Integrating Cost-effective Rollover Protective Structure Installation in High School Agricultural Mechanics: A Feasibility Study

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ABSTRACT. This study with three Appalachian county agricultural education programs examined the feasibility, effectiveness, and impact of integrating a cost-effective rollover protective structure (CROPS) project into high school agricultural mechanics classes. The project aimed to (1) reduce the exposure to tractor overturn hazards in three rural counties through the installation of CROPS on seven tractors within the Cumberland Plateau in the east region; (2) increase awareness in the targeted rural communities of cost-effective ROPS designs developed by the National Institution for Occupational Safety and Health (NIOSH) to encourage ROPS installations that decrease the costs of a retrofit; (3) test the feasibility of integration of CROPS construction and installations procedures into the required agricultural mechanics classes in these agricultural education programs; and (4) explore barriers to the implementation of this project in high school agricultural education programs. Eighty-two rural students and three agricultural educators participated in assembly and installation instruction. Data included hazard exposure demographic data, knowledge and awareness of CROPS plans, and pre-post knowledge of construction and assessment of final CROPS installation. Findings demonstrated the feasibility and utility of a CROPS education program in a professionally supervised secondary educational setting. The project promoted farm safety and awareness of availability and interest in the NIOSH Cost-effective ROPS plans. Seven CROPS were constructed and installed. New curriculum and knowledge measures also resulted from the work. Lessons learned and recommendations for a phase 2 implementation and further research are included.

KEYWORDS. Agricultural education, agricultural mechanics CROPS, tractor safety, youth equipment safety

INTRODUCTION

Agriculture consistently ranks among the most dangerous occupations in the United States. Tractor overturns, the leading cause of farming-related injuries or deaths, killed 96 people per year on average.1 The National Agricultural Tractor Safety Initiative2,3 reported that annually 110 deaths occur from tractor overturns and another 52 deaths occur when operators fall from moving tractors or run over second riders or bystanders. Tractor-related fatalities account for fully one third (33%) of agricultural-related deaths. A regional
A study examined the prevalence and costs of nonfatal injuries during overturns of agricultural tractors. The study surveyed a random (8%) sample of 6,063 Kentucky farms stratified across the state’s six agricultural districts as well as by farm size, commodity, and production. The empirical estimate was that for every 100 operator fatalities from overturns of non–rollover protective structure (ROPS) tractors, there are 446 nonfatal injuries. Of these 446 nonfatal injuries, 367 require medical treatment at a clinic or hospital emergency department. Of these 367 emergency medical care cases, 267 require hospital admission. Of those admitted, 58 suffer a permanent disability. In large measure, these are preventable fatalities and injuries. ROPS in combination with seat belts are known to be 98% effective in preventing tractor operator deaths from overturns and ejections from the tractor seat. Unfortunately, the percentage of ROPS-equipped tractors has stubbornly remained flat. Farm Safety Surveys from both 2006 and 2011 show that 59% of the nation’s farm tractors lack ROPS. What accounts for the persistence of non–ROPS-equipped tractors? The combination of smaller family farms, older, non–ROPS-equipped tractors, and the costs of retrofitting older model tractors with ROPS are the most often cited reasons.

In recent years, NIOSH has sought to address the problem of cost in ROPS retrofits through the design and testing of cost-effective ROPS (CROPS) plans. These plans and information about construction materials and installation for several brands and models of tractors are available on the National Institution for Occupational Safety and Health (NIOSH) Web site. CROPS instruction and installations have been reported in the literature with farmers in New York, Vermont, and Virginia. This report describes the results of a preliminary study to examine the feasibility of integrating these CROPS plans into the power and mechanics classes in secondary (high school) agricultural education programs.

There are 8,000 agricultural education programs in the United States, with more than 100,000 students, the majority of whom plan futures in agriculture, either on their own family farm operations or in agribusiness or other agricultural careers. Preparing these future farmers to engage in a culture of safety has become an increasingly important part of agricultural education programs. Curricula typically include classes in farm machinery operation and safety. Future farmers will do much of the repair work, including welding, on their operations themselves, or supervise or hire others to do so. Over half of all farms have welding or oxy-acetylene systems. In Kentucky, the site for this study, there are 12,725 agricultural education program juniors and seniors enrolled in agricultural mechanics and power equipment classes where a welding project is integrated into the class requirements. In Kentucky, 36% of agricultural education graduating seniors will enter the workforce directly and need to be prepared for that experience directly out of high school. Our research team reasoned that making these future farmers aware of the CROPS retrofit plans and costs, and having this knowledge and skill, would be an important sustainability strategy to reduce workers’ exposure to fatality and injury through retrofits of older tractors often found in any agricultural operation. A pilot study was funded through a NIOSH Agricultural Center small grant feasibility program.

