

Seatbelt Use During Tractor Overturns

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ABSTRACT. *In 2002, the Kentucky Farm Tractor Overturn Survey was administered, in which 6,063 randomly selected farm operators responded to questions that addressed the presence and use of seatbelts in the event of a tractor overturn. Data were analyzed to determine the proportion of seatbelt presence and use on tractors that overturned differentiated by whether they were equipped or not equipped with a rollover protective structure (ROPS). In 537 overturns reported for which the ROPS status was known, 92 involved ROPS-equipped tractors, of which 60 had a functioning seatbelt, and 19 operators of these tractors used the seatbelt that was present during the overturn. However, of the 445 overturns of non-ROPS tractors, eight had a functioning seatbelt, and three of these operators wore the seatbelt. Two of the three operators that wore seatbelts on non-ROPS tractors suffered a permanent disability. In contrast, of the 19 operators who wore a seatbelt on ROPS-equipped tractors, 18 experienced no or minor injuries, and one required outpatient care. Seatbelts are known to save lives but are a secondary safety device to ROPS, for ROPS alone saves lives and is a necessary pre-condition for seatbelt presence and use.*

Keywords. *Injuries, Overturns, Rollovers, Seatbelts, Tractors.*

Lotka (1964) and Johannessen (1985) described the history of the seatbelt, which was first patented in 1885 and used on horsedrawn vehicles to secure passengers from being thrown from their seats on rough roads. Zink (1963) stated that as seatbelts were essential for protecting the occupant in the event of an automobile overturn, they should apply to tractors equipped with rollover protective structures (ROPS). Lamouria et al. (1964) recommended that a seatbelt and protective helmet be designed into the rollover protective system.

Pratt and Hard (1998) found that two of 33 fatalities occurred in overturns with ROPS-equipped tractors. These fatalities occurred when the operators were thrown outside of the safety zone provided by the ROPS. In addition to protecting an operator in the event of an overturn, seatbelts can restrain operators within a safety zone in the event of a collision or keep them from falling from the tractor seat (Lehtola et al., 1994).

Recognized as a restraint device, the Society of Automotive Engineers (SAE) published a recommended practice for seatbelts in 1955 (SAE, 1955). In their 1967 ROPS standard, the American Society of Agricultural Engineers (ASAE) referred to the seatbelt standard, SAE J4c, and required that ROPS-equipped tractors have a seatbelt assembly installed (ASAE Standards, 1967).

In Kentucky, Browning et al. (1999) reported on the presence of seatbelts from a sample of 259 tractors based upon 138 on-site farm visits. Seatbelts were observed on 66.7% of those tractors that had either a frame- or cab-type ROPS. Myers (2000) found

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that both the effectiveness and use of occupant restraints were important, but Myers (1998) reported that few farmers wore seatbelts.

If a tractor lacks a ROPS, manufacturers warn that a seatbelt should be neither present nor used since it foregoes the operator the opportunity to jump free or be thrown clear to escape being crushed by an overturning tractor (Bittner et al., 1994). The purpose of this article is to report findings based on an examination of a random sample of tractor overturns to determine the propensity of seatbelt presence and use as an intervention to reduce injury severity on ROPS-equipped tractors and as a hazard on non-ROPS tractors.

Method

The Kentucky Farm Tractor Overturn Survey was administered by telephone in 2002 to a sample of 6,063 principal farm operators selected randomly from 76,017 farms statewide (USDA, 1997). This survey achieved a 79% response rate (Cole et al., 2004). Table 1 shows background information collected in the survey.

The survey was conducted in two tiers in which the first tier asked general questions regarding the tractors on the farm and farmstead demographics, which included whether the farm entity or a member of the farm household had experienced an overturn. If so, they were asked a second tier of questions related to only the most recent tractor overturn. Some of the questions related to the presence of seatbelts on tractors and their use during the overturn event and the injuries associated with the overturns.

