Cost−Effectiveness of a ROPS Retrofit Education Campaign

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ABSTRACT. *A community educational campaign implemented in two Kentucky counties was effective in influencing farmers to retrofit their tractors with rollover protective structures (ROPS) to protect tractor operators from injury in the event of an overturn. This article reports on the cost−effectiveness of this program in the two counties when compared to no program in a control county. A decision analysis indicated that it would be effective at averting 0.27 fatal and 1.53 nonfatal injuries over a 20−year period, and when this analysis was extended statewide, 7.0 fatal and 40 nonfatal injuries would be averted in Kentucky. Over the 20−year period, the cost−per−injury averted was calculated to be $172,657 at a 4% annual discount rate. This cost compared favorably with a national cost of $489,373 per injury averted despite the additional program cost in Kentucky. The principle reason for the increased cost−effectiveness of the Kentucky program was the three−fold higher propensity for tractors to overturn in Kentucky. The cost−per−injury averted in one of the two counties was $112,535. This lower cost was attributed principally to incentive awards financed locally for farmers to retrofit their tractors with ROPS.*

Keywords. *Costs, Effectiveness, Overturns, Rollover protective structures, Rollovers, Tractors.*

The agricultural tractor has been the leading cause of fatal injuries on farms, most of which have been attributed to overturns. The use of rollover protective structures (ROPS) as well as seatbelts on tractors has been shown to be a cost−effective technology for reducing overturn−related fatalities nationally (Myers, 2000; Pana−Cryan and Myers, 2002).

The problem of agriculture−related fatalities has been particularly acute in Kentucky, where the fatality rate for agriculture has been 3.5 times the national rate. To combat this problem, University of Kentucky researchers conducted an intervention (community education campaign) in their state that was effective in promoting the retrofit of ROPS on older tractors or the replacement of these tractors with ROPS−equipped tractors (Cole and Westneat, 2001).

They initiated the three−year intervention ("Promoting ROPS and Seat Belts on Family Farm Tractors") in January 1997 in two rural counties. Geographically removed from these treatment counties (A and B), two other counties served as controls for the study. However, an equipment dealer in one control county launched its own retrofit intervention, which rendered it unsuitable as a control for this study. Thus, one rather than two counties was used as a control.

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The aim of the intervention was to promote the use of ROPS and seatbelts on farm tractors. The intervention was a community education campaign that focused on multi−agency, multi−modal message dissemination, which included farm safety coalitions, health care providers, agri−businesses, schools, media (television, radio, and newspaper), agricultural extension services, and local private employers (Brandt et al., 2001).

In January 1997, a pre−intervention random sample survey of 1,648 of farm households in the four counties established baseline data for evaluating the effectiveness of the intervention. Then in September 2000, a post−intervention survey was conducted with 1,209 of the original farm households from the pre−intervention sample to gauge the impact of the intervention. Data from these surveys are shown in table 1 (Cole and Westneat, 2001). The number of non−ROPS tractors was calculated for the two treatment counties for the year 1997 based on the number of farms located there and the average number of tractors reported per farm in each county in the pre−intervention survey.

This article reports on a cost−effectiveness analysis of this intervention, and policy−makers may use its results to design future programs for promoting the retrofit of ROPS on older tractors. Some parameters in the analysis were varied to examine the sensitivity of the results to alternative values where uncertainty was known or suspected.

Method

This study aimed to determine the cost per injury averted by the intervention. A two−step model was used, as recommended by Haddix and Shaffer (1996) for decision and cost analyses of public health interventions. Decision analysis was used to determine the increment of injuries averted by comparing the outcomes from the treatment counties (A and B) to a control county (C) with the use of a series of probabilities that affect injury outcomes. The cost analysis generated the net cost of the intervention, which was divided by the increment of injuries averted (both fatal and nonfatal) to produce the cost per injury averted.

Table 1. Retrofits and replacement tractors over three years as reported in pre− and post−intervention farm tractor surveys in three Kentucky counties, 1997 and 2000.

