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## The NIOSH CROPS Demonstration Project: A Study in New York and Virginia with an Emphasis on Youth

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### Abstract

The agriculture, forestry, and fishing (AgFF) industry sector has had the highest rate of work-related deaths over the past several years. Tractors are the single largest source of occupational fatalities in this industry sector, and tractor rollovers are the largest category of tractor fatalities. The risk of death due to tractor rollovers has been found to be reduced considerably when rollover protective structures (ROPS) are used in conjunction with seatbelts. Increasing the number of tractors with ROPS and seatbelts is one way in which tractor rollover fatalities can be mitigated. The NIOSH cost-effective rollover protective structure (CROPS) project was designed as a demonstration project to determine if CROPS, a type of ROPS, could be retrofitted in the field and were acceptable to farmers. To this end, the CROPS project was successful, with 50 tractors being

retrofitted with CROPS in the field. All study participants were asked to complete a pretest, test, and posttest regarding the CROPS retrofit demonstration and their knowledge and attitudes toward ROPS. CROPS demonstrators were the participants who retrofitted their tractors with CROPS. Demonstrators were asked to recruit three to five other participants, known as observers, to watch the demonstration. The rationale was to generate interest in ROPS/CROPS among other farmers and community leaders. Overall, 16% of the participants had youth operating tractors on their farms. Participants reported that 44 youth operated tractors on their farms, more than 25% of these young tractor operators were 4 to 10 years old, and half of the youth operating tractors on participant farms were 13 years old or younger. Only one participant group (demonstrators) included individuals who had all of their tractors protected with ROPS/CROPS for young tractor operators (28%), but they accounted for only one farm each among the New York and Virginia demonstrators. The survey question on ROPS importance did not show an overall increase after respondents participated in the CROPS demonstration project. However, one Virginia observer asked to become a Virginia demonstrator and installed a CROPS on his tractor. Additionally, the questions on attitude toward ROPS showed a general increase in mean scores, with some of the lowest response categories on the follow-up survey not being selected by respondents, indicating a potentially positive impact on participants' safety attitudes toward ROPS. For the safety attitude questions, the majority remained the same. This study indicates there is still much work to be done to reduce the number of deaths in production agriculture due to tractor rollovers. CROPS could be a valuable addition to the efforts of retrofitting ROPS on tractors in order to reduce the number of deaths due to tractor rollovers.

### Keywords

Cost-effective rollover protective structures (CROPS); Injury prevention; Rollover protective structures (ROPS); Tractor safety

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The U.S. agriculture industry continues to have a high rate of occupational fatalities. While the overall rate of work-related fatalities has been showing a small general decline over the past decade, the agriculture, forestry, and fishing (AgFF) industry sector has had the highest rate of work-related deaths over the past several years (Hard et al., 2015). Additionally, the AgFF sector has been ranked third in the total number of work-related deaths for many years. Production agriculture, an agriculture subsector, is most closely affiliated with the occupation of farming. As an occupation, farming is considered high risk, with a fatality rate of 23.9 per 100,000 workers and 232 deaths in 2013 (BLS, 2015).

Tractors are the single largest source of fatalities in this industry sector and in the farming occupation. Tractor fatalities can be due to rollovers, runovers, and entanglements, but tractor rollovers are the largest category of tractor fatalities (NIOSH, 2004, 2014b). Tractor deaths have been found to be reduced considerably when rollover protective structures (ROPS) are used in conjunction with seatbelts (MMWR, 1993; Pana-Cryan and Myers, 2000). Tractor manufacturers adopted a voluntary standard developed and approved by ASAE in 1985 (S318: Safety for agricultural field equipment), which required practically all new tractors sold in the U.S. to be equipped with ROPS and seatbelts as standard equipment (ASABE, 2009). However, this left a large number of tractors still in use that were not

equipped with ROPS or were never designed for ROPS. Generally, tractors manufactured prior to the mid-1960s were not engineered or designed for ROPS (Cole and Westneat, 2012).

The concern regarding these pre-ROPS tractors is that, since they were not designed or engineered for ROPS, the axle housings (where two-post ROPS are generally attached) might not be strong enough to absorb the impact or withstand the loads that could be applied in a tractor rollover event. However, limited research has shown that the tractor housings of several of these models were strong enough to support a ROPS and withstand an overturn (Li and Ayers, 1997; Ayers, 1997; Wen et al., 1994). Additionally, the rear axle housings of some of these pre-ROPS tractors were not square, making a compression attachment of the ROPS to the axle difficult. Some promising work has been done in this area indicating that engineering plastics could be a potential solution, but additional research is needed (Comer et al., 2007). The Ford 8N and Massey Ferguson 135 both have round axle housings; however, where the rear fenders mount, there is a flat surface flange on both the top and bottom, which is part of the axle casting. It was at this location that the cost-effective rollover protective structure (CROPS) brackets were mounted. NIOSH tested the CROPS on four tractor models (Ford 8N, Massey Ferguson 135, Ford 3000, and Ford 4000) in accordance with testing criteria outlined in SAE J2194 and did not record a failure of the axle housings. The test results are available at: <http://www.cdc.gov/niosh/top-ics/aginjury/crops/>.

Recent data indicate that about 59% of the tractors on U.S. farms have ROPS (NIOSH, 2014b). Previous international work on reducing tractor fatalities due to rollovers has shown that a significant reduction in these deaths does not occur until 75% to 80% of the population of tractors have ROPS (Springfeldt, 1996; NIOSH, 2004; Thelin, 1998; Hard and Myers, 2011). Therefore, it is paramount to increase the number of tractors that have ROPS, either through replacement with newer ROPS-equipped tractors or by retrofitting older tractors with ROPS, in order to achieve a reduction in tractor rollover fatalities.

