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Cost effectiveness of a dealer’s intervention in retrofitting rollover protective structures

M L Myers, H P Cole, S C Westneat

Objective: To evaluate the cost effectiveness of a 4.5 year education campaign that promoted farmers’ adoption of rollover protective structures (ROPS) to prevent tractor overturn injuries.

Design: Randomized controlled trial, decision analysis, and cost effectiveness analysis.

Setting: One treatment county and one control county in the State of Kentucky.

Intervention: A campaign by a local tractor and equipment dealership to encourage farmers to purchase and install ROPS and seatbelt retrofit kits for older tractors.

Main outcome measures: Number of injuries averted and cost per injury averted.

Results: The dealership’s 4.5 year intervention was shown to potentially reduce both fatal (0.26) and non-fatal (1.50) injuries by 2.6% in its county over the intervention period using a 20 year analytic horizon. When extrapolated statewide, 6.7 lives would be saved and 39 non-fatal injuries would be averted over the combined 24.5 year combined intervention period and analytic horizon. The intervention for this period was cost effective with a "savings" of $35,713 per injury (fatal plus non-fatal) averted at a 4% discount rate.

Conclusions: Tractor manufacturer promotions can influence their dealerships to promote ROPS retrofits by their customers. A manufacturer backed dealer ROPS retrofit campaign was cost effective in reducing overturn related injuries.

Abbreviations: ROPS, rollover protective structure.
tractors for the protective value of the ROPS as opposed to other reasons. The response rate to the telephone surveys was 86%. The survey gathered data for a repeated measures design from large random samples of farmers from each county.1

METHOD
The method used in this study was cost effectiveness analysis that included decision and cost analyses. A decision analysis was used with a decision tree as the principal tool5 as shown in figure 1 for which the summary measure was the incremental number of injuries (fatal and non-fatal) averted by the intervention. A cost analysis was used for which the summary measure was the cost per injury averted.6 The software Microsoft Excel was used for a spreadsheet analysis as described by Petitti.7

DECISION ANALYSIS
In the event of an overturn, the operator may incur a fatal injury, a non-fatal injury, or no injury with different probabilities under the “Dealer intervention” and “No dealer intervention” strategies.1 The framework for the decision analysis included the following key points:

- The audience comprises tractor and ROPS manufacturers and dealers.
- The time frame for the intervention was 4.5 years starting in July 1995 and extending up to January 2000. The initial intervention survey (January 1997) and post-intervention survey (January 2000) covered the last three years of the equipment dealership’s emergent intervention. The results from the three year period that the survey covered are assumed to reflect the intervention effect for the 4.5 year period. This assumption has an embedded bias of an elevated baseline, thus the impact of the program is likely greater than the results of this study show.
- The unit of intervention used in this study was 2000 hours of annual tractor operation. This unit is consistent with existing literature and represents 40 hours per week of operation over a 50 week period—a full time work equivalent.6 The number of non-ROPS tractors in the intervention and the non-intervention counties were established based upon the initial intervention survey as shown in table 1.
- This population of non-ROPS tractors was reduced annually at the observed tractor replacement rate of 4.2% per year in the control county over the 20 year analytic horizon for this study. This rate was based upon data from the post-intervention survey.
- The type of analysis was incremental. Thus, it measured the effectiveness of the intervention compared with an alternative; in this case the true control county that received no intervention.

Seven probabilities were used in the decision tree: The annual probability of an overturn per 2000 hours of tractor operation under both strategies ($Pr_o$) was 0.007604;9 The probability of death resulting from an overturn with an ROPS installation ($Pr_f$) was 0.0115. The probability of death resulting from an overturn without an ROPS ($Pr_{f}^r$) was 0.09593. The probability of a non-fatal injury for an overturn with an ROPS ($Pr_i$) was 0.17. The probability of a non-fatal injury for an overturn without an ROPS ($Pr_{i}^r$) was 0.69. The probability of no injury for an overturn with an ROPS ($1-Pr_{i}$) was 0.83. The probability of no injury for an overturn without an ROPS ($1-Pr_{i}^r$) was 0.31.

