

A Stable Dynamic Cohort Analysis of Installing Cost-Effective Rollover Protective Structures (CROPS)

K. Owusu-Edusei Jr., E. A. Biddle

ABSTRACT. *Cost-effective rollover protective structures (CROPS) are less costly model-specific rollover protective structure (ROPS) retrofits that are being developed and evaluated with the hope of increasing adoption and eventually preventing or mitigating injuries due to tractor overturns. A dynamic cohort of the estimated retrofittable non-ROPS tractors (accounting for attrition due to aging) was tracked over a 20-year period to determine the expected costs, as well as the expected number of fatal and non-fatal injuries resulting from tractor overturns. Two alternatives were tracked: No-ROPS and Install-CROPS. For a starting cohort size of 1,065,164 (an estimate for the year 2004), the Install-CROPS option prevented an estimated total of 878 (192 fatal and 686 non-fatal) injuries over the 20-year period. Expected costs were \$513 million (cost of installing CROPS on all the non-ROPS tractors plus cost of the associated injuries) and \$284 million (cost of injuries resulting from the No-ROPS option) over the same time period. Thus, the net cost per injury prevented was \$260,820. When the cost of intervention (\$1,000 for purchasing, shipping, and installation of existing ROPS retrofit) was used in the analysis, the cost-effectiveness ratio was \$927,000 per injury prevented over the 20-year period. Thus, installing CROPS instead of existing ROPS retrofits improved the cost-effectiveness ratio substantially, with a 72% reduction in the net cost per injury prevented.*

Keywords. *Cost-effectiveness analysis, CROPS, ROPS, Sensitivity analysis, Stable dynamic cohort.*

This study builds on an earlier study by Owusu-Edusei and Biddle (2007) in which costs and effects of installing cost-effective rollover protective structures (CROPS) on a retrofittable tractor were compared with installing existing rollover protective structures (ROPS) retrofits, assuming that they have the same effect. Thus, in that earlier study, the focus was on a unit of the targeted population, i.e., one retrofittable tractor. However, because decisions made at the societal level on issues pertaining to intervention can affect everyone within the target population, it is also important that the population of concern is analyzed in its entirety. Although estimates of the number of non-ROPS tractor models are not available, there are estimates of the number of all retrofittable non-ROPS tractors. Therefore, using these estimates to determine costs and effects would be very informative for decision makers to effect change in the target population as a whole, and not in part.

Submitted for review in July 2006 as manuscript number JASH 6553; approved for publication by the Journal of Agricultural Safety and Health of ASABE in November 2006.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health (NIOSH). Mention of company names or products does not imply endorsement by NIOSH.

The authors are **Kwame Owusu-Edusei Jr.**, Prevention Effectiveness Fellow, and **Elyce A. Biddle**, Economist, Division of Safety Research, National Institute for Occupational Safety and Health, Morgantown, West Virginia. **Corresponding author:** Kwame Owusu-Edusei, 1095 Willowdale Rd., MS/1811, Morgantown, WV 26505; phone: 304-285-6259; fax: 304-285-6235; e-mail: kfo0@cdc.gov.

Providing information for decision making at the macro level is vital because tractor overturn continues to be the leading cause of occupational injuries in the agricultural industry. Between 1992 and 2004, the U.S. Department of Labor reported more than 1,000 deaths from tractor overturns (USDOL, 2004). ROPS have proven to be the major intervention, with an estimated prevention rate ranging from 75% (CDC, 1995) when seatbelts are not used to 99% (Morgan et al., 2002) when seatbelts are used. It is estimated that about half of the 4.8 million tractors in the U.S. do not have ROPS installed (Reynolds and Groves, 2000; Myers and Snyder, 1995), posing an occupational safety and health problem. Of the 2.4 million estimated non-ROPS tractors, close to 50% are retrofittable, according to estimates for the year 2004 computed using the method developed by Myers and Snyder (1995), which accounts for retirement due to aging.