## Methods

The NIOSH CROPS project was designed as a demonstration. Rogers (1995) noted that “potential adopters of a new idea are aided in evaluating an innovation if they are able to observe it in use under conditions similar to their own.” Demonstration projects, in the simplest terms, typically seek to determine if something is feasible or to demonstrate that it can be done. NIOSH researchers wanted to determine if the CROPS retrofit models designed by NIOSH personnel could be retrofitted on various tractors in the field and if they were acceptable to the farmers (CROPS demonstrators) who retrofitted them. The NIOSH researchers also wanted to know if farmers could successfully retrofit the CROPS design on their farms.

The principal investigator collaborated with researchers from the New York Center for Agricultural Medicine and Health (NYCAMH) and used questions from previous studies developed by NYCAMH for assessing readiness to change and pre-intervention surveys

(May, 2006; Sorenson, 2006). The survey questions were used for assessing attitudes and knowledge of ROPS in the current study.

Collaborator organizations were recruited in two states (New York and Virginia) that had an on-going ROPS retrofit program. These organizations were the New York Center for Agricultural Medicine and Health and the Virginia Farm Bureau safety office. Demonstrators for the study were recruited by these state collaborators, and the demonstrators recruited observers for their individual farm; observers were often neighbors, relatives, or friends. In return for the demonstrator's participation, NIOSH provided a CROPS (all mounting hardware and a new seatbelt) to the demonstrator free of charge (an estimated \$700 retail value) and printed installation instructions. In addition, NIOSH personnel were on-site to assist with the installation and provide tools if needed. Tools were available from a work trailer outfitted with hand and power tools, a generator, and an oxy-acetylene torch. Due to the importance of the tractor operator's seat for proper seatbelt anchorage and operation, many installations also received a new tractor seat, provided by NIOSH. Additional information on the NIOSH CROPS project may be found in Hard et al. (2015).

The CROPS demonstration consisted of the demonstrator preparing his tractor for the CROPS retrofit (removing tractor fenders, front-end loaders, or any attached or towed equipment) and then retrofitting the CROPS. Demonstrators and observers were asked questions via a written survey before the CROPS demonstration began, immediately after the CROPS demonstration, and then about one year after the last demonstration was conducted in their respective state. The demonstrator and observer pretest and posttest scores in each state were compared on selected variables. Univariate and descriptive statistics were used to obtain the results reported. SPSS Statistics 21.0 was used for data analyses (SPSS, 2012).

Pretests were mailed to demonstrators prior to the CROPS retrofit, while the observer pretests were completed at the time of the demonstration. Demonstrators completed their pretest prior to the actual demonstration date, while observers completed their pretest at the demonstration site while the demonstrator was preparing the tractor for the retrofit. Tests were completed at the end of the CROPS demonstration by both groups. Posttests were mailed to both the demonstrators and observers in each state at the same time, approximately one year after the date of the last demonstration, following a modified Dillman mail survey protocol (Dillman, 2000). The modified Dillman survey protocol consisted of the following steps. Participants were first sent a cover letter indicating that they would soon be receiving a survey packet in the mail with an enclosed prepaid return mailer. Three to five days after mailing that initial notification, the survey was mailed. If a response was not received by seven to ten days after the survey mailing (i.e., two weeks since initial contact), a reminder letter was mailed. If a response was not received after an additional seven to ten days (three weeks since initial contact), another survey with a cover letter appeal to complete and return the survey was mailed. If a response was not received after another seven to ten days (four weeks since initial contact), a reminder letter was sent. Two weeks later (six weeks total), a final mailing was sent with another packet consisting of a survey and cover letter appealing to participants to complete the survey and indicating that this would be the final contact.

The survey consisted of questions on why the demonstrators had not retrofitted their tractors up to the point of participation in the study, the importance of retrofitting tractors, Likert-type questions regarding retrofitting a tractor, safety attitudes in selected areas, the number of tractors they own and use, whether their tractors had ROPS installed, whether youth 18 years old or younger operated tractors on their farm, days of work off-farm, demographic information (age and gender of respondent), type of farm, gross farm sales (in nine categories to enhance response rates), total farm income or percent of farm income to total family income, and total household income. Observers were asked the same questions with the exception of specifics on the retrofitted tractor.

## Results

The protocol of the program, the number of participants ( $n = 131$ ), and descriptive statistics along with comparisons of selected demographics to each group's state and national data in the 2007 Census of Agriculture were reported previously (Hard et al., 2015). Response rates for the surveys were 84% for demonstrators and 67% for observers in New York and 96% for demonstrators and 83% for observers in Virginia. This resulted in an overall response rate of 92% for demonstrators and 74% for observers.

### Youth Operating Tractors

A question on the pretest and posttest for both demonstrators and observers was “Do you have children (18 or under) on the farm operating a tractor?” The number of participants indicating youth driving tractors on their farms was fairly small (8% to 20%), depending on the participant group, with an overall response of 16%. If the answer was “yes,” a follow-up question of “What age(s)?” was available for the respondent to complete. The age range reported by participants for young tractor operators was 4 to 18 years old, and the participants reported that 44 youth operated tractors on their farms (table 1).

