

# Cost-Effectiveness of Roll-Over Protective Structures

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**Background** Roll-over protective structures (ROPS) are proven to prevent fatalities from agricultural tractor overturns, accounting for more than one-third of all production agriculture-related fatalities in the United States. In 1997, there were approximately 1.2 million ROPS-retrofitable tractors in the United States.

**Methods** A decision analysis is used to compare the health outcomes of installing ROPS on retrofitable tractors, relative to doing nothing. A cost-effectiveness analysis builds on these results to assess the costs and benefits of installing ROPS on retrofitable tractors.

**Results** Doing nothing would result in 1,450 fatalities and 1,806 nonfatal injuries, while installing ROPS would prevent 1,176 fatalities and 957 nonfatal injuries. Installing ROPS would cost \$489,373 per injury prevented.

**Conclusions** Installing ROPS on retrofitable tractors would reduce fatalities from tractor overturns by more than 80% and nonfatal injuries by about 53%. The cost per injury prevented would be similar to that of other injury-preventing interventions. ROPS would help prevent additional injuries from falling off tractors and tractor collisions with motor vehicles. *Am. J. Ind. Med. Suppl. 2:68–71, 2002. Published 2002 Wiley-Liss, Inc.*<sup>†</sup>

**KEY WORDS:** ROPS; tractors; cost-effectiveness; injuries; fatalities

## INTRODUCTION

Most of the 2.7 million farm operators, 2.2 million hired farm workers, and 2.9 million unpaid farm workers in the United States use tractors. Two million children live on farms, where some of them also work. An average of 200 fatal injuries per year on US farms is attributed to tractor overturns [NSC, 1997]. These deaths account for more than

one-third of all production agriculture-related fatalities [Murphy and Yoder, 1998]. In addition, overturns result in hundreds of nonfatal injuries per year. Using roll-over protective structures (ROPS) and seatbelts can prevent most of these fatal and nonfatal injuries [CDC, 1993].

We examine the health and economic outcomes associated with installing ROPS to the approximately 1.2 million “retrofitable” tractors that currently lack them and for which ROPS are commercially available, relative to doing nothing. Our results can guide decisions on the protections needed to reduce injuries from tractor overturns and provide direction for future research.

An expanded and detailed version of this study has been published previously [Myers, 2000; Myers and Pana-Cryan, 2000; Pana-Cryan and Myers, 2000]. The current article reflects what was presented during the Agricultural Safety and Health in a New Century Conference in Cooperstown, NY, on April 28–30, 2000. This shorter version discusses only two of the three strategies discussed in the previously published study and notes that additional lives would be saved from falls and collisions with motor vehicles, if ROPS were installed on retrofitable tractors.

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## METHODS

Decision and cost-effectiveness analyses were used to examine the health and economic outcomes associated with installing ROPS to the tractors that currently lack them and for which ROPS are commercially available, relative to doing nothing. The summary outcome of a cost-effectiveness analysis is a ratio expressed as net costs (intervention cost minus cost of adverse health outcomes prevented) over adverse health outcomes prevented. In this study, the adverse health outcomes prevented are fatal and nonfatal injuries from tractor overturns.

The perspective is societal, which means that all costs and all benefits of the intervention are considered regardless of who incurs the costs or benefits from the intervention. The time frame or the period during which the intervention takes place is five years, to account for gradual retrofitting with ROPS. The analytic horizon or the period during which the consequences of the intervention take place is 23 years, because, according to the analysis by Myers and Snyder [1995], it would take this long to achieve the level of protected (with ROPS) versus total hours of tractor operation without the intervention that could be achieved if all tractors examined were retrofitted at the beginning of the study's time frame. The population and hours of use of retrofittable tractors were calculated using data from Myers and Snyder [1995].

To calculate the cost of ROPS retrofitting per injury prevented, all future health and cost outcomes are discounted. After the model is estimated using base-case assumptions, variables' values are changed within a range, in order to assess how much these changes influence the results. A complete list of alternative values for the variables used and respective results can be found in Table 3 in Myers and Pana-Cryan [2000] and Tables 4 through 6 in Pana-Cryan and Myers [2000].

The decision-tree in Figure 1 shows the events following the decisions to do nothing or to retrofit with ROPS. Following the decision to do nothing, a full-time tractor operator might be involved in an overturn with a given annual probability. If the tractor operator is involved in an overturn, he or she might incur a fatal injury. If the tractor operator is involved in an overturn and is not fatally injured, he or she might incur a nonfatal injury.