	Treatment			Control
Effectiveness Factor	County A	County B	A and B	(County C)
Total number of farms	1,444	765	2,209	1,264
Farmers surveyed (*n*)	301	283	584	322
Percent surveyed	20.8%	37.0%	26.4%	25.5%
Number of ROPS retrofits	15 (5.0%)	27 (9.5%)	42 (7.2%)	8 (2.4%)
Number replaced for ROPS	10 (3.3%)	15 (5.3%)	25 (4.3%)	8 (2.4%)
Total	25 (8.3%)	42 (14.8%)[a]	67 (11.5%)[a]	16 (5.0%)[a]
95% CI	5.6−12.2	11.0−19.6	9.1−14.4	3.0−8.1
Total non−ROPS tractors[b]	2,267	1,599	3,954	2,022
Tractor replacement rate	−−	−−	−−	4.2%[c]
Change to ROPS−equipped tractors	5.3%	7.1%	5.9%	3.1%

[a] Significant difference ($p < .05$) in farmers' intentional acquisition of ROPS−protected tractors.

[b] Calculated by multiplying the average number of tractors minus ROPS−equipped tractors per farm as reported by county times the total number of farms in the county.

[c] This percentage represents a normal annual replacement rate of tractors where no intervention was undertaken.

The model was similar to the one used by Pana−Cryan and Myers (2000, 2002) and Myers and Pana−Cryan (2000) in a national study, and its framework was adopted for the analysis presented in this article. A social perspective was used in which all costs and benefits were considered no matter who incurred them, but the costs of caregiver time and pain and suffering were not included (Leigh et al., 2001).

The Decision Tree

A decision tree (Haddix and Shaffer, 1996; Magee, 1964) as shown in figure 1 was used in which one of two choices was considered: (1) a "ROPS program," as implemented in counties A and B or (2) "no ROPS program" as experienced in county C. The ROPS program choice included ROPS retrofits on non−ROPS tractors and tractor replacements for ROPS protection. Including the replacement tractors also provided a solution to the lack of ROPS−retrofit kit availability for some early model tractors (Myers, 2000).

The following probabilities were used in the decision tree:

- Pr_r(t) = the probability of installing a ROPS in the two treatment counties.
- Pr_r(c) = the probability of installing a ROPS in the control county.
- Pr_o = the annual probability of an overturn per 2,000 hours of tractor operation.
- Pr_f(r) = the probability of death resulting from an overturn with a ROPS installed.
- Pr_f = the probability of death resulting from an overturn without a ROPS installed.
- Pr_i = the probability of a nonfatal injury resulting from an overturn without a ROPS installed, given survival.
- Pr_i(r) = the probability of a nonfatal injury resulting from an overturn with a ROPS installed, given survival.

Some base−case values as shown in figure 1 were varied to test their sensitivity.

Cost Analysis

This study relied on the cost of illness estimates derived by Leigh et al. (2000) for all occupations including farmers and by Leigh et al. (2001) for agricultural occupations. The cost−effectiveness of the intervention was calculated by dividing the net cost of the intervention by the number of injuries averted by the intervention. Calculating the net cost of the intervention was based on the following equation:

$$\text{Net Cost} = \text{Cost}_{\text{intervention}} + \text{Cost}_{\text{side effects}} - \text{Cost}_{\text{fatalities averted}} - \text{Cost}_{\text{nonfatal injuries averted}} \quad (1)$$

The net cost included the cost of all resources required for the intervention (i.e., the education and retrofit program) and the side effects of the cost of ROPS replacements when an overturn occurred over the 20−year analytic horizon. The direct (e.g., medical) and indirect (e.g., productivity losses) costs of injuries averted were subtracted from the intervention and side effects costs to derive the net cost (Haddix and Shaffer, 1996). Since ethically everyone has been found to be entitled to a normal lifetime regardless of age, this article assumes that one life is equal in value to another (Nord, 1999).

Sensitivity Analysis

Uncertainties in the parameters used within the model were identified. These uncertainties were analyzed by varying parameter values within a range drawn from the literature. As each parameter was varied to test its sensitivity, the other parameters were held at their base−case values. In the decision analysis, the parameters tested were the length of the analytic horizon, individual county results, overturn probability, and probabilities of fatal and nonfatal injury. In the cost analysis, the parameters tested included the analytic horizon, the discount rate, individual county results, the cost of a ROPS retrofit, and the cost of injuries averted using agriculture−specific costs.