Table 1: Initial and post-intervention survey results, 1997 and 2000

<table>
<thead>
<tr>
<th>Effectiveness factor</th>
<th>County Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of farms</td>
<td>949</td>
<td>1264</td>
</tr>
<tr>
<td>Number surveyed</td>
<td>321 (33.8%)</td>
<td>322 (25.5%)</td>
</tr>
<tr>
<td>Number of retrofits reported in survey</td>
<td>33</td>
<td>8</td>
</tr>
<tr>
<td>Total number of tractors</td>
<td>2752</td>
<td>3034</td>
</tr>
<tr>
<td>Number of tractors with no ROPS</td>
<td>1879</td>
<td>2022</td>
</tr>
<tr>
<td>Percentage of tractors retrofitted</td>
<td>6.0%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Normal tractor replacement rate per year</td>
<td>4.2%</td>
<td></td>
</tr>
<tr>
<td>Cost per ROPS installation</td>
<td>$649</td>
<td>$691</td>
</tr>
</tbody>
</table>

*Only survey results from the control county were used for the normal annual tractor replacement rate.

Figure 1: A decision tree that shows two choices—a dealer intervention to promote ROPS retrofits on older tractors and no dealer intervention (control)—used in Kentucky, and health outcomes associated with tractor overturns.

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installed (Prf (r)) was 0.0115;14 The probability of death resulting from an overturn without an ROPS installed (Prf) was 0.0593;13 The probability of a non-fatal injury resulting from an overturn without an ROPS installed, given survival (Prs (r)) was 0.69;14 The probability of a non-fatal injury resulting from an overturn with an ROPS installed, given survival (Prs (r)) was 0.17;12 The probability of installing an ROPS in the emergent intervention county (Prr(e)) was 0.060;1 and the probability of installing an ROPS in the control county (Prr(c)) was 0.016.1 This latter probability differs from another study7 because it included tractor replacement decisions made so as to acquire ROPS protection. Through a product of these probabilities, the decision tree provided a result of the number of fatal and non-fatal injuries per 2000 hours of tractor operation.

To derive the number of lives saved for each strategy, the number of non-ROPS tractors was calculated for the intervention county for the year 1997 based upon the number of farms located there (as reported in 1997 Census of Agriculture tables) and the average number of tractors reported per farm in the initial intervention survey. The hours of annual tractor use for non-ROPS tractors, 238 hours, was multiplied times the non-ROPS tractor population to derive the hours of tractor use in the intervention county, which was converted to the equivalent of 2000 hours of use per year for the multiplication calculation described above.8 The experiences reported over the three year survey period were extrapolated back over the 4.5 year intervention period, and the ROPS retrofits were assumed to occur proportionately over the 4.5 year intervention period.

### COST ANALYSIS

The cost effectiveness analysis includes net cost based upon the equation below.13

\[
Net \text{ Cost} = \text{Cost}_{\text{intervention}} + \text{Cost}_{\text{side effects}} - \text{Cost}_{\text{direct}} - \text{Cost}_{\text{indirect}}
\]

The net cost includes the cost of all resources required for the program. The direct (for example, medical) and indirect (for example, productivity losses) costs of the injury averted were subtracted from the intervention cost and side effect cost to derive the net cost.6 The cost of the intervention includes the funds expended on the program, the in-kind expenditures made for farmer participation, and the investment farmers made by purchasing an ROPS.

These costs included the donation of a tractor ($3000) for the demonstrations with a dummy driver, expenses for tractor safety or farm days ($200 each), time donated to and spent at these days (200 hours per event times $10 per hour), and the cost of the ROPS retrofits during the intervention period.

The cost of the ROPS was a total of the purchase price, shipping fees, and a one-time installation. For this dealer, the cost per ROPS varied between $300 and $400, the shipping fee was $85 each, and the installation time typically was 2 hours and 10 minutes during which two extra workers were needed to hold the ROPS uprights and top bar in place during bolting. However, because the dealer did not perform all the retrofits, we used the farmers’ average cost estimate for ROPS retrofits that we obtained from the post-intervention survey data. Farmers in the intervention county estimated their cost for retrofitting a tractor with an ROPS at an average of $649.