The aims of this feasibility study were to (1) reduce the exposure to tractor overturn hazard in three Kentucky counties through the installation of cost-effective ROPS on six tractors located on farms within the Cumberland Plateau in the east region (Laurel, Whitley, and McCreary counties); (2) increase awareness in the targeted rural communities in Kentucky of cost-effective ROPS designs developed by NIOSH to encourage ROPS installations that decrease the costs of a ROPS by several hundred dollars; (3) test the feasibility of integration of CROPS construction and installations procedures into the required agricultural mechanics classes in these three rural county agricultural education programs; and (4) explore barriers to implementing such a program in high school agricultural education (mechanics) programs. The design employs methods for a process/outcome evaluation developed by Patton.
METHODS

Process-Outcome Evaluation Design

A process-outcome evaluation was implemented for this preliminary feasibility study. Outcomes, as defined in this framework, are changes in individuals, organizations, communities, or governments, depending on the goal and reach of the activities. Evaluation is a utilization process of systematic inquiry directed at collecting, analyzing, and interpreting information so that one can draw conclusions about the merit, worth, value, or significance about a program, project, or policy under investigation; outcome evaluation, then, at its most general level is a systematic examination of the outcomes (changes, usually benefits), resulting from a set of activities implemented to achieve a stated goal, and a systematic examination of the extent to which those changes actually resulted in those outcomes. Feasibility, as an adjective, refers to being “capable of being done, effected, accomplished, or suitable.” Thus, the primary outcome in this feasibility study relates to the practicality, suitability, and possibility of the processes involved in a CROPS assembly and installation project be accomplished in a public school agricultural mechanics class. Elements of all four stages of evaluation promulgated by the Centers for Disease Control and Prevention (CDC), including formative, process, impact, and outcome, are embedded in the Patton model.

Pilot Sites and Participants

Four agricultural educators in Montgomery, McCreary, Laurel, and Whitley counties initially agreed to participate as pilot sites to evaluate the feasibility of constructing and installing CROPS in their local communities. Farmers in this region are likely to have low ROPS prevalence, as the study sites are Appalachian counties that are characterized by small farms, poverty, and the dangerous topography associated with the eastern Kentucky Appalachian region (see Table 1). One county was not able to complete its participation commitment due to staffing constraints, leaving three pilot school sites. The agricultural educators who did participate are as follows:

| County   | Average size of farm (acres) | Percentage of farms owned by families/individuals | Percentage of persons in poverty |
|----------|-----------------------------|--------------------------------------------------|---------------------------------|
| McCreary | 97                          | 93.5                                             | 35.2                             |
| Laurel   | 95                          | 94.7                                             | 40.1                             |
| Whitley  | 121                         | 96.6                                             | 38.3                             |
| KY KDA   | 164                         | 73.4                                             | 19.4                             |
| Census   |                             |                                                  |                                  |

Note. Farms in these counties have less than national average in farm acreage (414), are primarily family farms, and a majority are in low-income production categories, reflecting the lower socioeconomic context of the region.

Teacher A is department chair at Whitley County High School. He has over 20 years of service in the teaching profession and is well respected in the agricultural mechanics profession. He has prepared numerous state winning teams in agricultural mechanics. There are approximately 250 students in this agricultural education program, with 48 in agricultural mechanics classes during this study.

Teacher B, the lone agricultural education teacher at McCreary Central High School, was in his first year teaching during the study. As a graduate of the University of Kentucky, this teacher was very passionate about teaching agricultural mechanics and was a student taught under the guidance of Teacher A at Whitley County, an adjacent school district. There were 100 students in this agricultural education program, with 23 in agricultural mechanics classes during the study.

Teacher C is a second-year teacher at North Laurel High School. He is very committed to farm safety after the paralysis or deaths of three farmers in his community. North Laurel had 250 students in its agricultural education program, with 27 in agricultural mechanics classes during the study year.