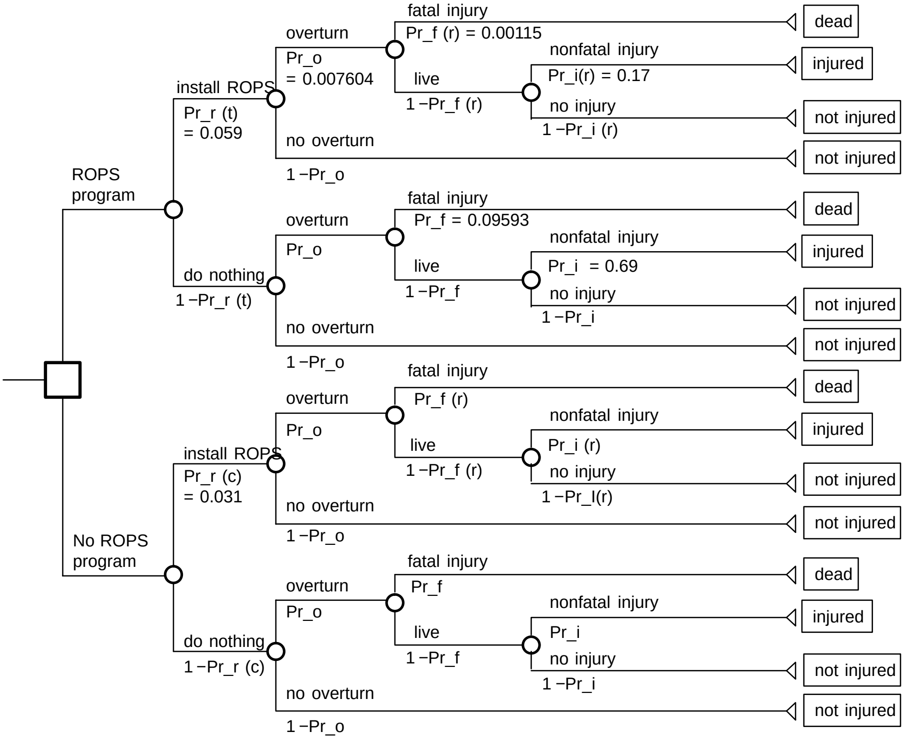

Figure 1. A decision tree that shows two choices—ROPS program (treatment) and no ROPS program (control)—used in Kentucky and health outcomes associated with tractor overturns.

Analyses

Since the time dimension added complexity in this study, the temporal part of the analysis is discussed separately below. An incremental analysis using the decision tree and the cost analysis follows the temporal analysis.

Temporal Analysis

Time factors included in this study were the length of the analytic horizon, the intervention period, the normal replacement rate of non−ROPS tractors, the adjustment for inflation, and the discount rate used to value money and health in the future.

The unit of exposure to the overturn hazard used was 2,000 hours of annual tractor operation, which was consistent with existing literature and was based on 50 forty−hour weeks of work per year. Myers and Snyder's (1995) estimated 238 hours of annual operation of non−ROPS tractors was used to calculate non−ROPS tractor exposure.

The Kentucky ROPS−retrofit intervention was implemented over three years (January 1997 to January 2000), and a 20−year analytic horizon beyond this intervention period was used to measure the future effect of the intervention. This time period may go well beyond 20 years when one considers the disability or the consequences of an overturn to the surviving family. Thus, another horizon of 30 years was assumed in a sensitivity analysis.

Throughout the intervention period, equipment dealer ROPS retrofit sales were examined and recorded bimonthly (Struttmann et al., 2001). These data were used to calculate the proportion of ROPS retrofits or non−ROPS tractor replacements for ROPS for each of the three years of the intervention. The proportion of the total ROPS retrofit sales reported by the dealers in the treatment counties was 20% in 1997, 42.5% in 1998, and 37.5% in 1999 (Cole and Westneat, 2001).

The model assumed an annual depletion of non−ROPS tractors over the analytical horizon. A 4.2% annual replacement rate reported in control county C was used. This value was near the value reported by Kelsey and Jenkins (1991) of a 4.0% annual replacement rate.

A 4% discount rate was used, as recommended by Shaffer and Haddix (1996) and used by Pana−Cryan and Myers (2000). This rate was also applied to future fatal and nonfatal injuries in cost−effectiveness calculations (Muennig, 2002). A sensitivity analysis was performed for the recommended low and high rates of 0% and 8%.

Past cost estimates related to injuries were adjusted to 1997 for inflation (Shaffer and Haddix, 1996). The direct costs were adjusted using the U.S. medical price index, whereas the indirect costs were adjusted using the U.S. consumer price index (Gold et al., 1996, pp. 197−198).