Credibility of the study was improved by enlisting the Kentucky Agricultural Statistical Service (one of four entities used nationally by the USDA for the Agricultural Census) to review, approve, and administer the survey instrument. In addition, a large random sample was used, which was proportional to the six agricultural districts in Kentucky. These districts represent a wide variety of commodities that are similar in range from the southern to the northeastern to the midwestern United States. Moreover, Kentucky borders seven other states that have similar agricultural production to one or more of these six districts.

Results

When asked about their most recent tractor overturn, the respondents reported 551 overturns. Of these overturns, the respondents reported that 92 involved ROPS-equipped tractors, 445 involved non-ROPS tractors, and for another 14, the ROPS status of the tractor was unknown.

As shown in table 2, 60 of the 92 ROPS-equipped tractors had functioning seatbelts, while eight respondents did not know whether a seatbelt was present or functional.

Table 1. Background information collected from the Kentucky Farm Tractor Overturn Survey, 2002.

Item	Number
Number of farms in the sample	6,063
Number of tractors on these farms	10,472
Number of these tractors equipped with ROPS	4,265
Number of ROPS-equipped tractors known to be of the frame-type	2,366
Number of ROPS-equipped tractors known to be of the cab-type	1,515
Number of overturns (most recent/farm) of ROPS-equipped tractors ^[a]	92
Number of overturns (most recent/farm) of non-ROPS tractors ^[a]	445

^[a] The ROPS status on another 14 overturns was unknown.

Table 2. Comparison of seatbelt presence and use between ROPS-equipped and non-ROPS tractors during 543 overturns.

	ROPS-equipped	Non-ROPS	Unknown
Number	92 ^[a]	445	6
Equipped with functioning seatbelt	60 (65.2%) unknown = 8	8 (1.8%) ^[b]	8
Operator used seatbelt	19 (31.7%) unknown = 6	3 (37.0%) unknown = 2	8

^[a] Model years for 17 tractors that were reported with no functioning seatbelt were 1968, 1970 (two), 1972 (two), 1974, 1979 (three), 1982, 1983, 1984, 1986, 1988, 1990, 1991, and 1994.

^[b] Model years reported for these tractors were 1968, 1970, 1981, 1982, 1983 (two), 1990, and 1991.

Nineteen of the operators on the tractors that were known to have functioning seatbelts had fastened them at the time of the overturn. On the 60 tractors that were equipped with both a ROPS and a functional seatbelt, there was no significant difference by age ($p \leq 0.77$) between those using (mean = 40.8 years, SD = 15.2) and not using (mean = 44.5 years, SD = 16.9) a seatbelt.

Compliant behavior regarding seatbelt use relative to gender was indeterminate, since no females drove a tractor with a functioning seatbelt in this sample. However, two females were among the operators who had no functioning seatbelt on ROPS-equipped tractors.

Of the 445 non-ROPS tractors, eight were equipped with a functional seatbelt, and three operators of these tractors wore a seatbelt during the overturn, while two respondents did not know whether the operator wore a seatbelt. The tractors reported thus-equipped were a 1968 International-Harvester 140, 1970 International-Harvester 484, 1981 Ford F, 1983 Ford 4610, 1983 Case 1290, 1982 and 1990 Ford 4600, and 1991 International-Harvester. Ironically, three of the tractor operators that had functioning seatbelts on a non-ROPS tractor used them when they should not have, and two of these three operators were permanently disabled as a result of lateral overturns; one was a 90° overturn, and the other was a 180° overturn. The third operator was uninjured in a rear overturn. The three operators were males aged, respectively, 21 years, 49 years, and 58 years.