In addition, a side effect of the intervention was the cost of an ROPS replacement whenever a tractor overturned, in which the tractor was equipped with an ROPS as a result of the intervention. The cost for these replacements was calculated as $1072. The costs are summarized in table 2.

The direct and indirect costs incurred as a result of an occupational injury were based upon those used by Leigh et al.11 The framework in the cost analysis included the following key points:

- The analytic horizon included the 4.5 year intervention period plus another 20 years since the injury consequences extended well beyond the ROPS retrofit period.
- The perspective was social in which all costs were included irrespective of who pays them.
- The approach was cost-of-injury (disease) in which the cost of pain and suffering was not included.
- All occupations including farming were used to calculate the costs of an injury, because 59% of the principle farm operators in Kentucky had jobs off the farm and were thus engaged in non-agricultural employment.14 However, agricultural occupations were used in a sensitivity analysis.15
- The discount rate of 4% was used so as to be consistent with the rate used in similar cost effectiveness studies.16 This rate lies between that recommended by the CDC12 in 1994 of 5% and the current recommended rate of 3%.17
- All human life was considered of equal value for a normal lifetime no matter the age.18
- US dollars were used as the measure of cost.

### Table 2: Cost inventory in 1997 US dollars for the base case intervention county and the agricultural occupations scenario before discounting and inflation adjustment

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost factors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost_{intervention} + Cost_{side effects}</td>
<td>Older tractor: One donated for overturn demo</td>
<td>$3000</td>
</tr>
<tr>
<td></td>
<td>Farm day expenses: Nine farm days at $200 each</td>
<td>$1800</td>
</tr>
<tr>
<td></td>
<td>In-kind participation: Two farm days/year; 50 people at 4 hours at $10/hour; 4.5 years</td>
<td>$18 000</td>
</tr>
<tr>
<td></td>
<td>ROPS investment: 170 ROPS at $649</td>
<td>$110 397</td>
</tr>
<tr>
<td></td>
<td>ROPS replacement: Replacement ROPS for overturns over 20 years</td>
<td>$1072</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$134 269</td>
</tr>
<tr>
<td></td>
<td>Agriculture15</td>
<td>All occupations15</td>
</tr>
<tr>
<td>Cost_{direct}</td>
<td>Fatal injury: Lifetime medical, insurance administration, property damage, emergency services, and third party injuries</td>
<td>$33 853</td>
</tr>
<tr>
<td></td>
<td>Non-fatal injury: Lost earnings, household production, and fringe benefits</td>
<td>$383 695</td>
</tr>
<tr>
<td>Cost_{indirect}</td>
<td>Non-fatal injury: Lost earnings, household production, and fringe benefits</td>
<td>$10 551</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$682 589</td>
</tr>
</tbody>
</table>
RESULTS
With no intervention, 2.4 deaths and 16 non-fatal injuries could be expected over a 20 year period in the intervention county. When extrapolated statewide, 64 deaths and 420 non-fatal injuries could be expected over the same period.

As shown in table 3, the intervention launched in the dealership's county was effective in reducing these deaths and non-fatal injuries (undiscounted) by 0.26 and 1.50, respectively. When extrapolated statewide the dealer intervention could be effective at saving 6.7 lives and averting 39 non-fatal injuries over a 20 year period. For the base case scenario at a 4% discount rate, the “savings” (negative costs) per injury averted was $35 713. However, at a 0% discount rate, this savings was raised to $57 395 per injury averted, and conversely at an 8% discount rate, the savings was reduced to $11 526 per injury averted.

For the agricultural occupations scenario, the cost per injury averted of $28 344 did not show a savings as was the case for all occupations. A cost effectiveness analysis also was calculated for the ROPS promotion effort in two intervention counties conducted by the University of Kentucky and multiple community partners. The university/community partners’ intervention was found to be as effective in preventing fatalities as the local ROPS promotion effort by the tractor dealership in one county. However, the partner intervention effort indicated a net cost for each tractor overturn injury averted as compared to a net savings shown by the dealer’s intervention.