Incremental Analysis

Table 2 shows the base−case values for probabilities used in the decision analysis and in the sensitivity analyses with references for these values. Both the probability of installing a ROPS in the two treatment counties, Pr_r(t), and the probability of installing a ROPS in the control county, Pr_r(c), were based on reports by a large random sample of farmers questioned in each set of counties in the post−intervention survey, as shown in table 1. In addition, the percentage change to ROPS−equipped tractors for each treatment county (A and B) was separately tested for sensitivity within the model.

The annual probability of an overturn per 2,000 hours of tractor operation (Pr_o = 0.007604) was calculated similar to Myers and Pana−Cryan's approach (2000) and using Kentucky data (Cole et al., 2000a). This probability was about three times the national probability of an overturn, but the overturn fatality rate in Kentucky was also about three times greater than the national rate. This difference was consistent with Myers and Pana−Cryan's (2000) observation that the propensity for overturns may vary by region. The terrain (steep banks and slopes, entrenched streams, and karst topography including sinkholes) as well as narrow winding roads in Kentucky may have made overturns more likely. The probability of an overturn was tested for sensitivity by using Myers and Pana−Cryan's (2000) value of 0.001148 from their national study.

The probability of death resulting from an overturn with a non−ROPS tractor (Pr_f = 0.09593) was based on experience in Kentucky over the 20−year period from 1980 to 1999 (Cole et al., 2000a). Myers and Pana−Cryan's (2000) value for the probability of death given an overturn (0.4) was used to test its sensitivity within the model.

The probability of death resulting from an overturn with a ROPS installed (Pr_f(r) = 0.00115) was derived by multiplying a ROPS effectiveness ratio times Pr_f. The ratio was derived by dividing the overturn fatality rate in Sweden when nearly all tractors were ROPS−equipped by the rate when few tractors were ROPS−equipped. During 1986 to 1990 with 93% ROPS−equipped tractors, the rate was 0.3 fatalities per 100 million driving hours, whereas the rate was 25 fatalities per 100 million driving hours with 6% ROPS−equipped tractors during 1957 to 1960 (Springfeldt et al., 1998). The ratio—the effectiveness of ROPS to prevent death—was 0.012.

Table 2. Base−case and alternative values for probabilities used to evaluate the effectiveness of the ROPS retrofit campaign in two Kentucky counties.

	Base Case		Alternative	
Variable	Value	Reference	Value	Reference
Pr_r(t), installing a ROPS in the two treatment counties	0.059	Cole and Westneat, 2001	0.053, 0.071	Counties A and B
Pr_r(c), installing a ROPS in the control county	0.031	Cole and Westneat, 2001		
Pr_o, overturn per 2,000 hours of tractor operation	0.007604	Cole and Westneat, 2001	0.001148[a]	Myers and Pana−Cryan, 2000
Pr_f, death resulting from an overturn without a ROPS	0.09593	Cole et al., 2000a	0.4	CDC, 1994
Pr_f(r), death resulting from an overturn with a ROPS	0.00115	Springfeldt et al., 1998	0.00240	Pratt and Hard, 1998
Pr_i, nonfatal injury resulting from an overturn without a ROPS, given survival	0.69	Cole et al., 2000a	0.83	Myers and Pana−Cryan, 2000
Pr_i(r), nonfatal injury resulting from an overturn with a ROPS, given survival	0.17	Springfeldt et al., 1998	0.34	Assumed
Effectiveness of a ROPS to prevent a fatal injury	0.012	Springfeldt et al., 1998	0.025	Pratt and Hard, 1998
Effectiveness of a ROPS to prevent a nonfatal injury	0.242	Cole et al., 2000a		

[a] Myers and Pana−Cryan (2000) reported this value as 0.00145, which was recalculated as shown.

Although the data were less robust, an alternative value was used to test the sensitivity of the "ROPS−cab" only data from Sweden. One study (Pratt and Hard, 1998) identified two deaths related to overturns of ROPS−equipped tractors out of 31 fatal tractor overturns. These overturns occurred in the U.S., where there is a mix of frame−type and cab−type ROPS. The ROPS effectiveness ratio based on this data after correcting for hours of use (Myers and Snyder, 1995) between non−ROPS and ROPS−equipped tractors was 0.025. Thus, the alternative probability of death was 0.00240 (0.025×0.09593).