In New York, farms that had youth 18 years old or younger operating tractors were crop, crop and livestock, dairy, or “other” farms (horse and gentleman farms). New York demonstrator farms with youth operating tractors ranged in size from 103 to 150 acres and had gross farm sales of \$10,000 to \$24,999. The New York observer farms ranged in size from 27 to 450 acres with a mean of 140 acres, median of 100 acres, and mode of 170 acres. These farms had gross farm sales of <\$2,500 to \$300,000-\$499,999. Virginia demonstrator farms that had youth 18 years old or younger operating tractors were either crop farms or crop and livestock farms. The Virginia demonstrator farms ranged from 110 to 400 acres in size and had gross farm sales of \$5,000-9,999 to \$50,000-\$99,999. The Virginia observer farms were crop and livestock farms and ranged in size from 140 to 800 acres with a mean of 435 acres and a mode and median of 400 acres. Virginia observer farms that had youth 18 years old or younger operating tractors had gross farm sales of \$2,500-\$4,999 to \$50,000-\$99,999.

Farmers who indicated more than one youth operating a tractor on their farm were New York demonstrators (one), New York observers (four), Virginia demonstrators (two), and Virginia observers (four). Of the farms that had multiple youth operating tractors, two youth were the maximum reported.

## Tractors with ROPS

Demonstrators and observers were asked “How many other tractors do you own/use?” and whether or not the tractors were protected with ROPS (table 2). The New York demonstrators answered the question 24 out of 25 times (96%) with a range of zero to ten additional tractors used on their farms. Four New York demonstrators indicated no additional tractors, eight had one additional tractor, five had two tractors, five had three tractors, one had six tractors, and one had ten tractors, for a total of 49 tractors. Including the 25 tractors used in the CROPS demonstrations, there was a total of 74 tractors. Eighteen (24%) of these tractors were protected with ROPS prior to the CROPS demonstration, and 42 (57%) were protected after the CROPS demonstration. The highest number of tractors protected with ROPS on any New York demonstrator farm was three, but after the CROPS demonstration nine New York demonstrators (38%) had all their tractors protected with ROPS, with four of these nine demonstrators having only the single demonstration tractor retrofitted with a CROPS.

Virginia demonstrators answered the question 24 out of 25 times (96%) with a range of zero to six additional tractors. One Virginia demonstrator indicated no additional tractors, seven had one additional tractor, eight had two tractors, two had four tractors, four had five tractors, and two had six tractors, for a total of 63 tractors. Including the 25 tractors used in the CROPS demonstrations, there was a total of 88 tractors. Thirty-one (35%) of these tractors were protected with ROPS prior to the CROPS demonstration, and 56 (64%) were protected with ROPS afterward. The highest number of tractors protected with ROPS on an individual Virginia demonstrator farm was four, with a total of seven farms (29%) after the CROPS demonstration having all tractors protected with ROPS (one had only the demonstration tractor retrofitted with a CROPS, three listed one additional ROPS-equipped tractor, and three listed two additional tractors that were protected with ROPS).

New York observers answered the tractor question 91% of the time (41 out of 45 respondents), with a range of 0 to 15 additional tractors (twelve had no tractors, eleven had one tractor, six had two tractors, three had three tractors, six had four tractors, one had six tractors, one had eleven tractors, and one had fifteen tractors) for a total of 88 tractors (table 2). Twenty-four (18%) of these tractors were protected with ROPS prior to the CROPS demonstration, and this remained the same after the CROPS demonstration. The highest number of tractors protected with ROPS on any New York observer farm was ten, with six farms (18%) having all tractors protected with ROPS (five had one tractor and one had four tractors that were all protected with ROPS).

For Virginia observers, 34 of 36 (94%) provided responses to the tractor question, with a range of zero to six additional tractors on their farms (two had no tractors, four had one tractor, nine had two tractors, nine had three tractors, three had four tractors, four had five tractors, and three had six tractors) for a total of 99 tractors. Fifty-three (53%) of these tractors were protected with ROPS prior to the CROPS demonstration, and 54 (54%) were protected with ROPS afterward. The highest number of tractors protected with ROPS on a single Virginia observer farm was six, with ten farms (36%) having all their tractors protected with ROPS (three had one additional tractor with ROPS, four had two tractors with ROPS, two had three tractors with ROPS, and one had five tractors with ROPS).



## Youth Operating Tractors with ROPS

Table 2 provides tractor and ROPS usage by CROPS study participants. Three New York demonstrators indicated that youth 18 years old or younger operated tractors on their farms. All three had an additional one to two tractors on their farm. Only one farm (33%) indicated that all the tractors that youth potentially operated were protected with ROPS. Nine New York observers reported that youth 18 years old or younger operated tractors on their farms, and they had 0 to 15 additional tractors (on the farm with 15 additional tractors, ten had ROPS). One farm did not complete the additional tractor question, one farm had no additional tractors, one farm had two additional tractors, two farms had three additional tractors, three farms had four additional tractors, and one farm had 15 (this largest number of tractors was on a dairy farm with gross farm sales of \$300,000 to \$499,000). None of the New York observer farms that reported youth operating tractors had all of their tractors equipped with ROPS. Four Virginia demonstrators reported youth operating tractors. They indicated two (three farms) to five (one farm) additional tractors, with a range of two to four tractors having ROPS. One Virginia demonstrator (25%) reported that all tractors operated by youth had ROPS. Four Virginia observers reported that youth 18 years old or younger operated tractors on their farms. They had three to six additional tractors. All of these farms had at least one tractor without an approved ROPS, potentially exposing a young tractor operator to injury if a rollover occurred with the unprotected tractor.