Harris et al. (2002) developed and evaluated CROPS (weld-free ROPS constructed with common structural elements and fasteners), with designs tailored to specific tractor models. Two models (Ford 3000 and Ford 4000) have been tested successfully according to the static testing procedures of the ROPS consensus performance standard, SAE J2194 (Harris et al., 2005). The estimated unit cost of CROPS was \$290 in 2003 (\$300 in 2004 dollars). To date, developed designs can be installed by one person (Harris et al., 2005) in about one hour (expert opinion). A previous cost estimate for ROPS retrofitting, including shipping and installation, was \$1,000 (Scharf et al., 1998). Hence, CROPS are aptly referred to as “cost-effective ROPS” to imply that they are as effective as existing ROPS, but less costly.

This study adopts a holistic approach, which takes into account total costs and the effects of retrofitting all the estimated retrofittable non-ROPS tractors with CROPS. In doing so, three broad assumptions have been adopted:

- All the retrofittable tractors are models with adequate axle housing geometry or structural strength.
- All the CROPS installed are as effective as the manufacturers’ ROPS retrofits.
- Depreciation and maintenance costs are negligible.

This study tracks costs and effects of installing CROPS on all the estimated retrofittable tractors (accounting for the annual attrition rate) and estimates the expected costs and effects, over a 20-year period, from a societal perspective. The result is compared with installing existing ROPS retrofits to determine how much the cost-effectiveness ratio is reduced. The intervention proposed in this study includes the use of seatbelts. However, as recommended by tractor manufacturers (Deere, 1994), it is assumed in this study that non-ROPS tractor operators do not use seatbelts.

Methods

In this study, Markov cohort analyses of two options are modeled using TreeAge software: No-ROPS (do nothing) and Install-CROPS. For each option, two subjects (the operator and the tractor) are tracked. Each tractor is assumed to be operated for a specified number of hours each year, which is the average annual operation time. A stable dynamic cohort, as used in this study, implies that operators are allowed to come in and go out at the beginning of each cycle or year, and the number of tractors in operation ensures that the cohort is stable for each particular year (i.e., exits are balanced by entries, so that the cohort size is consistent with the estimated existing number of retrofittable tractors for each year). Tractors that cause fatal injuries and do not retire are operated by another operator in the next year to keep the cohort size stable for that year. It is assumed in this study that the value of life is the same for all operators.

Following Weinstein and Stason (1977) and Haddix et al. (1996), a cost-effectiveness ratio (CER) is computed by dividing the net cost of the intervention by the net effect (the difference in the number of fatal and non-fatal injuries). Net cost is the overall total cost of the intervention minus the savings attributable to the intervention, i.e., the cost of intervention minus the cost of fatal and non-fatal injuries prevented.

Data

Actual values for the analysis do not exist, so this study uses estimates from published literature, ROPS manufacturers, and expert opinion on CROPS installation time. Sources and values used are presented below.

Stable Dynamic Cohort Size (Number of Tractors)

The dynamic cohort size is equivalent to the number of tractors in operation each year, which is adopted from Myers and Pana-Cryan (2000) using the method proposed by Myers and Snyder (1995). For 2004, the estimated number is 1,065,164. Myers and Snyder (1995) concede that their estimates are conservative. Therefore, a sensitivity analysis was conducted with a starting cohort size of 1,500,000 retrofittable tractors to examine how that affects the CER.

Analytic Horizon

A 20-year period is used in this study to be consistent with previous studies. Following Owusu-Edusei and Biddle (2007), a sensitivity analysis was conducted from 5 through 30 years.

Cost of Intervention

According to Owusu-Edusei and Biddle (2007), the unit cost of intervention, which includes the CROPS, shipping, handling, and opportunity cost of installation time, is \$450 (in 2004 dollars). Thus, the overall total cost of the intervention is obtained by multiplying the unit cost (\$450) by the starting cohort size (1,065,164), yielding \$479,323,800. One thousand dollars (\$1,000) was used as the upper limit of the unit cost of intervention in the sensitivity analysis because if the cost of CROPS increases to \$1,000, then farmers would be indifferent between CROPS and existing ROPS retrofits.