The probability of a nonfatal injury resulting from an overturn without a ROPS installed, given survival (Pr_i = 0.69) was derived from data collected in the Kayles' simulation study (Cole et al., 2000a). This study engaged 369 Kentucky high school students in an exercise to field−test a farm safety simulation exercise. The students were located in five geographically dispersed counties. They reported knowledge of 128 tractor overturns that resulted in 28 deaths, 8 disabilities, 19 serious injuries, 42 slight injuries, and 31 non−injuries. Thus, of the 100 survivors of an overturn, 69 experienced a nonfatal injury. To test the sensitivity of this value in the analysis, an alternative value of 0.83 from Myers and Pana−Cryan (2000) was used.

The probability of a nonfatal injury resulting from an overturn with a ROPS installed, given survival (Pr_i(r) = 0.17), depended on a ratio calculated from Swedish data (Springfeldt et al., 1998). Nonfatal injuries in Sweden related to tractor overturns for the period 1984 to 1990 numbered 4.6 when more than 88% of the tractors had a ROPS. The number of nonfatal injuries for the period 1957 to 1964 totaled 19 when about 26% of the tractors had a ROPS. An estimate for Pr_i(r) was calculated by multiplying the ratio 4.6/19 (0.242)—the effectiveness of ROPS to prevent nonfatal injury—times Pr_i as derived above. The literature is void of better data than these.

Nonetheless, a doubling of the probability of a nonfatal injury was assumed as an alternative in a sensitivity analysis. Through a product of these probabilities, the decision tree provided the annual number of fatal and nonfatal injuries expected for each choice (CDC, 1994).

Cost Analysis

The cost of the intervention included the funds expended on the intervention, cash donations, the investment made by farmers for a ROPS and seatbelt (including purchase, installation, freight, and transport), and the in−kind expenditures made by volunteers, public service activities by the media, and business and agency participation. These are summarized in table 3.

The cost of the intervention included a portion of a grant provided by the National Institute for Occupational Safety and Health to the University of Kentucky for the campaign. Organizations within each county also contributed to the intervention from which 16 ROPS retrofit incentive awards ranging from $100 (5) to $250 (11) and totaling $3,250 were made. In the pre−intervention survey of farmers in the control and treatment counties, their mean estimate of the cost of a ROPS retrofit was $674. The total in table 3 was adjusted for the incentive awards to avoid double counting, and one $100 award was removed from the calculation since it was for a retrofit in a neighboring county. Alternative values used for a sensitivity analysis for the unit cost for ROPS retrofits were $1,000 from Pana−Cryan and Myers (2000) and $400 from Harris et al. (2002).

Estimated from the sample in the post−intervention survey in the two treatment counties, farmers retrofitted 145 of their tractors with a ROPS or replaced 89 non−ROPS tractors with ROPS−equipped tractors for the safety value of the ROPS as opposed to other reasons. The cost of the tractor replacements was treated as a ROPS

Table 3. Cost inventory for the treatment counties.

Cost Factors	Value ($)
$Cost_{intervention}$	
University of Kentucky (portion of research grant from CDC/NIOSH[a] used for the intervention)	130,884
Cash donations (includes ROPS incentive awards of $3,250)	5,450
ROPS investment (111 ROPS adjusted for the control (234 − 123) at $674 less incentive awards[b])	72,132
In−kind participation (volunteer hours, media items, and donated materials)	174,724
Total	383,190
$Cost_{side\ effect}$	
Probable ROPS replacement cost after overturn during intervention period plus 20−year analytic horizon	983
$Cost_{fatalities\ averted}$ in 1997 dollars[c]	
Direct costs per fatality	33,850
Indirect costs per fatality	682,586
Total	716,436
$Cost_{nonfatal\ injuries\ averted}$ in 1997 dollars[c]	
Direct costs per nonfatal injury	8,819
Indirect costs per nonfatal injury	25,028
Total	33,847

[a] Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health.
[b] Excludes deduction for a $100 incentive provided for a retrofit to a tractor in a neighboring county.
[c] Sources: Leigh et al. (2000, 2001) as adjusted for inflation.

retrofit from a cost standpoint since the purchased tractor had value for purposes beyond its increased safety value (Cooper et al., 1993).

In−kind participation was estimated from detailed community intervention activity records for the first 18 months of the intervention (Cole and Westneat, 2001). That estimate was doubled to provide the total in−kind cost for the intervention.

Direct costs included lifetime medical, insurance administration, property damage, emergency services, and injuries to third parties. Indirect costs included lost earnings, household production, fringe benefits, and time loss. These costs were generalized for all workers and were not specific to agricultural workers.