Eighty-two students of the 98 total students in agricultural mechanics and power equipment classes at these sites returned the consents to participate in CROPS assembly and installation
projects in these three high school agricultural education programs.

**PROCEDURES**

Agricultural educators in these three rural Kentucky county high school agricultural education agricultural mechanics and power equipment classes implemented CROPS construction and installations for two CROPS in their communities and submitted one to the Kentucky State Fair for judging. A member of the research team who is the agricultural educator engaged with the teachers, provided them with training and information about the NIOSH CROPS Web site, and worked with the local teachers to locate businesses that could provide the parts to build the CROPS from the NIOSH-designed plans. Teachers were asked to integrate the CROPS project as part of their welding and farm safety units, as we wanted to have an authentic instructional process, to determine feasibility in actual classroom practice. Teachers were required to keep daily progress logs during the CROPS project construction unit in their agricultural mechanics classes that were submitted for review to the researchers at the conclusion of the projects.

After obtaining parental consents, demographic data (including awareness of CROPS installations) were collected pre-implementation. A posttest-only design was used for the CROPS knowledge of assembly and installation. We reasoned students would have no pre-implementation knowledge of the NIOSH plans (a fact borne out by the pretest survey). Additionally, post project completion, the researchers conducted follow-up interviews. Teachers \((n = 3)\) were interviewed about their classroom experiences and specifically about the feasibility of integrating the CROPS project into their curriculum and planned experiences for their students. We used an open-ended unstructured interview protocol, asking them to talk with us about the class experience of building and installing the CROPS. Teacher interviews were taped and transcribed. Researchers also interviewed a group of students \((n = 20)\), at all three school sites, who indicated they were willing to be interviewed on the student assent protocol. We selected this group because they had all indicated some prior experience with building home-made ROPS for a tractor. We had not anticipated such a group and we asked about their experiences building or knowing someone who’d built one. The semistructured interview protocol had four questions. Two questions were directed at students who had indicated a homemade ROPS experience: (1) “Can you tell me more about the home-made ROPS you are aware of (who, what was it made of)?” (2) “Based on your knowledge of a well-constructed CROPS from NIOSH plans for your class project, would you say that homemade ROPS was safe? Why or why not?” The last two questions asked about their class experiences with CROPS in class: (3) “Talk about your experiences learning to build a CROPS in class.” (4) “Are you prepared to build CROPS should you need one? Do you anticipate that you might do so in the future? Why or why not?” In the final analysis of transcribed and observational data for this article, we decided the questions on the homemade ROPS were not cogent to the feasibility study of CROPS. Rather, quotes from questions 3 and 4 provided illustrative quotes for the feasibility evaluation. Overall, we also note that the 20 students interviewed represent approximately 25% of the 82 total students for which we had consents to participate.

**Measures**

Pre-implementation measures included a modified 30-item Farm and Rural Life Survey (FRLS) of demographic with additional surveillance items related to various farm injury and hazard exposures, such as tractor injuries and fatalities, hearing loss, and highway/farm equipment collisions, and an 8-item pretest survey of knowledge and awareness to measure students’ CROPS knowledge and skill for construction and installation as well as for ROPS effectiveness. This measure, as shown in Appendix A in Supplemental Material, has been used for over a decade in numerous NIOSH funded projects; however, this version also included items about purchases of ROPS on
their farm or work site and about any knowledge of locally home-made ROPS. The posttest measure, designed to evaluate the practicality of using the NIOSH plans in high school agricultural mechanics classes, included several items inquiring about the student’s class experience building and installing CROPS using NIOSH plans and future plans for building CROPS on family tractors. The knowledge posttest also included eight items related to the CROPS construction and installation plans that were scored as true/false items (n = 58). We acknowledge the lacks in these outcome measures. However, the focus of the study was practical implementation, rather than piloting fully refined measures. In fact, one outcome from this process evaluation was the development of a knowledge measure, based on an examination of the agricultural mechanics curriculum skills and the NIOSH plans. Teachers provided feedback on common elements of each (see Appendix B in Supplemental Material). Thus, we did not conduct an item analysis of this rudimentary feedback postproject form. Postproject interviews with teachers focused on the feasibility of integration of CROPS construction/installation into their classes. Student interview focused on their instructional experiences and engagement. We also monitored the actual number of CROPS installations, teacher implementation notes in a daily log format, community media coverage, and the costs of materials and other salient practical aspects of the CROPS projects at each site.