Following the decision to retrofit with ROPS, a full-time tractor operator has the same annual probability of having an overturn as in the do-nothing option. He or she might wear a seatbelt during the overturn and the retrofitted ROPS might fail. The final outcomes are the same as in the do-nothing option, but their probability of occurring is lower with a ROPS retrofit.

## PROBABILITIES AND COSTS

One hundred forty-five of 100,000 full-time tractor operators have an overturn every year [CDC, 1993; Myers

and Snyder, 1995; NSC, 1997; Myers and Pana-Cryan, 2000]. According to the do-nothing option, an overturn results in a fatal injury 40% of the time [CDC, 1993] and in nonfatal injuries, given survival, 83% of the time [CDC, 1993; NIOSH, 1996; Myers and Pana-Cryan, 2000].

Farmers wear seatbelts on ROPS-equipped tractors 8% of the time [Kelsey et al., 1996]. A ROPS without a seatbelt reduces fatal injuries by 95% [CDC, 1993, Myers and Pana-Cryan, 2000] and nonfatal injuries, given survival, by 76% [CDC, 1993; NIOSH, 1996; Myers and Pana-Cryan, 2000]. A ROPS with a seatbelt reduces fatal injuries by 100% and nonfatal injuries, given survival, by 88% [Myers and Pana-Cryan, 2000]. A ROPS fails during 1% of overturns, which results in as many injuries as the do-nothing option [Woodward and Swan, 1980].

It costs approximately \$1,000 to retrofit a tractor [Scharf et al., 1998]. The total direct and indirect cost of a fatal occupational injury was \$665,000, while the total direct and indirect cost of a nonfatal occupational injury was \$12,500 in 1997 dollars [Leigh et al., 1996]. According to recent recommendations, cost-effectiveness analyses should use a social real discount rate of 3–5% [Shaffer and Haddix, 1996]. To be consistent with the estimates from the study by Leigh et al. [1996] that were derived using a 4% discount rate, the same rate was used to discount all future costs and health outcomes and calculate the cost-effectiveness of ROPS. All costs used in this study are expressed in 1997 dollars.