## Economic Variables

Of the 131 participants, 90 (69%) answered the question about gross farm sales within nine categories (table 3). Categories were used to increase response rates, with finer detail at the lower range of sales and a larger grouping at the top range of sales.

Participants were asked for their total gross family income or the percentage of the total gross family income that is farm income. These were not mutually exclusive categories, and not every participant who answered the gross farm sales question also answered the family income question. Thus, each question was analyzed separately, with 30% of the participants providing a response for the gross family income question. The range of gross family income across all participants was \$0 to \$150,000 but varied across participant types (demonstrator and observer) and by state (table 3). This question had the lowest response rate of the economic questions.

The percentage of family income that was farm income had usable responses 40% of the time. The percentage of family income that came from the farm ranged from 0% to 100%. New York demonstrators had gross farm sales of <\$10,000 65% of the time, and New York observers had gross farm sales of <\$10,000 in 50% of the cases. Virginia demonstrators had gross farm income of <\$10,000 in 54% of the cases, and 44% of Virginia observers indicated <\$10,000 in gross farm sales.

## Economic Variables and Youth

Four (44%) of the New York observers who listed <\$10,000 of gross farm sales had youth 18 years old or younger operating tractors on their farms. The range of gross farm sales for New York participants with youth operating tractor on their farms was <\$2,500 to \$300,000-

\$499,999. One (25%) Virginia demonstrator had youth 18 years old or younger operating tractors on a farm with <\$10,000 in gross sales, and one (25%) Virginia observer had youth 18 years or younger operating tractors on a farm with <\$10,000 in gross sales. The range of gross farm sales for the Virginia participants with youth operating tractors on their farms was \$2,500-\$4,999 to \$50,000-\$99,999.

### Days Work Off-Farm

Days of work off-farm are listed in table 4 along with variables that could be associated with work off-farm (age, farm size, gross farm sales, gross family income, and percentage of family income that is farm income). The younger New York demonstrators worked more off-farm (70% worked off-farm, and 40% worked >200 days off-farm) than the older participants; however, two 63-year-olds and one 69-year-old worked >200 days off-farm. The mean ages of New York demonstrators by category for working off-farm was “none” (72 years), “any” (63 years), and “>200 days” (50 years). New York observers followed a similar trend but had younger mean ages by category for working off-farm: “none” (60 years), “any” (46 years), and “>200 days” (42 years).

Virginia demonstrators worked off-farm 58% of the time, with 42% indicating no off-farm work. The mean ages of Virginia demonstrators by category for working off-farm was “none” (74 years), “any” (55 years), and “>200 days” (58 years). Virginia observers worked off-farm 55% of the time, with 45% indicating no off-farm work. The mean ages of Virginia observers by category for working off-farm was “none” (57 years), “any” (54 years), and “>200 days” (44 years).

### ROPS and Safety Attitudes

**ROPS Importance**—The question “How important do you believe it is to have rollover protection on your tractor(s)” was asked on the pretest and posttest with four responses allowed: “not at all important” (coded as 4), “not very important” (coded as 3), “important” (coded as 2), and “very important” (coded as 1). The participants' initial scores were compared to their final scores, with a decrease in score indicating an increase in importance.

In New York, the majority (31) remained the same, with four demonstrators decreasing by one point and two increasing by one point. Six New York observers increased their scores by one point, while three decreased their ROPS importance scores by one point. In Virginia, the majority (36) likewise remained the same, with two demonstrators increasing their scores by one point while three decreased by one point. Eight observers decreased their scores by one point, while three increased their scores by one point.

**ROPS Attitude**—Five questions were asked of the participants regarding their attitudes toward ROPS with a Likert-type 10-point response scale. The numbers 1 through 10 allowed the respondents to select any of those points along the scale. The questions were: “Installing a rollover protective structure on at least one of my unprotected tractors is: (Q1) “bad farm practice” [1] to “good farm practice” [10], (Q2) “not cost effective” [1] to “very cost effective” [10], (Q3) “inconvenient” [1] to “convenient” [10], (Q4) “unnecessary” [1] to “necessary” [10], and (Q5) “irresponsible” [1] to “responsible” [10]. The New York



demonstrators had fewer lower responses to all five questions from the pretest to the posttest, with mean scores increasing for all five questions, while the New York observers indicated a decrease in the number of lower responses in one of the five questions, with mean scores increasing or remaining the same for three of the five questions. The Virginia demonstrators had fewer low responses for four of the five questions, and mean scores increased for three of the five questions. The Virginia observers had fewer low responses for two of the five questions, and mean scores increased for three of the five questions.

**Safety Attitude**—Five questions with four response levels (strongly disagree [1], disagree [2], agree [3], and strongly agree [4]) were asked of the participants (demonstrators and observers) before and one year after the CROPS demonstration. The questions were: (Q1) “It is less likely that anyone on my farm would be killed or hurt in a tractor rollover when compared to other farms,” (Q2) “Most people who are important to me think that I should retrofit at least one of my unprotected tractors,” (Q3) “It is expected of me that I retrofit at least one of my unprotected tractors,” (Q4) “I feel pressured to retrofit at least one of my unprotected tractors,” and (Q5) “If I have a ROPS/CROPS on my tractor, I will wear my seatbelt whenever I am on the tractor.” Each question is analyzed separately in table 5. In general, the majority of the responses were unchanged, with Virginia participants being more likely than New York participants to decrease their score, which indicates a less favorable opinion on a particular question. Nine of the 20 subgroups in table 5 show a decline in mean score.