Probability of Overturn

Following Owusu-Edusei and Biddle (2007), overturn probabilities are computed from estimates reported by Pana-Cryan and Myers (2000) and Cole et al. (2000). Overturn probabilities adjusted for actual operation time, as used in the model, are adopted from Owusu-Edusei and Biddle (2007) and presented in table 1. The overturn probabilities are different for the two options (No-ROPS and Install-CROPS) because the probabilities computed were based on operating time, which is substantially different (Myers and Snyder, 1995). A scale factor of 1.69 is used to account for the change in probability resulting from the change in operation time when a CROPS is installed. The scale factor is varied from 1 through 3 in the sensitivity analyses to determine how it affects the CER.

Social Discount Rate

This research uses a discount rate of 4% to maintain consistency with the discount rate used in previous cost-effectiveness studies conducted on ROPS and CROPS (Owusu-Edusei and Biddle, 2007; Myers et al., 2004; Pana-Cryan and Myers, 2000). Weinstein and Stason (1977) argued that inconsistencies occur when the numerator of the ratio is

Table 1. Calculation of annual overturn probabilities.^[a]

Annual Probability (2000 h)	Convert Probability to Rate: -Ln(1-prob)/time	Convert the Resulting Rate to Probability: 1-Exp(-rate*time)	
		Non-ROPS Equipped	ROPS Equipped
0.00145	0.001451052	0.000172692	0.000291704
0.007604	0.007633058	0.000907921	0.001535422

^[a] Ln is the natural log, and Exp is exponential. Time is equal to 1 in the second column, 238/2000 or 0.119 in the third column and 402/2000 or 0.201 in the fourth column.

discounted and the denominator is not. Thus, both costs and effects (fatal and non-fatal injuries) are discounted using the same discount rate. The sensitivity analysis was conducted for values from 0% to 10%.

Cost of Injuries

We found no specific study that estimated the cost of injuries resulting from tractor overturns. The most closely related types of injuries for which current validated estimates exist are the Motor Vehicles Injury costs estimates (which include wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage, and employers' uninsured costs) reported by the National Safety Council (NSC, 2005) in 2004 dollars. Tractor damage costs and wages (productivity losses) might be lower for the agricultural community, so we used the agricultural industry cost of fatal and non-fatal injuries estimated by Leigh et al. (2001) as the lower bound estimates for the sensitivity analysis. All costs were adjusted to 2004 dollars.

Summary

The variables used in this study are described in table 2. Figures in parentheses were used for the sensitivity analysis.

Table 2. Variables and sources of estimates used in the study.

Variable	Values	Source
Analytic horizon (years)	20 (5-30)	Assumed
Starting cohort size (2004)	1,065,164 (1,500,000)	Myers and Snyder, 1995 (assumed)
Cost of intervention	\$450 (\$1000)	Manufacture and installation time (Scharf et al., 1998)
Cost of fatal injury	\$1,130,000 (\$491,432) ^[a]	NSC, 2005 (Leigh et al., 2001)
Cost of non-fatal injury	\$49,700 (\$14,453) ^[a]	NSC, 2005 (Leigh et al., 2001)
Discount rate	0.04 (0.00-0.10)	CDC recommendation
Probability of fatal injury without CROPS	0.09593 (0.4)	Cole et al., 2000 (CDC, 1993)
Probability of fatal injury with CROPS	0.00115 (0.0024)	Springfeldt et al., 1998 (Pratt and Hard, 1998)
Probability of non-fatal injury without CROPS	0.69 (0.83)	Cole et al., 2000 (Myers and Pana-Cryan, 2000)
Probability of non-fatal injury with CROPS	0.17 (0.34)	Springfeldt et al., 1998 (Myers and Pana-Cryan, 2000)

(continued)

Table 2 (cont'd). Variables and sources of estimates used in the study.

Variable	Values	Source
Probability of overturn without CROPS	0.000172692 (0.000907921)	Computed from estimates by Myers and Pana-Cryan 2000 (Cole and Westneat, 2001)
Probability of overturn with CROPS	0.000291704 (0.001535422)	
Scale factor of probabilities	1.69 (1-3)	Computed (assumed)

[a] Adjusted for inflation.