RESULTS

Representative Sample of Pilot Site Counties

Exposure to Hazard

Of the 82 students who took the demographic/pretest, 86% were male and the age ranged from 15 to 19 years for the total sample. The majority were juniors or seniors (77%) planning to enter the workforce or attend college after graduation; the remaining were sophomores. Fifty-four percent of the students have lived on a farm (44/82), 91% of those (40) have one or more tractors. Of those 40 students with tractors, 60% have a ROPS and seat belt on at least one of their tractors. However, 40% did not have a ROPS on any of their tractors. Sixty-two (75%) students reported they have worked on a farm. Of these working on farms, almost half (48%) have operated tractor(s) without a ROPS. Of all students at all three school sites, 35% (29/82) reported a tractor overturn involving self, family, or friend, with the majority of incidents involving a family member (71%). Only 8% of all students’ families purchased at least one ROPS to retrofit tractor that did not have one. Finally, of students who responded to a question regarding the reason for not deciding to buy a ROPS (n = 25), nearly half reported the decision to not buy the ROPS was due to cost (48%).

Awareness of CROPS

Pretest data show most students had little awareness of the CROPS designs, assemblies, or installation procedures; however, 28% (23/82) reported they knew what a CROPS was, no doubt because their teachers had introduced the project to classes prior to researchers attending class to distribute human subject consents. Not surprisingly, 99% (81/82) of all the students at all three sites had never built a CROPS.

Knowledge of CROPS Assembly

Post project all reported having built a CROPS, as part of the class work. The posttest results of knowledge of basic CROPS assembly key steps are shown in Table 2. Instructions to students were on the knowledge measure were “Please Circle “T” for True or “F” for False for each statement that refers to the NIOSH PLANS that you used to construct a CROPS in your agricultural mechanics class.” For the open-response item, sample responses are shown at the end of the table. Items related to CROPS construction knowledge were scored as percentage correct on each item. Students scored well on items related to the following: Axle housing attachments: 84%; Incremental tightening procedures: 95%; Seat belt attachment for complete ROPS: 98%; Understood how
### TABLE 2. CROPS Posttest Measure

| Posttest statement                                                                 | Percentage correct (%) |
|-----------------------------------------------------------------------------------|------------------------|
| The side bars of a CROPS are attached to the axle housing                          | 84                     |
| Incremental tightening procedures are used on a CROPS assembly                      | 95                     |
| The side bars of a CROPS are attached to the fender metal                          | 67                     |
| The maximum torque for all bolts on a CROPS is 180 ft/lbs                          | 30                     |
| CROPS assembly uses a horizontal MIG weld                                           | 68                     |
| The top bar of a CROPS is welded to the side assemblies                             | 70                     |
| CROPS plans are available from NIOSH for John Deere model tractors                 | 47                     |
| CROPS also must have a seat belt installed for maximum safety and protection in a  | 98                     |
| tractor roll over.                                                                  |                        |
| **Open Response Question:** Describe in your own words how you attached the top of |                        |
| the CROPS to the side bars: Sample of student responses: wasn’t sure how to       |                        |
| assess the open ended—see output                                                   |                        |
| **Acceptable responses:**                                                           | 80                     |
| - By drilling holes and placing bolts in correct places                             |                        |
| - Drilled holes in the four places where the bolts go through. Once you have them |                        |
| in you torque them in.                                                              |                        |
| - I would bolt them together with being torqued at 140 lbs/ft.                     |                        |
| - We cut, welded, and punched holes in the metal to build the ROPS and attached it  |                        |
| to the tractor with specified tools and safety.                                     |                        |
| **Problematic responses:**                                                          |                        |
| I don’t believe I was in class that day.                                            |                        |
| By welding them together                                                            |                        |
| Very carefully                                                                     |                        |
| Bolts                                                                              |                        |

**Note.** The knowledge of CROPS assembly posttest true/false items (as total percentage of students responding correctly) shows overall understanding of the CROPS assembly process \(n=58\), although gaps in student knowledge regarding several technical requirements and procedures are in evidence.