### Knowledge of Tractor Deaths

Observers were asked the question “Are you aware that tractors account for the largest single identifiable source of occupational deaths in farming?” with a dichotomous “yes” or “no” answer. It was believed that the demonstrators, because they had already volunteered to retrofit their tractors with CROPS, were already at a higher level of understanding of the risk and danger of not having ROPS protection. Almost three-quarters of the observers (72%) knew that tractors were the leading cause of occupational deaths in farming; conversely, 28% were not aware of this fact.

### Follow-up Responses on Issues with CROPS

Demonstrators were provided the opportunity to respond to whether they had any problems with the CROPS (dichotomous “yes” or “no”) and an open-field question for clarification if they answered in the affirmative. Twelve demonstrators indicated that they had problems with the CROPS; six of these were getting used to the height of the CROPS, five noted the stabilizer bar hitting the CROPS mounting bracket at full lift, two were tire clearance issues (moving the fenders out caused tires or tire chains to rub the fenders), and two wanted to be able to mount a canopy for sun protection. One farmer did not leave the CROPS on his Ford 8N tractor. He had an issue with the stabilizer bar hitting the lower CROPS bracket in the full lift position. It was suggested to him that a J-type stabilizer bar could potentially solve the problem, but it is unknown if this was actually tried. This demonstrator did not complete the follow-up survey, but the observers who attended the demonstration at his farm reported the end result. The other demonstrators who noted an issue with the stabilizer bars (arms) hitting the CROPS mounting bracket either did not use the stabilizer bars (two) or modified

the bracket or stabilizer bars, which is not recommended. The stabilizer bar issues were noted on Ford 8N (one), MF 135 (three), and Ford 3000 (one) tractors.

Demonstrators and observers were asked if they would be interested in retrofitting their tractor or another tractor with ROPS/CROPS in the future (“yes,” “no,” “maybe,” and an open-field response). In New York, 19 demonstrators and 19 observers indicated that they would be interested in doing so in the future. In Virginia, 24 demonstrators and 26 observers indicated that they would be interested in retrofitting another tractor with ROPS or CROPS in the future. Of the 12 who responded “no,” four indicated that they no longer had tractors (and were at an age they could retire), two indicated that any future tractors they purchase would have ROPS, two indicated that all their tractors currently had ROPS, one indicated that all his tractors had ROPS except one, which was used in a barn and clearance issues prevented installing a ROPS or CROPS, one replied that all his tractors were collector tractors and were not used in the field anymore, and one stated that the cost of the ROPS plus the limited hours of tractor use did not justify obtaining a ROPS for his tractor. One observer responded “no” but did not provide any additional information.

## Discussion

Since 1996, NIOSH has conducted the National Childhood Agricultural Injury Prevention (NCAIP) program, which seeks to reduce the number of childhood agricultural injuries (NIOSH, 2014a). Thus, youth operating tractors on farms were of interest in this study. The number of participants who reported youth operating tractors on farms was small (8% to 20%, and 16% overall). However, this could be a reflection of the increasing average age of farmers, meaning that their children could have left the farm or were over the age of 18. Additionally, some very young ages for tractor operation were reported (4 to 10 year olds comprised 27% of the youth driving tractors). According to the U.S. Department of Labor's child labor requirements in agricultural occupations under the Fair Labor Standards Act (USDOL, 2007), which prohibit youth under 16 years old from “operating a tractor over 20 power-take-off horsepower” but allow exemptions for 14 and 15 year olds who have received tractor and machinery operation training, youth 13 years old and younger should not be operating tractors. These youth made up 50% of the young population in this study who were operating tractors. However, for farm parents, there is no minimum age requirement or regulation pertaining to when they should allow their children to operate hazardous equipment on their own farms (USDOL, 2007). It was interesting to note that for this question (i.e., children 18 years old or younger operating tractors on the farm), a few of the older farmers (65+ years old) answered in the affirmative but listed ages of 40 years for these children. We believe this reflects the complex parent-child relationship between older parents and adult children. Even though the children are now adults and take on major responsibilities of operating the farm, they are still viewed as “children” by older farmers.

Previous studies have found that farms smaller than 300 acres, having an operator 65 years old or older, or with farm income of less than \$10,000 per year all had significant associations with not having ROPS on tractors (Myers, 2010; Loring and Myers, 2008). In this study, all New York demonstrator farms were smaller than 300 acres, as well as 27 of the 29 farms of New York observers who answered the farm size question. Many of the

Virginia demonstrator farms (75%) as well as 22 of 31 of the Virginia observer farms (71%) were also smaller than 300 acres. Half of the New York and Virginia demonstrators were 65 years old or older, but only 28% of the New York observers and 33% of the Virginia observers were in this age category. Almost two-thirds (65%) of the New York demonstrators and over half (54%) of the Virginia demonstrators had gross farm sales of < \$10,000. Fifty-eight percent of the New York observers and not quite half (44%) of the Virginia observers fit this category. This study supports previous findings that these variables are associated with farmers who do not have ROPS on their tractors.

The ROPS importance question did not show an overall increase in farmers' views on ROPS after they had participated in the CROPS demonstration, with the majority of their responses remaining unchanged. However, one Virginia observer asked to become a Virginia demonstrator and installed a CROPS on his tractor. Additionally, the attitude toward ROPS showed a general increase in mean scores, with some of the lowest response categories on the follow-up survey not being selected by respondents, indicating a potentially positive impact on participants' safety attitudes toward ROPS. For the safety attitude questions, the majority remained the same. In general, Virginia participants were more likely to decrease their scores. There was likely some effect due to the generally lower response rates on the posttest across all participant categories.