CONCLUSION
Effectiveness was increased nearly fourfold with respect to the number of ROPS that farmers installed on their tractors following the dealer’s intervention compared with ROPS retrofits in the control county. The cost effectiveness of the dealership’s program at a savings of $35 713 per injury averted was economically and starkly appealing when compared with similar national results of a cost of $489 373 per injury averted.16 19

A dealer’s intervention program for retrofitting ROPS resulted in a net social savings and not a social cost. Manufacturer backed ROPS promotions can influence dealers to mount retrofit programs. The death of a tractor operator due to an overturn can influence the wider community to invest in ROPS for their own tractors.

ACKNOWLEDGEMENTS
The authors wish to acknowledge that this work was supported by CDC/NIOSH Cooperative Agreements 1US50OH07547-01, U06/CCU412900, and U06/CCU417554. We are also grateful for the assistance and reviews provided by Regina Pana-Cryan, PhD, Senior Service Fellow, NIOSH/CDC. The University of Kentucky’s Office of Research Integrity reviewed and approved the research protocol and the informed consent procedures for the study on an annual basis under IRB Numbers 010499-P2B, 010759-P2B, and 010710-P2B. In addition, we wish to acknowledge the help provided by J & G Equipment in Nelson County, Kentucky for sharing information about their program with us. We are also indebted to the Kentucky Agricultural Statistics Service for their advice and assistance in conducting the two surveys described in this paper. We are also grateful to the farmers who consented to being interviewed.

Table 3 Results of the analysis of an intervention county as compared with a control county, sensitivity analyses at 0% discount rate and for agricultural occupations, and as compared with the results of the original two treatment counties.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Injuries (statewide extrapolation)</th>
<th>Cost in US dollars (savings)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discount rate</td>
<td>Fatal</td>
</tr>
<tr>
<td>Intervention</td>
<td>0%</td>
<td>2.20 (57.5)</td>
</tr>
<tr>
<td>Control</td>
<td>0%</td>
<td>2.45 (64.3)</td>
</tr>
<tr>
<td>0% discount rate</td>
<td>0%</td>
<td>0.26 (6.7)</td>
</tr>
<tr>
<td>Base case</td>
<td>4%</td>
<td>0.24 (6.2)</td>
</tr>
<tr>
<td>8% discount rate</td>
<td>8%</td>
<td>0.24 (6.2)</td>
</tr>
<tr>
<td>Agricultural</td>
<td>0%</td>
<td>0.26 (6.7)</td>
</tr>
<tr>
<td>Occupations†</td>
<td>4%</td>
<td>0.24 (6.2)</td>
</tr>
<tr>
<td>Original treatment</td>
<td>4%</td>
<td>0.27 (7.0)</td>
</tr>
<tr>
<td>counties†</td>
<td>0%</td>
<td>0.19 (5.0)</td>
</tr>
</tbody>
</table>

*A three year intervention period.

Key points
- A dealer’s intervention program for retrofitting ROPS resulted in a net social savings and not a social cost.
- Manufacturer backed ROPS promotions can influence dealers to mount retrofit programs.
- The death of a tractor operator due to an overturn can influence the wider community to invest in ROPS for their own tractors.

REFERENCES
Survey of UK children

As part of its work to promote active citizenship and community participation, the UK government has recently published the findings of a survey of children aged 8–10 and 11–15 years. The report includes issues of relevance to the prevention of unintentional injuries. It notes that the main reasons that 11–15 year old children expressed reasons for feeling unsafe in the neighbourhood were the fear of abduction and stranger danger (48%) and bullying (35%), with traffic causing far less concern (12%). Among 8–10 year olds, the fear of traffic was 23%. The 130 page report by Christine Farmer, 2003 Home Office citizenship survey: top-level findings from the children’s and young people’s survey can be downloaded from http://www.dfes.gov.uk/research/data/uploadfiles/RW29.pdf.