Students who agreed to be interviewed after the project demonstrated high enthusiasm and heightened understanding of how high the risk of overturn was on non–ROPS-equipped tractors and how crucial installation of CROPS was for tractor safety. One student reported his experience participating in the class project:

We had two people to a group, and they each had a part. My group handled one side of the vertical tube. I liked the cutting and drilling part of the project best. I liked the hands-on work. I did not really find using the plans challenging. Other classes should do this. I can read plans better now.

Another mentioned issues resulting from the shop tools on-hand and available, “Good experience. It went together exceptionally well except for drill bits.” A comment from one student at North Laurel represented many and demonstrated the impact of the project:

I learned how important a ROPS is to farmer safety. This was a great experience to be involved in. Not many have that experience . . . We should look at this issue for future farmers. We can save a life with a ROPS. I’d feel better as farmer doing
something to save lives. We can put more on tractors. I’ve felt unsafe on tractors without ROPS and even one with a poor-made ROPS. If we can do more, we can help a lot and save lives.

Students were asked how prepared they felt to build and install a CROPS after participation in the project. One commented:

Yes. Hope to purchase one with a ROPS. Gonna build them if need to. I feel prepared if something happens. More information is needed for farmers. Not a lot of farmers can afford a ROPS. They need to know how to use a plan. Several farmers in this county are low income. I’d like to see everyone without a ROPS have a set. We need to find away to help farmers get ROPS on their tractors like apply for ROPS through Extension.

Overall, the interview data reflect that the project was a positive learning experience for student participants, said one, “I learned a lot of techniques and the plans were helpful. I’d feel confident building one again.”

Classroom Integration of Project

Teachers report that the CROPS assembly project was using the NIOSH plans and was easily integrated into classroom project work in welding/project planning and measurement as well as into tractor safety unit. According to teacher logs, each CROPS took approximately 10 direct instructional hours for actual assembly, not including classroom instruction in reading the plans, preparing materials, or welding skill and safety instruction. Two of the three teachers did not have students use the NIOSH Web site directly, but rather downloaded the plans and used them in hard copy for their class projects. This approach explains the finding that only 53% of students knew the tractor models for which NIOSH CROPS plans are available. The teachers also reported that a complete project enhanced the classroom experience for students and included a full range of project skill. One said, I think any time that you put a hands on project in front of a kid where they can see it come to life right in front of them and see the fruit of their labor when they’re finished, it impacts them a lot different than if you were just sitting in the classroom working out of a textbook or something. There’s [sic] a lot of projects that we work on that people will just bring in. They’ll bring a piece in and want us to just do a welding job on it or something like that. But when you can bring something in and do it from start to finish, from a pile of raw steel until you’ve got a finished product mounted on a tractor, the kids really, you can see it in them and in their attitude, how they watch something develop in front of them like that.

The CROPS safety project also had an impact on other aspects of the Agricultural Farm Safety program and on students’ attitudes toward farm safety.

Definitely a big impact. I could really tell a difference this year, when we had our tractor driving. We have our own tractor, we do tractor driving, teach that unit. This year, there was no question about seat belt. I always hear, “I don’t need to wear a seat belt. I’m good, I’m good, I’m good.” Now they understand, so now they do wear a seat belt. Actually, the seat belt on the tractor tore up. They wouldn’t even drive it until we got it fixed. I really truly think that in the future there may be three or four of them may actually go home and do this. They’ve talked about it a lot. And they’ve talked about how much they enjoyed it. Then they talk about the old tractors they got . . . “I’ve got one of them at the house”! I’ll build one for them.” It’s opened my eyes to the idea that possibly there’s a chance there may be a change in some of these young guys, the way they operate on the farm. If it helps one in the next ten years from getting killed or getting hurt, then we’ve accomplished something.
I’ve got some of those other students say, “Well, that’s the class where we built that rollover bar in last year. That’s the class where you tear engines apart.” And I’m not the only one that’s trying to sell my program anymore. I’ve got students trying to sell classes as well, “You need to take this course. You need to take that course.”

The teachers also gained awareness of the NIOSH CROPS plans. The most experienced teacher in the group noted:

I appreciate, now that I know that you can build those . . . it used to, you had to buy everything from the factory now that I know you can build one, that is just as safe as anything you can buy from a factory, which is a big cost savings.