However, a sensitivity analysis was conducted using agriculture−specific data (Leigh et al., 2001). This data included directs costs of $33,853 regarding fatal injuries and $1,729 regarding nonfatal injuries and indirect costs of $383,695 regarding fatal injuries and $10,551 regarding nonfatal injuries. The costs of injuries related to agriculture were lower since the average wage was 58% of all occupations, but there were several reasons why this was too low regarding potential lost earnings for tractor overturn injury victims.

First, 59% of the principle farm operators in Kentucky had jobs off the farm and were thus engaged in non−agricultural employment as well (Brandt et al., 2001). Second, demographic factors of the agricultural population suggested higher lost earnings for the victims: males rather than females, and farmers rather than farm workers (Myers et al., 1998; Durden and Gaynor, 1998). Third, farmers accumulate wealth beyond earned income through the implicit income by way of the increased value of their landownership over time (Alston, 1986), and thus the adage, "Money poor, but land rich." Fourth, according to Leigh et al. (2001), the agricultural estimates were based on several assumptions since the data were incomplete; small farms and self−employment were undercounted, and farmers typically were not covered by workers' compensation, which was a source of data.

Results

Over the 3−year intervention period plus the 20−year analytic horizon, the decision model indicated that if no retrofits or tractor replacements for ROPS protection occurred, 4.8 tractor drivers in the two treatment counties would be killed and an additional 32 would be nonfatally injured in overturns. Over 30 years, 5.8 fatal and 38 nonfatal injuries would be expected to result from tractor overturns. However, to prevent these injuries, farmers elected to retrofit or replace tractors for ROPS protection significantly faster in the presence of the intervention, as shown in table 1.

Injuries Averted

As shown in table 4, the intervention in the two treatment counties was expected to avert 0.27 fatal and 1.53 nonfatal injures over a 20−year period as compared to the control county. When examined over a 30−year period, these results were 0.33 fatal and 1.86 nonfatal injuries averted.

However, when treatment county B was evaluated separately from county A in the analysis, the equivalent of 0.40 fatal and 2.53 nonfatal injuries were averted over the 20−year period. This was 32% and 40%, respectively, more effective when compared to the combination of both treatment counties. The cost−effectiveness model was very sensitive to the probability of a fatality associated with an overturn and was sensitive to the probability of an overturn. The model was insensitive to the change in the probability of a death and moderately sensitive to a change in the probability of a nonfatal injury related to an overturn with a ROPS−equipped tractor.

Table 4. Results of the decision and sensitivity analyses of education strategies for preventing tractor−overturn−related injuries in selected Kentucky counties.

Scenario	Injury Outcome	Number of Injuries (undiscounted)[a] Treatment	Control	Injuries Averted[b]	Base−Case Variance (%)
Base case, 20 years	Fatal	4.55	4.82	0.27	0
	Nonfatal	30.07	31.60	1.53	0
30−year analytic horizon	Fatal	5.49	5.82	0.33	19
	Nonfatal	36.28	38.14	1.86	18
Treatment county A, 20 years	Fatal	4.61	4.84	0.23	−15
	Nonfatal	30.56	31.69	1.13	−26
Treatment county B, 20 years	Fatal	4.44	4.84	0.40	32
	Nonfatal	29.16	31.69	2.53	40
Pr_o = 0.001148	Fatal	0.69	0.73	0.04	−85
	Nonfatal	4.54	4.78	0.23	−85
Pr_f = 0.4	Fatal	18.96	20.09	1.28	448
Pr_i = 0.83	Nonfatal	39.55	41.64	2.09	75
Pr_f(r) = 0.00240	Fatal	4.55	4.82	0.27	0
Pr_i(r) = 0.34	Nonfatal	30.58	31.88	1.30	−15

[a] To allow for comparisons, all calculations are based on the total number of non−ROPS tractors (3,959) in the two treatment counties in 1997.
[b] These differences are rounded.

The above results were extrapolated to gauge the potential effect of the treatment intervention if expanded statewide. The fatal and nonfatal injuries expected if no intervention were implemented over two analytic horizons are shown in table 5. Also shown are the lives saved and nonfatal injuries averted over the two horizons by an expanded statewide intervention. Respectively, for the analytic horizons of 20 and 30 years, 7.0 and 8.6, lives were potentially saved, and an additional 40 and 49 nonfatal injuries were potentially averted.