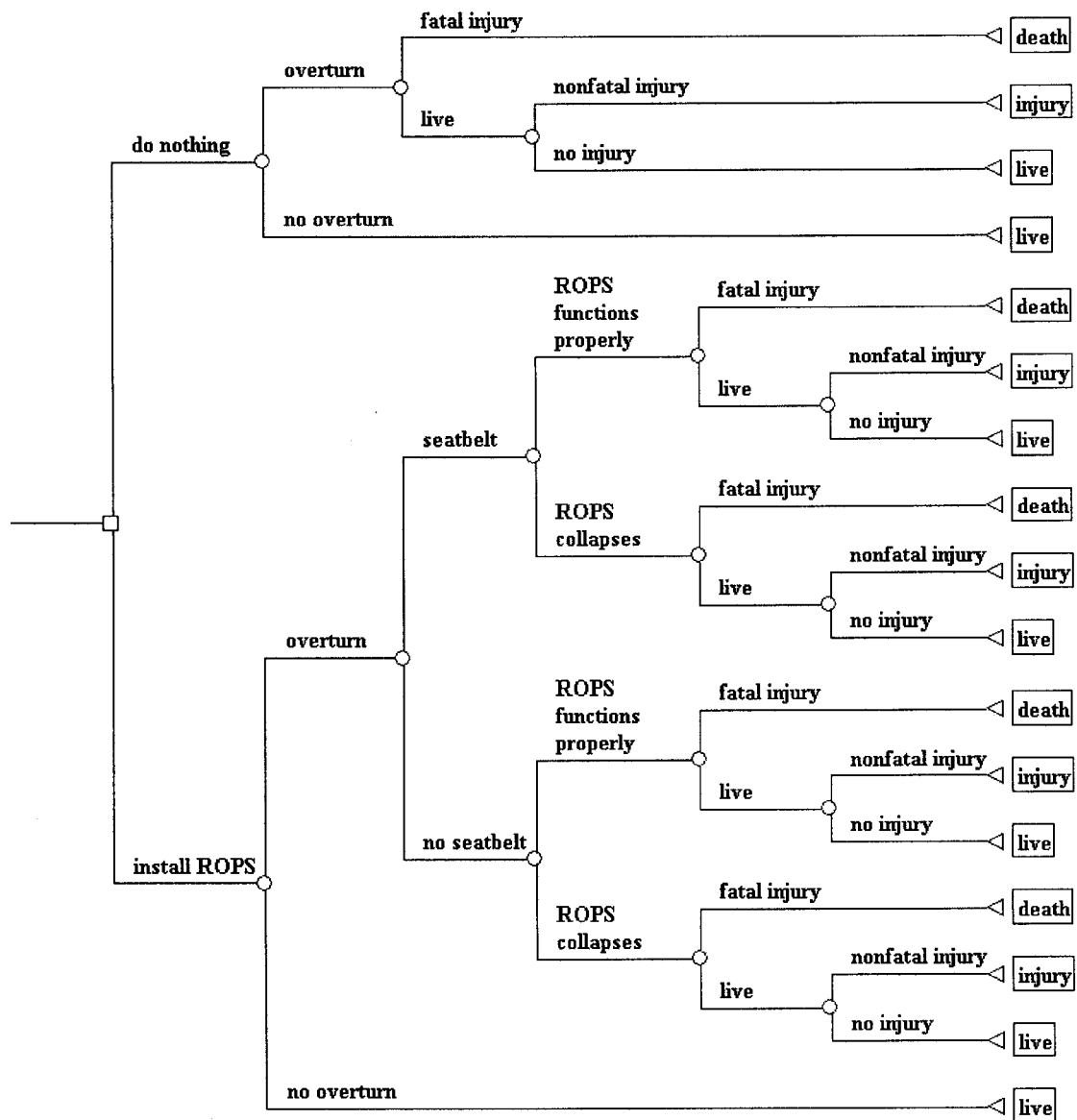
## RESULTS

Installing ROPS would prevent 1,176 fatal and 957 nonfatal (undiscounted) injuries. Using a seatbelt 100% of the time would prevent an additional 57 fatal and 271 nonfatal (undiscounted) injuries. Retrofitting with ROPS would cost \$489,000 per injury prevented, which is within the range of cost-effectiveness ratios for other injury prevention interventions. Sensitivity analyses show that the cost-effectiveness ratio ranges from \$75,000 (when all overturn injuries are assumed fatal) to \$1,471,000 (when ROPS without seatbelts are not effective to reduce fatal injury after an overturn) per injury prevented.

A ROPS would have to cost \$350 in order for the (monetary) benefits to be equal to the costs of retrofitting with ROPS. However, the purpose of cost-effectiveness analyses is to help policy makers prioritize interventions given limited resources rather than identifying cost-saving interventions or interventions that "break even."

## DISCUSSION

The cost-effectiveness ratio we calculate is within the range society considers acceptable, for example, implementing mandatory air bags and the 55 mph speed limit cost



**FIGURE 1.** Decision-tree showing the alternative strategies and health outcomes associated with tractor overturns.

\$408,000 and \$1.2 million per life saved, respectively [Graham and Vaupel, 1981].

The priority should be to retrofit with ROPS and secondarily to assure compliance in seatbelt use. However, ROPS in combination with seatbelts do save farmers lives. For every 20 lives saved by a ROPS, another life could be saved if every operator on a ROPS-equipped tractor would wear a seatbelt. Recent data from Kentucky indicates that approximately 69% of known fatalities due to either the lack of ROPS or non-use of seatbelts on ROPS-equipped tractors are attributable to overturns, while the rest involve being thrown or falling from tractors, including runovers, and tractor collisions with motor vehicles [Cole et al., 1999].

Many of these fatalities that are related to non-overturn incidents may be preventable when a seatbelt is used in combination with an installed ROPS. Therefore, the effectiveness of ROPS with and without seatbelts to prevent injuries from events other than overturns should be further examined.

In Nordic countries, cabs without seatbelts are used as the restraint system, whereas in the United States a ROPS frame in addition to a seatbelt is seen as the restraint system. However, seatbelts are rarely worn by farmers in the United States, and a passive system (cab) may be more effective in restraining the tractor operator within the protective zone of the ROPS. The cost-effectiveness of passive versus active operator restraints should be examined.

A ROPS cost-effectiveness analysis from the farmer's perspective is needed. Assuming that the cost of ROPS may be a major deterrent to the farmers installing them on their tractors, economic incentives to encourage retrofitting need to be investigated.

ROPS availability needs to be assessed and monitored. Especially useful in understanding the population of different models of tractors with and without a ROPS was the Traumatic Injury Surveillance of Farmers survey project of 1994 [Myers and Snyder, 1995]. This project should be replicated every 10 years in order to monitor the trends in the tractor population relative to the use of ROPS. Seatbelt use should also be monitored.

Voluntary policies requiring ROPS have been found to be ineffective [Karlson and Noren, 1979], but in order to better understand the issues involved, the distributional consequences of mandatory and voluntary policies on ROPS should be studied. Finally, investigations on the types and costs of injuries from tractor overturns are needed.

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