QI: 15</td>
</tr>
<tr>
<td>Authors/Year/ Country</td>
<td>Primary Objective</td>
<td>Methods</td>
<td>Intervention</td>
<td>Results*</td>
<td>Authors’ Conclusions</td>
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<td>Anderson et al, 1998 (report)</td>
<td>To evaluate the Child Safety on Farms Project (Giddy Goanna) by assessing farm safety knowledge, attitudes, and behavior of children and their parents</td>
<td>Retrospective cohort study involving an intervention group and control group made up of children from 3 schools and members of the Giddy Goanna Kids’ Club (N = 452; response rate: 87%)</td>
<td>The Giddy Goanna project targets children 2-12 y of age and their families; the main part of the program was the development and dissemination of a story and puzzle booklet (other strategies include the Giddy Goanna Kids’ Club, Farm Safety Demonstration Days, and other resources); intervention targeted various farm hazards (e.g., tractor safety, protective clothing when riding horse or motorbike, swimming alone, chemicals and poison, hearing protection, overhead power lines)</td>
<td>Average score in intervention group versus average score in control group: children’s knowledge (maximum: 17): 12.8 vs 11.9 (P = .003); children’s attitudes (maximum: 6): 5.7 vs 5.0 (P &lt; .000); children’s behavior (maximum: 11): 8.5 vs 8.0 (0.086)</td>
<td>Overall, the booklet improved knowledge and attitudes of children; children in the intervention group reported better behavior than children in the control group but this was not statistically significant; QI: 15</td>
</tr>
<tr>
<td>Anderson et al, 2000 (report)</td>
<td>“To measure the change in farm safety knowledge and attitudes in children who attended a Giddy Goanna Farm Safety Demonstration Day”</td>
<td>Pretest/posttest evaluation with control group; sample involved children in grades 1-7 from eligible schools (children randomly selected from each class)</td>
<td>One component of the Giddy Goanna project is Farm Safety Demonstration Days conducted by the local community; these involve children traveling from a primary school to a local farm or other site, for a series of talks and demonstrations about relevant farm safety topics; intervention targeted various farm hazards (e.g., tractor safety, protective clothing when riding horse or motorbike, swimming alone, chemicals and poison, hearing protection, overhead power lines)</td>
<td>Increase in knowledge (intervention versus control group): P = .030; improvement in overall attitudes: P = .006 (no numbers provided)</td>
<td>Children attending the Demonstration Day showed higher levels of knowledge and attitudes, compared with those who did not attend; younger children showed greater increases in knowledge, whereas older children showed greater improvement in attitudes; QI: 19</td>
</tr>
<tr>
<td>Landsittel et al, 2001, United States (published article)</td>
<td>To “evaluate the effectiveness of 3 specific educational safety interventions in reducing farm hazards”</td>
<td>Controlled trial with pre/post measurements involving 4 counties from central Pennsylvania; for youth intervention, subjects were 7-17 y of age from farm families</td>
<td>As part of the Pennsylvania Central Region Farm Safety Pilot Project, different interventions were applied in each county, i.e., self-audit intervention (73 farmers conducted 2 self-audits ~6 mo apart), youth education intervention (64 youths from 30 farms), community coalition intervention (community level action to promote farm safety, e.g., hazard-reduction cost-share program, youth farm safety day camp, and distribution of fact sheets and other safety literature, 41 farms); project focused on safety of tractors, PTO machines, buildings and structures, and emergency procedures; 2 control groups</td>
<td>Percent change in hazard scores (SD), according to initial hazard conditions of the farm: low hazard at time 1: youth education, −0.32 (28.93); community coalition, −13.91 (21.22); self-audit, −13.77 (17.98); pre/post control, −6.67 (19.77); high hazard at time 1: youth education, −5.73 (7.88); community coalition, −11.47 (16.94); self-audit, −30.60 (15.42); pre/post control, −18.50 (22.40)</td>
<td>Overall, “self-audit was the most effective intervention . . . the community coalition and pre/post control group also showed reductions”; youth intervention showed little effect on improving hazard conditions; the effectiveness of interventions was dependent on initial hazard conditions of the farms; this highlights “the need to target specific interventions for more or less hazardous farms”; QI: 18</td>
</tr>
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TABLE 4. Characteristics of Studies Evaluating Farm-Based Interventions to Prevent Acute Childhood Agricultural Injuries