Cost−Per−Injury Averted

At a 4% discount rate over a 20−year period, the intervention in the two Kentucky counties resulted in a cost of $172,657 per injury averted. As shown in table 6, varying the analytical horizon to 30 years reduced this cost by 13% to $150,504. A 0% discount rate reduced the cost to $98,652 per injury averted over 20 years, while an 8% discount rate increased that cost to $247,241 per injury averted.

Table 6 also shows the results of a comparison of the two treatment counties, A and B. While the pooled cost of injury averted was $172,657, the cost effectiveness differs

Table 5. Tractor overturn−related injuries extrapolated statewide for two analytic horizons, Kentucky (undiscounted).[a]

Horizon (years)	No Intervention (Injuries)		Intervention Effect (Injuries Averted)	
	Fatal	Nonfatal	Fatal	Nonfatal
20	126	828	7.0	40
30	140	928	8.6	49

[a] The numbers of injuries and of injuries averted were extrapolated by the ratio of the total number of working tractors in the State of Kentucky (150,620) to the total number of tractors in the treatment counties (5,751) (Source: USDA, 1999, p. 22, table 13).

Table 6. Results of sensitivity analyses of alternatives as compared to the cost−effectiveness of the base−case intervention in two treatment counties at a 4% discount rate and 20−year analytic horizon.

	Injuries Averted		Cost[a]		
Alternative	Fatal	Nonfatal	Total ($)	Per Injury Averted ($)	Variance from Base Case (%)
Base case	0.27	1.53	222,072	172,657	0
$400/ROPS	0.27	1.53	192,652	149,784	−12
30−year analytic horizon	0.27	1.53	213,959	150,504	−13
$1000/ROPS	0.27	1.53	257,075	199,872	14
County A	0.23	1.13	234,001	238,798	38
Agriculture	0.27	1.53	275,735	214,379	19
8% discount rate	0.27	1.53	243,878	247,241	30
County B	0.40	2.53	237,663	112,535	−35
0% discount rate	0.27	1.53	177,417	98,652	−57

[a] To allow for comparisons, all calculations are based on the total number of non−ROPS tractors (3,959) in the two treatment counties in 1997.

between the treatment counties. The intervention in county B was shown to be more cost−effective at $112,535 per injury averted as compared to $238,798 per injury averted in county A.

The sensitivity of the unit cost of the ROPS was also tested in our model. When the unit cost of a ROPS retrofit was increased from $674 to $1,000 (48%), the cost−per−injury averted rose 14% to $199,872. Conversely, when the unit cost of a ROPS was reduced to $400 (41%), the cost per injury was reduced by 12% to $149,784. For the agricultural occupations alternative, the cost per injury averted was $214,379 or 19% higher than the base case, which included all occupations.

Discussion

Cost−effectiveness analysis is of value in comparing alternative interventions. The education intervention examined in our study was about one−third the cost−per−injury averted as presented in the national study by Pana−Cryan and Myers (2000). That analysis concluded that installing a ROPS on tractors would cost $489,373 per injury averted, which was consistent with other accepted intervention costs such as the use of air bags in automobiles. The current results were lower despite the added costs of an intervention program, which was not calculated into Pana−Cryan and Myers' (2000) study.

One factor that made the Kentucky intervention more cost−effective was the cost of a ROPS retrofit at $674 rather than $1,000, although this accounted for only 14% of the variance. A more important factor was the three−fold greater propensity for a tractor to overturn in Kentucky than in the nation as a whole.

The intervention cost is probably somewhat lower than reported in this study because the ROPS project had goals other than a community education intervention to promote ROPS. Even though they were developed, tested, revised, and evaluated with people in counties A and B, the community education materials were intended for statewide and national distribution. The intention was to produce and make widely available an effective community education intervention including the methods, activities, materials, and lessons learned. This was accomplished in part when the full set of materials became available on the National Agricultural Safety Database web site (Cole et al., 2000b). Farm Bureaus in Kentucky and many other states have used the materials, as have many other groups and organizations. As a result, there are three ways to look at the above observations:

- The intervention costs for counties A and B were less than the total project costs.
- The cost to other counties using the intervention would likely be less than the cost of the intervention reported in this article.
- The intervention materials, methods, and lessons learned potentially have an added future value, and the cost of the intervention for this study may eventually become more cost effective as other states and counties use aspects of the intervention to promote ROPS and reduce the risk of death and injury.