## Limitations

Participants enrolled in the study, especially the demonstrators, were likely a non-representative biased population, as some had previously indicated an interest in retrofitting their tractor through their state ROPS retrofit program. However, a previous analysis (Hard et al., 2015) indicated that they were similar in several selected demographics to their state's Census of Agriculture and national Census of Agriculture. Observers were recruited by the demonstrators and were a convenience sample, as they were often neighbors, relatives, or friends.

## Conclusions

Demonstration projects, in the simplest terms, seek to determine if something is feasible or to demonstrate that it can be done. In terms of this definition, the CROPS project was successful in demonstrating that the CROPS retrofit models designed by NIOSH could be retrofitted on various tractors, and they were acceptable to the vast majority of CROPS demonstrators who retrofitted them. Additionally, it was shown that farmers could retrofit the CROPS design on their own tractors. Posttest responses from the demonstrators who retrofitted their tractors indicated some concerns with the height of the CROPS and stabilizer bar interference with the CROPS mounts. These two issues should be investigated further in any future work or design modifications of the CROPS.

Many of the participants in the CROPS project exhibited characteristics similar to those reported in other studies for farmers who would likely not have ROPS on their tractors (age of 65+, farm size of <300 acres, farm income of <\$10,000). The participant group with the

highest percentage for having all tractors on a farm protected with ROPS was the New York demonstrators (38%). This value ranged from 21% to 38% across participant groups.

The CROPS demonstration had mixed results in impacting participants' ROPS or safety attitudes. There was not much change in the participants' attitudes toward the importance of ROPS; however, one Virginia observer decided to become a Virginia demonstrator and installed a CROPS on his tractor. Additionally, the questions on the participants' attitudes toward ROPS showed a decrease in several of the lowest response categories, with an associated increase in mean scores for several of the questions, which indicates a positive increase in attitudes toward ROPS. Responses on five selected safety attitude questions generally remained the same for the majority of respondents. These results support previous findings regarding the difficulty of changing attitudes in general and farmer safety attitudes in particular (Murphy, 1992; Cole et al., 2002; May et al., 2006).

The number of youth 18 years old or younger who operated tractors on participant farms was fairly small at 8% to 20%, depending on the participant group, and 16% overall. This could be a result of the increasing average age of farmers, whose children were older than 18 years, although some older farmers reported children 18 years old or younger operating tractors on their farms, which leads us to believe that they were hired youth or grandchildren. The large percentage (50%) of youth 13 years old and younger operating tractors, especially the very young (27% 10 years old), is of concern due to the known hazards of operating tractors. Of the farmers who indicated that youth 18 years old or younger were operating tractors on their farms, a small proportion of demonstrators were the only participant group that had all their tractors equipped with ROPS, although the actual numbers were small, with one farm each for New York and Virginia demonstrators.

This study indicates that there is still much work to be done to reduce the number of deaths in production agriculture due to tractor rollovers. CROPS could be a valuable addition to the efforts of retrofitting ROPS on tractors nationally.

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## References

- ASABE. S318.17: Safety for agricultural field equipment. St. Joseph, MI: ASABE; 2009.
- Ayers PD. ROPS design for pre-ROPS tractors. *J Agromed*. 1997; 4(3-4):309–311. [http://dx.doi.org/10.1300/J096v04n03\\_15](http://dx.doi.org/10.1300/J096v04n03_15).
- BLS. Number and rate of fatal occupational injuries to civilian workers, by major occupation group, 2013. Washington, DC: Bureau of Labor Statistics; 2015. Retrieved from [www.bls.gov/iif/oshwc/foi/cfch0012.pdf](http://www.bls.gov/iif/oshwc/foi/cfch0012.pdf)
- Cole HP. Cognitive-behavioral approaches to farm community safety education: A conceptual analysis. *J Agric Saf Health*. 2002; 8(2):145–159. <http://dx.doi.org/10.13031/2013.8428>. [PubMed: 12046802]
- Cole, HP.; Westneat, SC. Chapter 17: Preventing farm-related injuries: The example of tractor overturns. In: Crosby, RA.; Wendel, ML.; Vanderpool, RC.; Casey, BR., editors. *Rural populations*