Service to Communities

Students were positive about the service learning and impact of their CROPS project work. Ninety-six percent of students reported on the posttest that they believed the agricultural education department at their school should continue to provide an opportunity to build CROPS. In all three school districts the local weekly newspapers did feature articles on the farmers who received the CROPS and highlighted these agricultural education programs as high-impact farm safety community service projects (URL link to North Laurel paper article).

Cost of CROPS Materials for Project

The agricultural educator on the research team was responsible for the coordination of materials among the three schools and for purchasing the materials for the projects. In 2012, he reported the total cost for the seven CROPS projects totaled $6690.45, which equates to $955.78/CROPS, including the costs of providing each school with a seat and seat belt assembly, presuming this equipment would also be a need (and ordering tools, we didn’t want to delay projects, if they were then needed). This staffer noted in an e-mail to the project team, “On the bright side, 2013 is much, much better.” For a project extension, with additional supplemental funding for the 2013–2014 school year (more on this in Discussion below), the total cost for 20 CROPS was $10,422.53 ($4775.03 for seats and seat belts). These expenditures also included welding safety equipment (helmets, welding jackets, gloves, etc.) as well as the welding wire and electrodes. All totaled this cost equates to $387.66 to construct the CROPS and $238.75 to add a seat and seat belt. These combined are $626.41, which is much cheaper than the phase 1 pilot breakdown. Moreover, as shown in Table 3, for the four models the school sites constructed, when compared with the original engineering manufacturing (OEM)

| County               | Tractor models | Ford 4000 | MF 230 | MF 135 | Ford 8N |
|----------------------|----------------|-----------|--------|--------|---------|
|                      | OEM cost       | AM cost   | OEM cost | AM cost | OEM cost | AM cost |
| North Laurel Co. HS | $985           | $850      | $985    | $850   | $950    | $850    |
| McCreary Co. HS     |                |           |         |        |         |         |
| Whitley Co. HS      |                |           |         |        |         |         |

Table 3. OEM and AM ROPS Cost Comparisons

Note. For each NIOSH tractor model plan used at each school site, the original engineering manufacturing (OEM) cost without seat, seat belt, and labor and the agricultural mechanics (AM) CROPS with seat, seat belt, and labor cost are compared, and the number of CROPS installations per site is shown.
cost of a ROPS without the inclusion of seat, seat belt, and labor, the agricultural mechanics class CROPS tractor with seat, seat belt, and labor cost proved more economical. For the Ford 4000, MF 230, and MF 135, the CROPS (with seat belts and seats) was $135 cheaper; the OEM for the 8N was $750, but did not include the seat belt and seat, which would add approximately an additional $238.

**Hazard Reduction**

Seven CROPS were built in agricultural mechanics classes in the three Appalachian high school sites. The installs were on four Ford 4000, one 230 MF, one 135MF, and one 8N Ford (see Table 3). The projects promoted community awareness of ROPS and tractor safety, and over 100 students received supervised instruction by certified agricultural education teachers that these NIOSH plan exist, how to read and implement project planning, welding skills and safety, and finally in building and installing a CROPS retrofit. Moreover, we were able to ascertain additional information from one school site regarding the retrofits. A recipient of a Ford 4000 owned a small family farm, whose members used the tractor for bush hogging and manure spreading (North Laurel). The 135 MF and Ford 4000 McCreary recipients are both full-time farmers with 100- and 150-acre farms that do own other tractors (with ROPS) and are pleased with their CROPS retrofits. In the future we plan to gather more systematic rather than anecdotal information on these tractors.

**DISCUSSION**

**Impact and Hazard Reduction**

The integration of CROPS assembly and installation for non-ROPS tractors was feasible and provided an authentic project for real-world problem solving and community service for the teachers and students in the three rural Appalachian high schools that participated in this study. Increases in awareness of CROPS and knowledge of assembly and installation procedures were evident in the data. Most importantly, the installation of seven CROPS on non-ROPS tractors meets the high-impact criteria for NIOSH projects and significantly reduced exposure to hazard for the farmers whose tractors were outfitted with the CROPS. Media coverage in all communities as well as the State Fair display promotions contributed not only to the emphasis of safety in the statewide agricultural community of practice, but also to general dissemination of the CROPS approach to the public. One CROPS project was on display at the National Future Farmers of America (FFA) conference in Louisville, with over 300 FFA students and advisors visiting the booth and obtaining information about the CROPS project. Five more districts have been recruited to participate in a follow-up implementation. The most important results of this feasibility study were data used to inform another improved iteration of the CROPS integration concept. The new sites (five) will benefit from multiple lessons learned and improved procedures drawn from the initial preliminary research detailed below.