The probabilities of an overturn and of a fatality resulting from an overturn were the most sensitive parameters related to fatal injuries based on variation in their values in the model. Empirical information is needed for the probability of an overturn so the value will not depend on calculations derived from the probability of a fatal injury from an overturn. As the time horizon increased, both fatal and nonfatal injuries averted increased. With the higher probability of nonfatal injury from a tractor overturn, the number of injuries averted also increased, which indicated that better empirical information was needed to better define this probability.

Treatment county B was 1.7 times as effective as county A in preventing fatalities through increased ROPS protection, with a similar increased effectiveness for reducing nonfatal injuries. The principle reason for this increase may well have been the locally generated six−fold donation and 3.5−fold retrofit incentive levels in county B over county A.

In addition, a survey of dealers' in the treatment county suggested that some forms of communication were more effective than others. County A had the same elements but a less coordinated and coherent leadership structure among these groups than was the case in county B. Two key agencies in county A were less supportive and involved than in county B. A year into the project, one county A community leader became alienated following a disagreement with another community worker. Nevertheless, the majority of individuals and organizations in county A remained actively involved and supportive throughout the project (Struttmann et al., 2001).

The model was moderately sensitive to the unit cost of ROPS, and as the cost was reduced, the cost−effectiveness of the intervention increased, and vice versa. Subsidies, such as the retrofit incentive awards, appeared to have had a higher influence on retrofit behavior than changes in the unit cost of the retrofit kit.

The cost of the intervention was well documented. However, classifying all nonfatal injuries together as a single cost factor was problematic when there is a range in their severity. Overturn−related injuries may be more severe, and thus more costly, than the average nonfatal injury for all occupations, as was used in this study. Some victims may be so severely injured that they no longer farm, and thus they are neither counted in death records nor in farm−based surveys. Furthermore, such injuries may have catastrophic financial effects on a farm family with the loss of a farm, the loss of potential lifetime income, and the cost of care. Such costs can be gigantic. More research is needed to identify and quantify these catastrophic incidents and their associated costs. Moreover, liability cases include the cost of pain and suffering, which was excluded in this analysis, as was the cost of caregiver time.

This study used the social perspective independent of who incurred the costs. The distribution of who pays these costs and receives the benefits needs to be evaluated, and based on those results; other perspectives need to be evaluated, such as those of the farmer, the insurance company, the equipment dealer, or the tractor or ROPS manufacturer.

The model indicated that as the time horizon was lengthened, the intervention became more cost−effective. The reason for this change was the continuing accumulation of the costs of injuries into the future. There is a need to understand the long−term burden of tractor overturn−related injuries. The model was sensitive to the discount rate; thus, the time−value of money and health were found to be important parameters.

This study did not consider the latent effect of the intervention related to the continued investment in retrofits. Dealers in the treatment counties reported that 12% of their retrofit sales occurred through the 10 months following the intervention. Moreover, they also reported that 41% of their retrofit sales over the intervention period plus the 10 months following were outside of the treatment counties (Cole and Westneat, 2001). Thus, the impact of the intervention was broader than indicated by this study, both temporally and geographically.

One implication for policy was that an education campaign could save lives and prevent nonfatal injuries. However, the campaign, although intense, leaves most non−ROPS tractors unaffected. Additional intervention avenues are needed.

Conclusions

The intervention was found to be cost effective. The analysis indicated that if the intervention were implemented statewide, 7.0 tractor overturn−related fatalities and an additional 40 nonfatal injuries resulting from overturns would be averted over a 20−year period. Results indicated that the intervention in the two Kentucky counties resulted in a cost of $172,657 per injury averted, but this cost was found to be much lower in one of the counties, at $112,535 per injury averted.

This study suggested the need for further research in the following areas:

- Empirical information is needed to determine the probability of a tractor overturning.
- The cost reductions inherent in generalizing an intervention from a research study to wide application need to be examined.
- The influence of incentive programs to encourage ROPS retrofits needs to be investigated further, as well as the influence of lower costs of ROPS retrofits.
- The effectiveness of community−based coordinated efforts in education programs needs to be evaluated as compared to less coordinated efforts.
- The severity of nonfatal injuries related to tractor overturns needs to be evaluated from a cost perspective. Relatedly, there is a need to collect more comprehensive data on the frequency, severity, and probability of nonfatal injuries as related to tractor overturns.
- There is a need to evaluate retrofit interventions from other perspectives than the social perspective, such as the farmers' perspective.
- Even though this program was shown to be effective, there remains a need for more effective programs to extend protection to additional farm operators.

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