<table>
<thead>
<tr>
<th>Authors/Year/Country</th>
<th>Primary Objective</th>
<th>Methods</th>
<th>Intervention</th>
<th>Results*</th>
<th>Authors’ Conclusions</th>
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<tr>
<td>Hawk et al.,18 1995 (book)</td>
<td>To test “the hypothesis that direct participation in program development and implementation increases intervention efficacy as measured by changes in safety-related behavior”</td>
<td>Quasieperimental, pretest/posttest involving farm families from 5 counties in Iowa</td>
<td>The Farm Safety Walkabout “was a family activity structured by use of a booklet guiding participants through a ‘walkabout’ of their farm in which they identified and discussed farm hazards and safety practices”; intervention targeted various primary (eg, unguarded machinery, seatbelt use, extra riders, uncovered manure pits, unsafe storage of agricultural chemicals and veterinary supplies) and secondary (eg, CPR and first aid training; presence of fire extinguishers) prevention strategies</td>
<td>Mean behavior scores: intervention group A (interactive protocol): pretest: 11.96; posttest: 13.56 (P = .0009); intervention group B (standard protocol): pretest: 12.36; posttest: 14.06 (P = .0001); control group (no intervention): pretest: 13.10; posttest: 15.34 (P = .0001)</td>
<td>“There were no significant differences among the 3 groups”; regression analyses showed that “demographic variables, more than group status, contributed significantly to differences in single behavioral outcomes, when all 3 groups are compared”; QI: 20</td>
</tr>
</tbody>
</table>

CPR indicates cardiopulmonary resuscitation.

* Results of primary outcome(s), first outcome(s) reported if primary outcome not indicated, or outcome(s) most relevant to review questions.
study measured changes in hazard scores.47 Finally, 1 study examined changes in the numbers of fatalities.41

Two studies were classified as cluster RCTs,35,47 5 were controlled trials,29,33,41,46,48 4 used cohort designs,39,40,44,45 1 was described as a quasiexperimental, separate-sample, pretest/posttest, control group design,34 and 8 were before/after studies.30–32,36–38,42,43 The studies were generally of moderate methodologic quality (median QI: 18; maximal score: 29; interquartile range [IQR]: 15–19). Generally, most performed well on components assessing reporting (median score: 8 of 11; IQR: 6–9) and bias (median: 6 of 7; IQR: 5–6). The studies performed poorly on components related to external validity (median: 1 of 3; IQR: 1–2), confounding (median: 2 of 7; IQR: 2–3), and power (median: 0 of 3; IQR: 0–0).

Seventeen studies were conducted in the United States and 3 were conducted in Australia.33,44,45 Seven studies were published in peer-reviewed journals between 1999 and 2002,32,33,35–37,39,46 and 1 was published in a book.48 Four studies were identified as abstracts,30,31,40,47 4 were presentations,29,41–43 3 were reports,38,44,45 and information for 1 was found on a Web site.34

School-Based Interventions

Seven studies evaluated educational programs administered within the school setting.29–35 These studies consistently reported positive results in terms of short-term knowledge acquisition or changes in attitudes toward farm safety. Results showed enhanced outcomes with active, hands-on participation, as opposed to passive activities.

Community- and Farm-Based Interventions

The community-based interventions varied widely in their method of delivery and the type of injury targeted. The interventions included theater (n = 1),36 camps (n = 2),37,38 tractor safety initiatives (n = 5),39–43 and multifaceted interventions (n = 4).44–47 A study evaluating the effect of theater on farm health and safety knowledge showed an increase in short-term knowledge.36 Two studies that evaluated the effectiveness of farm safety camps showed improved short-term safety knowledge.37,38 and 1 study showed some evidence that knowledge was maintained over the longer term (≥1 year).37

Five studies evaluated tractor safety programs.39–42 One study evaluated a community-wide intervention and found that the number of fatalities decreased and the number of ROPS sales increased during a 2-year period.41 The other studies evaluated tractor training programs and produced inconsistent results. Two studies evaluated the tractor training program in Wisconsin, using the 1992 and 1993 cohorts.42,43 Both studies found little difference in safety behaviors 1 year after training, although the first study noted that parents observed an increase in safety knowledge.42,43 A study of the 4-H Tractor Program showed positive changes in safety behaviors but no change in attitudes (which is inconsistent with what is known about the progression of developing changes in behaviors),39 whereas a study of the tractor training program in Ohio reported a positive change but did not present data to support the findings.40