Results

Using a cohort size of the 1,065,164 estimated retrofittable tractors at the beginning of 2004, the Install-CROPS option prevented 192 (discounted) fatal injuries and 686 (discounted) non-fatal injuries over the 20-year period, yielding a total of 878 (tables 3 and 4). Expected costs were \$513 million (cost of installing CROPS on all non-ROPS tractors plus cost of associated injuries) and \$284 million (cost of injuries resulting from the No-ROPS option) over the same time period. Therefore, the net cost per injury prevented was \$260,820 [(513 million - 284 million)/878]. The cost increased to \$927,000 per injury prevented when the unit cost of intervention was replaced by the unit cost of installing an existing ROPS (\$1,000 for ROPS retrofit, including shipping and installation), representing a substantial reduction of about 72% in the net cost per injury prevented with CROPS.

Table 3. Stable dynamic cohort analysis summary report: No-ROPS option.

Year	Cohort Size ^[a]	Tractors Lost to Attrition, Cumulative	Cumulative Injuries		Cost ^[b]	Cumulative Cost ^[b]	Effect: Fatal + Non-Fatal ^[b]	Cumulative Effect ^[b]
			Non-Fatal	Fatal				
2003	1,065,164	--	--	--	--	--	--	--
2004	1,043,623	21,541	113	17	\$24,200,937	\$24,200,937	125	125
2005	1,022,082	43,082	223	34	\$22,789,822	\$46,990,759	118	243
2006	1,000,541	64,623	331	51	\$21,451,455	\$68,442,214	111	353
2007	979,000	86,164	437	67	\$20,182,326	\$88,624,539	104	458
2008	957,459	107,705	540	83	\$18,979,089	\$107,603,629	98	556
2009	935,918	129,246	641	99	\$17,838,554	\$125,442,182	92	648
2010	914,377	150,787	740	114	\$16,757,676	\$142,199,858	87	734
2011	892,836	172,328	836	129	\$15,733,555	\$157,933,413	81	815
2012	871,295	193,869	930	143	\$14,763,422	\$172,696,836	76	892
2013	849,754	215,410	1022	157	\$13,844,641	\$186,541,477	71	963
2014	828,213	236,951	1111	171	\$12,974,696	\$199,516,172	67	1030
2015	806,672	258,492	1198	184	\$12,151,189	\$211,667,362	63	1093
2016	785,131	280,033	1283	197	\$11,371,836	\$223,039,198	59	1152
2017	763,590	301,574	1365	210	\$10,634,458	\$233,673,656	55	1206
2018	742,049	323,115	1445	222	\$9,936,979	\$243,610,635	51	1258
2019	720,508	344,656	1523	234	\$9,277,421	\$252,888,056	48	1306
2020	698,967	366,197	1598	246	\$8,653,898	\$261,541,954	45	1350
2021	677,426	387,738	1672	257	\$8,064,615	\$269,606,568	42	1392
2022	655,885	409,279	1742	268	\$7,507,859	\$277,114,428	39	1431
2023	634,344	430,820	1811	278	\$6,982,001	\$284,096,429	36	1467

[a] Number of tractors in service.

[b] Discounted.

Table 4. Stable dynamic cohort analysis summary report: Install-CROPS option.