- and health: Determinants, disparities, and solutions. San Francisco, CA: Jossey-Bass; 2012. p. 303-322.
- Comer RS, Ayers PD, Liu J. Evaluation of engineering plastic for rollover protective structure (ROPS) mounting. *J Agric Saf Health*. 2007; 13(2) <http://dx.doi.org/10.13031/2013.22615>.
- Dillman, DA. Mail and internet surveys: The tailored design method. New York, NY: John Wiley & Sons; 2000.
- Hard DL, Myers JR. Adoption of rollover protective structures (ROPS) on U.S. farm tractors by state: 1993-1995, 2001, and 2004. *J Agric Saf Health*. 2011; 17(2) <http://dx.doi.org/10.13031/2013.36499>.
- Hard DL, McKenzie EA Jr, Cantis D, May J, Sorensen J, Bayes B, et al. Maass J. A demonstration project in New York and Virginia: Retrofitting cost-effective rollover protective structures (CROPS) on tractors. *J Agric Saf Health*. 2015; 21(3):173-185. <http://dx.doi.org/10.13031/jash.21.11066>. [PubMed: 26373215]
- Li Z, Ayers PD. Strength test for pre-ROPS tractor axle housings. *J Agromed*. 1997; 4(3-4):303-307. [http://dx.doi.org/10.1300/J096v04n03\\_14](http://dx.doi.org/10.1300/J096v04n03_14).
- Loring KA, Myers JR. Tracking the prevalence of rollover protective structures on U.S. farm tractors: 1993, 2001, and 2004. *J Saf Res*. 2008; 39(5):509-517. <http://dx.doi.org/10.1016/j.jsr.2008.08.003>.
- May, JJ.; Sorensen, JA.; Burdick, PA.; Earle-Richardson, GB.; Jenkins, PL. Rollover protection on New York tractors and farmers' readiness for change. *J Agric Saf Health*, 12(3). 2006. <http://dx.doi.org/10.13031/2013.21228>
- MMWR. Public health focus: Effectiveness of rollover protective structures for preventing injuries associated with agricultural tractors. *MMWR*. 1993; 42(3):57-59. [PubMed: 8421458]
- Murphy, DJ. Safety and health for production agriculture. St. Joseph, MI: ASAE; 1992.
- Myers JR. Factors associated with the prevalence of non-ROPS tractors on farms in the U.S. *J Agric Saf Health*. 2010; 16(4) <http://dx.doi.org/10.13031/2013.34837>.
- NIOSH. National agricultural tractor safety initiative. Seattle, Wash: University of Washington, Pacific Northwest Agricultural Safety and Health Center; 2004. Retrieved from <http://nasdonline.org/1906/d001837/national-agricultural-tractor-safety-initiative.html>
- NIOSH. Childhood agricultural injury prevention initiative. Atlanta, GA: CDC-NIOSH; 2014a. Retrieved from <http://www.cdc.gov/niosh/topics/childag/>
- NIOSH. National estimates of agricultural machinery on U S farms Farm Safety Survey, table FS-4. Atlanta, GA: CDC-NIOSH; 2014b. Retrieved from <http://www.cdc.gov/niosh/topics/aginjury/FSS/pdfs/FS-4.pdf>
- Pana-Cryan R, Myers ML. Prevention effectiveness of rollover protective structures: Part III. Economic analysis. *J Agric Saf Health*. 2000; 6(1):71-80. <http://dx.doi.org/10.13031/2013.2913>. [PubMed: 10938754]
- Rogers, EM. Diffusion of innovations. New York, NY: Simon & Schuster; 1995. The change agent; p. 255-356.
- Sorensen JA, May JJ, Jenkins PL, Jones AM, Earle-Richardson GB. Risk perceptions, barriers, and motivators to tractor ROPS retrofitting in the New York State farm community. *J Agric Saf Health*. 2006; 12(3):215-226. <http://dx.doi.org/10.13031/2013.21229>. [PubMed: 16981445]
- Springfeldt B. Rollover of tractors: International experiences. *Saf Sci*. 1996; 24(2):95-110. [http://dx.doi.org/10.1016/S0925-7535\(96\)00069-0](http://dx.doi.org/10.1016/S0925-7535(96)00069-0).
- SPSS. SPSS Statistics for Windows, Ver 21.0. Armonk, NY: IBM; 2012.
- Thelin A. Rollover fatalities: Nordic perspectives. *J Agric Saf Health*. 1998; 4(3):157-160. <http://dx.doi.org/10.13031/2013.15353>.
- USDOL. Child labor requirements in agricultural occupations under the Fair Labor Standards Act (Child Labor Bulletin 102). Washington, DC: U.S. Department of Labor, Wage and Hour Division; 2007. Retrieved from <https://www.dol.gov/whd/regs/compliance/childlabor102.pdf>
- Wen, D.; Hetzel, G.; Perumpral, JV. ASAE Paper No 945001. St. Joseph, MI: ASAE; 1994. A technique for determining tractor axle housing strength for adding ROPS on older tractors.

**Table 1**  
**NIOSH CROPS study participants indicating youth operating tractors on farms**

Participants	New York		Virginia	
	Pretest	Posttest	Pretest	Posttest
Demonstrators, <i>n</i> (%) <sup>[a]</sup>	3 (12)	2 (9)	4 (16)	2 (8)
Youth age range (years)	10 to 17	10 to 15	7 to 16	13 to 16
Total number of youth	3	2	6	3
Observers, <i>n</i> (%) <sup>[a]</sup>	9 (20)	3 (10)	4 (11)	5 (17)
Youth age range (years)	4 to 18	5 to 16	10 to 17	12 to 16
Total number of youth	12	3	6	9

<sup>[a]</sup>Based on the number of valid responses.

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**Table 2**  
**Tractor and ROPS use by CROPS study participants**

Participants	New York	Virginia
Demonstrators	24 <sup>[a]</sup> /25	24 <sup>[a]</sup> /25
Additional tractors	0 to 10	0 to 6
Total number of tractors	74	88
Largest number of tractors with ROPS on a single farm	3	4
Tractors with ROPS prior to CROPS demonstration	18 (24%)	31 (35%)
Tractors with ROPS after CROPS demonstration	42 (57%)	56 (64%)
ROPS on all tractors used on farm	9/24 <sup>[b]</sup> = 37% <sup>[c]</sup>	7/24 <sup>[b]</sup> = 29% <sup>[d]</sup>
Observers	41 <sup>[a]</sup> /45	34 <sup>[a]</sup> /36
Additional tractors	0 to 15	0 to 6
Total number of tractors	88	99
Largest number of tractors with ROPS on a single farm	10	6
Tractors with ROPS prior to CROPS demonstration	24 (18%)	53 (53%)
Tractors with ROPS after CROPS demonstration	24 (18%)	54 (54%)
ROPS on all tractors used on farm	6/33 <sup>[b]</sup> = 18%	10/28 <sup>[b]</sup> = 36%

<sup>[a]</sup>Number who answered the tractor question on how many tractors they have.