The remaining studies evaluated a variety of community-based44–47 or farm-based48 initiatives. The studies found mixed results with respect to the youth interventions. One RCT evaluated the Partners for a Safer Community program and found no differences in terms of knowledge, attitudes, practices, and leadership skills.47 Landsittel et al46 compared several interventions, including self-audit, youth intervention, and community coalition. The effectiveness of the interventions varied according to the baseline farm hazard scores. Overall, the self-audit group showed the best results, whereas the youth intervention group showed little change. The community coalition intervention showed positive results among farms with low baseline hazard scores. Two studies evaluated different components of the Child Safety on Farms (Giddy Goanna) Project in Australia. The first study evaluated a farm safety booklet targeted to young children and found significant improvements in children’s knowledge, attitudes, and behavior, compared with the control group.44 The second study evaluated the impact of demonstration days that were part of the same multifaceted program, and the study found a significant increase in knowledge and improvement in attitudes.45 Finally, Hawk et al48 evaluated the Farm Safety Walkabout program and found that changes in hazard scores among the 2 intervention groups were not significantly different from those of the control group.

Research in Progress

We identified 3 ongoing studies evaluating prevention interventions. A pretest/posttest study is evaluating the effect of teaching teen farm workers about agricultural health and safety through school-based classes on English as a second language.49 The purpose of the second study is to develop, implement, and evaluate (with pretests and posttests) curricula for adolescents that focus on hazard recognition and problem-solving skills in the agricultural work setting.50 The third study will evaluate a health and safety curriculum for ninth grade students in rural Minnesota schools, using a cluster-randomized, nested, cohort design.51

DISCUSSION

Overall Findings

Overall, there is a paucity of controlled studies evaluating the effectiveness of interventions aimed at the prevention of childhood farm injuries. In an exhaustive search of the literature from 1980 onward, we identified only 23 studies relevant to the review questions. All relevant studies evaluated educational interventions. We did not identify any studies that evaluated the effectiveness of regulatory or engineering approaches that met our inclusion criteria (ie, intervention targeted at children).

Effectiveness and Dissemination of NAGCAT

To date, there is little tangible evidence with which we can make practical recommendations on whether
NAGCAT are likely to lower rates of injury or improve knowledge and attitudes regarding agricultural practices. The 1 study reviewed showed that an important number of injuries could be prevented through the application of NAGCAT.

The 2 studies that examined the effectiveness of dissemination strategies found that simple things can be done to improve the uptake of the NAGCAT guidelines. One study showed that making the guidelines available would lead to a degree of uptake by motivated farm families. Provision of information outlining the scientific basis for the guidelines and personal visits to the farm by a trained safety professional were shown to improve rates of uptake and decrease rates of injury, respectively.

**Effectiveness of Other Prevention Interventions**

The 20 studies relevant to this issue varied immensely in their method of delivery and target population. School-based programs consistently showed positive results in terms of short-term knowledge acquisition or changes in attitudes toward farm safety. We speculate that the success of these programs results from the age of the target group; that is, younger children may be easier to influence. Among the school-based programs, studies showed that outcomes were enhanced with active, hands-on participation, as opposed to passive activities. However, it is not known whether or how this increase in knowledge had any influence on behavior and ultimately injury rates.

Studies evaluating farm safety camps showed improved short-term safety knowledge, and 1 study showed some evidence that knowledge was maintained at 1-year follow-up assessments. Again, the success of these programs may be the result of the ages of the study participants. Studies evaluating tractor safety programs and community-based or farm-based initiatives showed mixed results.

**Comments on the State of the Literature**

We screened 5822 unique abstracts from 17 bibliographic databases. The vast majority of abstracts fell into 1 of several categories, ie, descriptive epidemiologic studies, descriptions of injury control programs without any evaluation or with only process evaluations, anecdotal reports of various approaches to farm safety prevention, or studies that had only limited relevance to the pediatric farm injury problem. The lack of controlled evaluations of farm safety interventions may be attributable in part to difficulties in conducting research in this area (eg, difficulty in identifying and recruiting farms or farm workers).

The volume of published literature evaluating prevention interventions does not reflect the amounts of public funds that have been committed in recent years to research on the childhood farm injury problem. This could reflect the fact that many of these projects are still in progress, but it could also reflect the need for more rigorous standards for the funding of such projects.

Much of the literature in this area is either unpublished or not indexed in databases, which makes it difficult to identify. Unpublished studies may be of lower quality because they have not gone through a rigorous peer-review process. This may affect the validity of results; however, we did not observe a notable difference in results for published versus unpublished studies.

Publication bias, or the selective publication of studies with statistically significant results, is important to consider for this body of literature. The dissemination of only positive results has implications for decision-makers, researchers, and program planners. There are ethical and scientific responsibilities to share research findings so that subsequent programs, research, and policies can build on past experiences, regardless of whether they are positive or negative.