Year	Cohort Size ^[a]	Tractors Lost to Attrition, Cumulative	Cumulative Injuries			Cumulative Cost ^[b]	Effect: Fatal + Non-Fatal ^[b]	Cumulative Effect ^[b]
			Non-Fatal	Fatal	Cost ^[b]			
2003	1,065,164	--	--	--	\$479,323,800	--	--	
2004	1,043,623	21,541	52	0	\$2,857,247	\$482,181,047	50	
2005	1,022,082	43,082	103	1	\$2,690,646	\$484,871,693	47	
2006	1,000,541	64,623	152	1	\$2,532,634	\$487,404,327	44	
2007	979,000	86,164	201	1	\$2,382,796	\$489,787,123	42	
2008	957,459	107,705	248	2	\$2,240,738	\$492,027,861	39	
2009	935,918	129,246	295	2	\$2,106,082	\$494,133,943	37	
2010	914,377	150,787	340	2	\$1,978,470	\$496,112,413	35	
2011	892,836	172,328	385	3	\$1,857,559	\$497,969,971	33	
2012	871,295	193,869	428	3	\$1,743,021	\$499,712,993	31	
2013	849,754	215,410	470	3	\$1,634,547	\$501,347,539	29	
2014	828,213	236,951	511	3	\$1,531,838	\$502,879,377	27	
2015	806,672	258,492	551	4	\$1,434,612	\$504,313,989	25	
2016	785,131	280,033	590	4	\$1,342,599	\$505,656,588	24	
2017	763,590	301,574	628	4	\$1,255,541	\$506,912,129	22	
2018	742,049	323,115	665	5	\$1,173,195	\$508,085,324	21	
2019	720,508	344,656	701	5	\$1,095,325	\$509,180,649	19	
2020	698,967	366,197	735	5	\$1,021,709	\$510,202,358	18	
2021	677,426	387,738	769	5	\$952,137	\$511,154,495	17	
2022	655,885	409,279	802	5	\$886,404	\$512,040,899	16	
2023	634,344	430,820	833	6	\$824,320	\$512,865,218	14	

[a] Number of tractors in service.

[b] Discounted.

Sensitivity Analysis

Due to the substantial differences in the estimates used in the study, one-way sensitivity analyses (SAs) were conducted on all the variables used. Two-way SAs were conducted for three variables, including two that resulted in negative CERs in the one-way SAs, and the unit cost of the intervention. Only dominant regions (regions representing cost savings) for the two-way SAs are shown and discussed here.

One-Way Sensitivity Analyses

All variables were found to exert the expected effects on the ratios. Table 5 provides a summary of the estimated CERs obtained from the sensitivity analyses for all the variables.

Table 5. Summary of one-way sensitivity analyses results.

Variable	Range of Values ^[a]	Estimated CERs (\$ per injury prevented)
Starting cohort size	1,500,000 - 1,065,000	228,000 - 260,820
Probability of overturn (without ROPS)	0.000915548 - 0.00017269	-223,000 - 260,820
Scale factor	1 - 3	193,000 - 606,000
Analytic horizon	30 - 5	190,000 - 1,160,000
Cost of intervention	\$450 - \$1,000	260,820 - 927,000
Discount rate	0.00 - 0.10	100,000 - 550,000
Probability of fatal injury without ROPS	0.4 - 0.09593	-420,000 - 260,820

(continued)

Table 5 (cont'd). Summary of one-way sensitivity analyses results.

Variable	Range of Values ^[a]	Estimated CERs (\$ per injury prevented)
Probability of non-fatal without ROPS	0.83 - 0.69	192,000 - 260,820
Cost of fatal injury	\$1,130,000 - \$491,432	260,820 - 400,000
Cost of non-fatal injury	\$49,700 - \$14,453	260,820 - 289,000
Probability of fatal injury with CROPS	0.00115 - 0.0024	260,820 - 269,000
Probability of non-fatal with CROPS	0.17 - 0.34	260,820 - 879,000

^[a] For consistency, some of the ranges in this column have been reversed to reflect the best (low CERs) to worst (high CERs) values in the “Estimated CERs” column.

Two-Way Sensitivity Analyses

The unit cost of intervention and two other variables that had negative CERs for the ranges used in the one-way sensitivity analyses (probability of overturn and probability of fatal injury without ROPS) were chosen for the two-way sensitivity analyses.

Sensitivity to the probabilities of overturn and fatal injury without ROPS. When the probability of fatal injury without ROPS is greater than 0.193, there are cost savings with the Install-CROPS option over the entire range of the probability of overturn used (fig. 2).

Sensitivity to the probability of overturn and cost of intervention. When the probability of overturn is over 0.00077 (0.001183 for CROPS-equipped tractors), then there is net savings to society even if the total cost of intervention increases to \$1,000 (fig. 3).

Sensitivity to the probability of fatal injury without CROPS and unit cost of intervention. The Install-CROPS option dominates if the probability of fatal injury without ROPS is 0.4 and the unit cost of intervention stays below \$900 (fig. 4).