<sup>[b]</sup>Number who answered if they had ROPS on their tractors.

<sup>[c]</sup>Four were demonstrators who had only one tractor that was retrofitted.

<sup>[d]</sup>One was a demonstrator who had only one tractor that was retrofitted.

**Table 3**  
**Economic variables by state and participant type**

Participants	New York		Virginia	
	Median	Range	Median	Range
<b>Demonstrators</b>	<i>n</i> = 17		<i>n</i> = 22	
Gross farm sales	\$2,500 to \$4,999	<\$2,500 to \$25,000-\$49,999	\$5,000 to \$9,999	<\$2,500 to \$50,000-\$99,999
Gross family income ( <i>n</i> = 8)	<i>n</i> = 8		<i>n</i> = 10	
	\$45,000	\$25,000 to \$80,000	\$60,000	\$32,000 to \$150,000
Percentage of family income that is farm income ( <i>n</i> = 9)	<i>n</i> = 9		<i>n</i> = 18	
	20%	1% to 35%	17.5%	0% to 100%
<b>Observers</b>	<i>n</i> = 24		<i>n</i> = 27	
Gross farm sales	\$2,500 to \$4,999	<\$2,500 to \$300,000-\$499,999	\$10,000 to \$24,999	<\$2,500 to >\$500,000
Gross family income ( <i>n</i> = 11)	<i>n</i> = 11		<i>n</i> = 11	
	\$5000	\$0 to \$100,000	\$50,000	\$0 to \$130,000
Percentage of family income that is farm income ( <i>n</i> = 12)	<i>n</i> = 12		<i>n</i> = 14	
	5.5%	0% to 70%	5%	0% to 75%

**Table 4**  
**Days work off-farm by participant type, age, farm size, gross farm sales, family income, and percentage of family income that is farm income**

Participants	Days of Work Off-Farm	Age (years)	Farm Size (acres)	Gross Farm Sales	Family Gross Income	Percentage of Family Income that is Farm Income
New York demonstrators	(n = 20) None = 6 Any = 6 >200 days = 8	(n = 24) Median = 64.5	(n = 23) Median = 90	(n = 17) Median = 2,500 to \$4,999	(n = 8) Median = \$45,000	(n = 9) Median = 20%
New York observers	(n = 29) None = 18 Any = 3 >200 days = 8	(n = 39) Median = 59	(n = 29) Median = 86	(n = 24) Median = \$2,500 to \$4,999	(n = 11) Median = \$5,000	(n = 12) Median = 5.5%
Virginia demonstrators	(n = 24) None = 10 Any = 5 >200 days = 9	(n = 24) Median = 64.5	(n = 24) Mean = 243 Median = 175 Mode = 175 Range = 5 to 1500	(n = 22) Median = \$5,000 to \$9,999	(n = 10) Median = \$60,000	(n = 18) Median = 17.5%
Virginia observers	(n = 34) None = 15 Any = 2 >200 days = 17	(n = 34) Median = 50	(n = 31) Median = 175	(n = 27) Median = \$ 10,000 to \$24,999	(n = 11) Median = \$50,000	(n = 14) Median = 5%

**Table 5**  
**CROPS study participant safety ranking by question and pre/posttest change**

Participants	Rank Increase	Remain Same	Rank Decrease	Pretest Mean	Posttest Mean	Mean Change
Q1: It is less likely that anyone on my farm would be killed or hurt in a rollover compared to other farms.						
New York demonstrators	7	7	6	2.38	2.50	0.12
New York observers	7	11	6	2.42	2.54	0.12
Virginia demonstrators	2	19	3	2.58	3.13	0.55
Virginia observers	7	11	10	2.57	2.55	-0.02
Q2: Most people who are important to me think that I should retrofit at least one of my unprotected tractors.						
New York demonstrators	4	8	6	3.26	3.26	0.00
New York observers	2	15	5	2.95	2.96	0.01
Virginia demonstrators	3	17	3	3.38	3.50	0.12
Virginia observers	6	12	3	3.00	3.12	0.12
Q3: It is expected of me that I retrofit at least one of my unprotected tractors.						
New York demonstrators	3	9	7	3.13	3.00	-0.13
New York observers	4	14	4	2.80	2.87	0.07
Virginia demonstrators	6	13	3	3.25	3.22	-0.03
Virginia observers	5	11	6	2.80	2.60	-0.20
Q4: I feel pressured to retrofit at least one of my unprotected tractors.						
New York demonstrators	5	9	4	2.67	2.72	0.05
New York observers	3	15	3	2.53	2.36	-0.17
Virginia demonstrators	3	10	6	2.68	2.73	0.05
Virginia observers	6	11	4	2.32	2.24	-0.08
Q5: If I have a ROPS/CROPS on my tractor, I will wear my seatbelt whenever I am on the tractor.						
New York demonstrators	3	14	3	3.33	3.40	0.07
New York observers	3	10	10	3.00	2.84	-0.16
Virginia demonstrators	2	15	6	3.33	3.17	-0.16
Virginia observers	3	14	10	2.94	2.69	-0.25