Only 8 of the relevant studies were published in peer-reviewed journals, with low to medium impact factors. This is another indication of the methodologic quality of studies in this area. There may be reason to think that this pattern in changing. For instance, we searched from the year 1980 onward and found nothing of relevance until the 1990s. The studies published in peer-reviewed journals were all from 1999 onward.

Of the 23 relevant studies, 4 were RCTs, 5 were controlled trials, and the others used quasietiological or observational methods. The lack of RCTs and community-based trials in this field is problematic, because these study designs represent the best standards of evidence for the effectiveness of interventions. Modifications of the standard RCT design that may be more appropriate in this setting include the cluster RCT, in which groups are randomized rather than individuals, and randomization of the introduction of prevention initiatives to various regions.

Irrespective of study type, there was a lack of methodologic rigor in many studies. Recurrent weaknesses were related to issues of confounding, statistical power, and generalizability. Few observational studies adequately controlled for potential confounders, reducing our confidence that the results reflect the interventions in question. Few studies reported a calculation for sample size or statistical power. Without such information, we were unable to determine whether the studies were large enough to detect important effects. Findings indicating a positive intervention effect might have been missed. The external validity (generalizability) of studies was also generally poor, which makes the application of results in the planning of injury control interventions challenging.

The majority of studies evaluated short-term process outcomes (eg, knowledge acquisition or changes in attitudes or behavior). Few studies evaluated injury occurrence. The timing of outcome assessment was also less than optimal. Outcomes were typically measured immediately or shortly after the intervention was delivered. It would be useful to determine the long-term effects of these interventions. Moreover, studies did not distinguish between programs directed at youths who work on farms and children who live and play around the farm worksite.
Content of Existing Research

Evaluative studies do not appear to address directly 1 of the leading injury prevention priorities for farm children. Approximately one-half of fatal farm injuries among children occur among those 0 to 6 years of age (toddler and preschool ages).53 Few studies were explicitly aimed at this age group.

Few of the studies relevant to our review evaluated structural changes (eg, ROPS and seatbelts, machinery with appropriate guarding/shut-off devices, correction of fall hazards in haylofts, and animal containment systems) that can be introduced to farms to make them safer for all people, including children. Most studies directly addressed training and behavior of the affected groups of children. The lack of literature identified in this area may reflect the scope of our review and the criteria for inclusion.

There were no studies that evaluated the efficacy of programs (eg, enhanced day care, “child-free zones,” or safe play areas) that aim to keep young children from coming into contact with farm worksite hazards. Programs aimed at providing childcare for farm children exist but have not been rigorously evaluated; therefore, their effectiveness is unknown. We did not identify any studies that examined the issue of supervision of children, whether toddlers or young workers, in the agricultural setting. There were also no studies of the effectiveness of incentive programs to improve safety training and/or the safety of farm worksites.

Challenges to Enhancing the Safety of Farm Worksites

An important consideration in the prevention of farm injuries among children is the fact that the farm worksite has not been subject to the imposition of occupational health and safety regulations. Dramatic changes in injury occurrence in other industrial worksites have come with the introduction of health and safety standards. We need to understand more about the reasons for this situation and how to invoke widespread changes in the attitudes of farmers toward the value of regulations in their workplace. Controlled studies that evaluate interventions to effect such changes, both individually and culturally, will be important for the implementation of effective agricultural injury control interventions.

There is evidence that the farm safety community is beginning to think about interventions that go beyond educational programs delivered to children. Some recent literature has addressed the lack of efficacy of educational interventions and the need for reassessment of other approaches (ie, regulatory).54 This has also been reflected in statements from groups such as the American Academy of Pediatrics.11

CONCLUSIONS

After an exhaustive review of the literature, we found that methodologically rigorous research evaluating interventions to prevent childhood farm injuries was lacking. Where possible, the global research community in the biomedical sciences has moved toward the use of evidence from RCTs, and system-atic reviews of such trials, in making decisions about the efficacy of prevention initiatives. We have shown that there are very few RCTs in the pediatric farm injury literature. Future research must focus on trials with methodologic rigor and adequate statistical power to answer questions of importance.

Most of the existing literature either is unpublished or appears in peer-reviewed journals of modest rank. There is little evidence available from this literature that is helpful in making decisions about what programs to implement to optimally prevent the occurrence of pediatric farm injuries. Moreover, an important omission in this body of literature is that of evaluations of interventions aimed at preventing injuries among toddlers and preschool-aged children. The interventions targeted at children and youths that have been evaluated focus solely on education. Although the importance of educational initiatives is obvious and some are efficacious, educational initiatives by themselves appear to be insufficient to eliminate recurrent injury control problems on farms. We did not identify any studies of regulatory approaches that specifically targeted children.

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