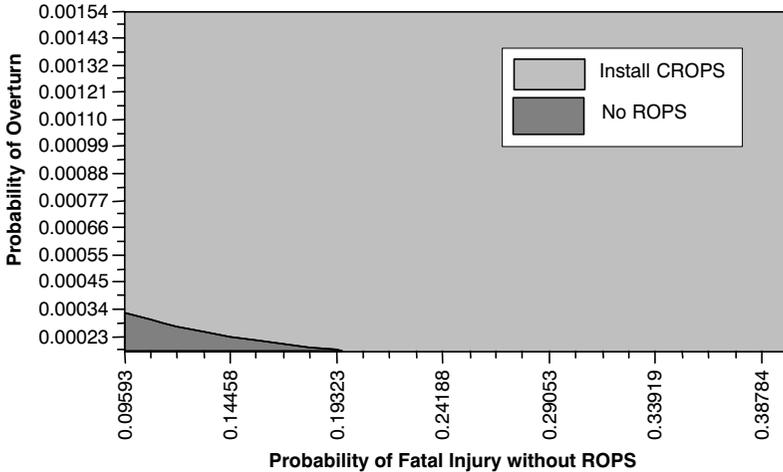


Figure 2. Two-way sensitivity graph for probability of fatal injury without ROPS and probability of overturn.

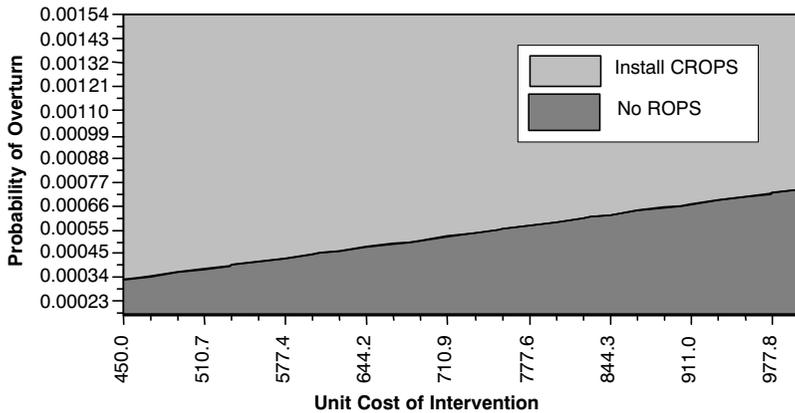


Figure 3. Two-way sensitivity graph for probability of overturn and cost of intervention.

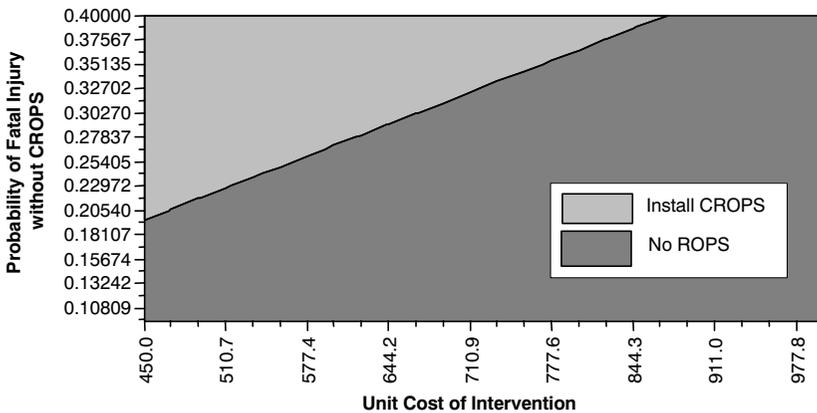


Figure 4. Two-way sensitivity graph for probability of fatal injury without CROPS and cost of intervention.