**Lessons Learned and Revisions to the Implementation of CROPS Projects in Agricultural Education Classes**

**Revision of the Knowledge Measure**

Based on feedback from the agricultural educators, the knowledge measure was revised to more closely align with curriculum content and newly adopted standards for agricultural education. These modifications include more specific content related to accessing the NIOSH plans, multiple dimensions of project planning, welding procedures and safety practices, reading and implementing plans, as well as the actual CROPS assembly and installation. The revised measure is shown in Appendix B.

**Training and Classroom Curriculum Guide for Instructors**

Resulting from this pilot, a complete CROPS curriculum tailored to agricultural equipment and power machinery instructional outcomes for instructors has been developed for use with the next group of Kentucky high school implementation sites. Objectives, activities, and strategies
for implementing the project are available for the new group of instructors. The data from the students’ knowledge measure from the pilot have informed content that needs emphasis and reinforcement in the phase 2 implementation. The revised knowledge measure is also available for classroom assessment.

**Costs of CROPS Project**

The knowledge of specific outlets to purchase the needed materials greatly improved the reduction of costs to buy the materials for the five new study sites. As previously noted, the costs were greatly reduced during this second phase of CROPS implementation. We learned that the costs of the project for high school implementation has several additional important cost considerations: (1) purchases should also include purchase of the drill bits, because the bits necessary to puncture the metal needed for the CROPS assembly are very expensive, not typically in a school shop; the original pilot site programs absorbed these unanticipated costs. Also, welding safety equipment, welding wire, and electrodes were not included in pilot year 1, but were in the 2013 expenditures. This addition was possible due to the reduction in overall costs of the CROPS assembly items.

**Sustainability and Impact**

In addition to hazard reduction and increased awareness of effective farm safety practices, a crucial dimension of the CROPS integration pilot is sustaining these high-impact strategies in agricultural education classes that will continue to train future farmers enrolled in agricultural mechanics and power machinery classes. This approach also mirrors health and safety promotion models targeting at-risk populations at the locations at which they are most assessable (in this case in schools, but often on-site at workplaces, for example) are at most risk. In the phase 2 implementation, we are also piloting a crowdfunding, social media component for FFA students. Crowdfunding is anticipated to be a viable source of the $1,000 annually that would cover the cost to retrofit a local non-ROPS tractor with a CROPS and the local agricultural education program would not be absorbing these costs. Designing such a project will provide a self-sustaining option for local FFA students to garner funds to support the purchase of CROPS materials select a local farmer for a CROPS installation and to further energize local communities in farm safety efforts.

**FUTURE RESEARCH**

This feasibility study has shown multiple positive aspects to an implementation of the NIOSH CROPS construction and installation for non-ROPS tractor retrofits. As an initial process-outcome evaluation, we were able to triangulate data from the teachers and students and from programmatic data (e.g., cost of ordering materials done by the university research team) to support a conclusion of feasibility for the implementation of CROPS assembly and installation in high school agricultural mechanics classes.

The follow-up phase 2 study will further hone the project for a larger implementation in agricultural education classes that are geographically distributed regionally or nationally. A larger implementation would support additional curricula and research extensions of this preliminary work. The farm safety units in schools could be enhanced, for example, with the ROPS Guide available online as well as other research projects using the NIOSH surveillance databases to further emphasize knowledge of injury and exposure to hazard. A multisite robust research design including intervention and control sites and pre-post knowledge measures would assess impact with statistical precision and more in-depth qualitative investigations. For example, in addition to the demographic, surveillance, and CROPS knowledge and skill measures, research should include additional assessments that might include stages of change instruments and perhaps state measures that are under development consequent to new agricultural education standards promulgated by national agricultural education organizations. Other considerations related to this initial work such as implications for the preparation of agricultural educators regarding the implementation of a CROPS project into classroom practice and possible industry pushback
might also be explored in the subsequent phases of the CROPS research efforts.

SUPPLEMENTAL MATERIAL

Supplemental information for this article can be accessed on the publisher’s website.

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