Discussion

The results obtained in this study are consistent with previous studies. Owusu-Edusei and Biddle (2007) reported a net cost per injury prevented of \$136,601 for CROPS over a No-ROPS option at a per tractor level. That estimate is substantially lower than the estimate found in this study because, in that earlier analysis, the effects were tracked over the entire analytic horizon. Thus, the effects of CROPS were realized over the entire period. On the contrary, in this study, some benefits of CROPS are lost due to attrition. The costs of intervention are incurred at the beginning of the program; thus, attrition over the years reduces the savings resulting from the intervention. As a consequence, this study found that the improvement in the CER when the unit cost of intervention is increased to reflect the cost of existing ROPS retrofits is slightly lower than was found in the previous study (72% vs. 73%).

Pana-Cryan and Myers (2000) reported \$489,373 per injury prevented, using a larger number of tractors and \$1,000 as the unit cost of intervention. Although they used a longer analytic horizon (23 years), the estimate from this study is almost one-half lower than the estimate they reported.

Myers et al. (2004) reported \$172,657 per injury prevented over a 20-year period. Their estimate is lower than the estimate found in this study primarily because of the estimated probability of overturn they used in their study. When their probability of overturn is used in this study, there is a substantial cost savings of about \$223,000 per injury prevented over the same analytic horizon. Another notable difference is the larger unit cost of intervention (\$647) that Myers et al. (2004) used. Finally, their study included additional costs for program implementation.

Limitations of the Study

The values used in this study were derived from published data, which varied substantially. To a large extent, the comprehensive sensitivity analyses addressed this limitation. The injury cost estimates used do not represent the total economic cost of injuries because intangible costs were not included. Thus, the net costs are overestimated. The probability estimates used are held constant throughout the period of the analysis. However, they are subject to change based on changes in operator behavior.

Benefits from the reduced severity of non-fatal injuries that occur with CROPS--equipped tractors are not captured in this study because the same average cost of non-fatal injuries is used in both alternatives. However, Myers et al. (2005) showed that non-fatal injuries are substantially less severe when ROPS are used in combination with seatbelts.

Conclusions

A stable dynamic cohort of the estimated retrofittable non-ROPS tractors was analyzed over a 20-year period for two options: No-ROPS and Install-CROPS. For a starting cohort size of 1,065,164, the Install-CROPS option prevented an estimated total of 878 (192 fatal and 686 non-fatal) injuries over the 20-year period. Expected costs were \$513 million for the Install-CROPS option and \$284 million for the No-ROPS option over the same time period. Thus, the net cost per injury prevented was \$260,820. When the cost of intervention for ROPS retrofitting (\$1,000, including purchasing, shipping, and installation) was used in the analysis, the CER was \$927,000 per injury prevented. This implies that the CER improved substantially (about 72% reduction in net cost per injury prevented) for the Install-CROPS option as compared to the ROPS retrofit option. Given the substantial reduction in the net cost per injury prevented, CROPS might increase the adoption rate and eventually save more lives.

Although the sensitivity analyses addressed concerns about the assumed values and the published estimates, the reliability of the results in such studies can be improved by undertaking further research to:

- Compute actual and more reliable estimates of the probability of events. The high sensitivity of the CER to the probability of overturn underscores this need.
- Assemble detailed information on the injuries that occur before and after interventions. This could help capture latent benefits (such as reduced severity) of non-fatal injuries when they occur with CROPS installed.
- Include intangible costs when estimating economic costs of tractor overturn injuries.

Acknowledgements

The authors would like to thank Jim R. Harris and Dr. David L. Hard at NIOSH, Dr. Ferdinand Vinuya at the World Bank, Washington, D.C., and Dr. Ferdinand DiFurio at Tennessee Technological University, Cookeville, Tennessee, for their comments and suggestions after reviewing the final report.

References

- CDC. 1993. Public health focus: Effectiveness of rollover protective structures for preventing injuries associated with agricultural tractors. *MMWR Weekly* 42(3): 57-59.
- CDC. 1995. Farm tractor related fatalities in Kentucky. *MMWR Weekly* 44(26): 481-484.
- Cole, H. P., and S. Westneat. 2001. The Kentucky ROPS Project. Final technical report for partners in prevention: Promoting ROPS and seatbelts on family farm tractors. Lexington, Ky.: University of Kentucky, Southeast Center for Agricultural Health and Injury Prevention.
- Cole, H. P., R. H. Macknight, S. R. Browning, D. B. Reed, T. W. Struttman, L. R. Piercy, and S. Westneat. 2000. Estimates of the probability of death during farm tractor overturns. Presented at the 2000 National Occupational Injury Research Symposium. Morgantown, W.V.: NIOSH.
- Deere. 1994. *Farm and Ranch Safety Management*. Moline, Ill.: Deere & Company Service Publications.
- Haddix, A. C., and P. A. Shaffer. 1996. Cost-effectiveness analysis. In *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation*, 27-45. A. C. Haddix, S. M. Teutsch, and D. O. Dunnet, eds. New York, N.Y.: Oxford University Press.
- Harris, J. R., E. A. McKenzie Jr., J. R. Etherton, D. M. Cantis. 2002. Designing cost-effective rollover protective structures (CROPS) at NIOSH. In *Proc. NIFS Annual Conference*. National Institute for Farm Safety.
- Harris J. R., D. M. Cantis, E. A. McKenzie Jr., J. R. Etherton, and M. Ronaghi. 2005. Commercialization of cost-effective rollover protective structures (CROPS). In *Proc. NIFS Annual Conference*. National Institute for Farm Safety.
- Leigh, J. P., S. A. McCurdy, and M. B. Schenker. 2001. Costs of occupational injuries in agriculture. *Public Health Reports* 116(3): 235-248.
- Morgan, S. H., H. P. Cole, T. Struttman, and L. Piercy. 2002. Stories or statistic? Farmers' attitudes towards messages in agricultural safety campaign. *J. Agric. Safety and Health* 8(2): 225-239.
- Myers, M. L., and R. Pana-Cryan. 2000. Prevention effectiveness of rollover protective structures: Part II. Decision analysis. *J. Agric. Safety and Health* 6(1): 41-55.
- Myers, J. R., and K. A. Snyder. 1995. Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993. *J. Agric. Safety and Health* 1(3): 185-197.
- Myers, M. L., H. P. Cole, and S. C. Westneat. 2004. Cost-effectiveness of a ROPS retrofit education campaign. *J. Agric. Safety and Health* 10(2): 77-90.
- Myers, M. L., H. P. Cole, and S. C. Westneat. 2005. Analysis of injury severity associated with tractor overturns in Kentucky. Presented at the 2005 NIFS Annual Conference.
- NSC. 2005. Estimating the costs of unintentional injuries, 2005. Itasca, Ill.: National Safety Council. Available at: www.nsc.org/Irs/statinfo/estcost.htm.
- Owusu-Edusei, K., and E. A. Biddle. 2007. Installing a cost-effective rollover protective structure (CROPS): A cost-effectiveness analysis. *J. Agric. Safety and Health* 13(2): 165-176.
- Pana-Cryan, R., and M. L. Myers. 2000. Prevention effectiveness of rollover protective structures: Part III. Economic analysis. *J. Agric. Safety and Health* 6(1): 57-70.
- Pratt, S. G., and D. L. Hard. 1998. Injury risk factors associated with agricultural workplace fatalities. *J. Agric. Safety Health* 1(special issue): 29-38.
- Reynolds, S. J., and W. Groves, 2000. Effectiveness of rollover protective structures in reducing farm tractor fatalities. *American J. Prev. Med.* 18(4s): 63-69.
- Scharf, T., P. Kidd, H. Cole, T. Bean, L. Chapman, K. Donham, and D. Baker. 1998. Intervention tools for farmers: Safe and productive work practices in safer work environment. *J. Agric. Safety and Health* 1(special issue): 193-203.
- Springfeldt, B., J. Thorson, and B. C. Lee. 1998. Sweden's thirty-year experience with tractor rollovers. *J. Agric. Safety and Health* 4(3): 173-180.
- USDOL. 2004. Census of fatal occupational injuries. Washington, D.C.: U.S. Department of Labor. Available at: www.bls.gov.
- Weinstein, M. C., and W. B. Stason. 1977. Foundations of cost-effectiveness analysis for health and medical practices. *New England J. Med.* 296(13): 716-21.