Table 3 shows a comparison of injury by severity experienced during tractor overturns between ROPS-equipped and non-ROPS tractors as related to seatbelt use. No death was reported from an overturn of belted operators on ROPS-equipped tractors, whereas one

Table 3. Injury frequency and severity related to tractor overturns with and without ROPS and with seatbelts.^[a]

Injury outcome by severity	ROPS-equipped tractors				Non-ROPS tractors		
	Number	Seatbelt			Number	Seatbelt	
		Present ^[b]	Not Used	Used		Present	Used
No or minor injury	79 (86%)	47 (78%)	29(71%)	18 (95%)	242 (55%)	6 (75%)	1 (33%)
Outpatient	9 (10%)	11 (18%)	10 (24%)	1 (5%)	97 (22%)	0	0
Hospitalized	3 (3%)	2 (3%)	2 (5%)	0	68 (15%)	0	0
Disability	0	0	0	0	14 (3%)	2 (25%)	2 (67%)
Death	1 (1%)	0	0	0	24 (5%)	0	0
Total (100.0%)	92	60	41	19	445	8	3

^[a] The frequencies reported in this table are small and are subject to variation; thus, caution should be used in their application.

^[b] Percentages in this column do not sum to 100% because of rounding.

death out of 92 overturns was reported on a ROPS-equipped tractor but for which a functional seatbelt was absent. The death occurred during the 1990s to a 19-year-old male. The decedent was driving on a public highway when he applied the brakes on the tractor to avoid colliding with a car, which resulted in the International Harvester 1866 overturning laterally 90°. The victim died one day after the incident. This death is in contrast with 24 deaths reported out of 445 overturns of non-ROPS tractors.

Moreover, the seriousness of injuries was reduced on ROPS-equipped tractors regardless of seatbelt use. No permanent disability was reported related to overturns of ROPS-equipped tractors, whereas 14 permanent disabilities were reported in 445 overturns of non-ROPS tractors. Two of these disabilities, as previously discussed, occurred when the operators wore seatbelts during lateral overturns of their non-ROPS tractors.

Seatbelt use on ROPS-equipped tractors was associated with one overturn injury incident, in comparison with 12 injury incidents when a functioning seatbelt was not used. One case of outpatient treatment occurred among belted operators on ROPS-equipped tractors, in contrast with 10 of the unbelted operator's treatment as outpatients. Two unbelted operators were hospitalized, but no belted operators were hospitalized. The one injury to a belted operator on a ROPS-equipped tractor occurred when a 22-year old male was driving along a creek side; the tractor overturned sideways 90° and dropped down a four-foot ledge into the creek. The tractor was a 2001 Massey-Ferguson 35. The victim was taken to a hospital for outpatient treatment and was able to return to his work after two weeks of recuperation.

Caution should be used in drawing inference from the frequencies reported above because the numbers are small. These small frequencies are subject to variance.

Discussion

Functioning seatbelts were present on 66% of ROPS-equipped tractors that overturned and on 2% of non-ROPS tractors that overturned. We relied on the respondents' memories and self-reports, which may be subject to bias. However, the proportion of ROPS-equipped tractors with seatbelts was close to the 67% of ROPS-equipped tractors with seatbelts observed by Browning et al. (1999) in their on-site visits in Kentucky. In addition, consistency between three previous studies in Kentucky have shown little variance regarding the proportion of tractors equipped with ROPS:

- Cole et al. (1998) found that respondents from a sample of 1,648 farm operators reported an average of 29.5% tractors that were equipped with a ROPS.
- Browning et al. (1999) found in their survey of 8,271 farm households that 29.2% of tractors were equipped with a ROPS.
- Cole and Westneat (2003) found in their observational study of 146 tractors owned by limited-resource farmers that 28.8% were ROPS-equipped when evaluated with the Agricultural Safety and Health Best Management Practices manual (Legault and Murphy, 2000).

Based on our study, seatbelt use on ROPS-equipped tractors reduced the injury cases from 29% to 5% during overturns. Seatbelts have been promoted as lifesaving augmentations to ROPS based on overturn experiments conducted with dummies (Berge and Swanson, 1967; Skromme, 1986) and their proven value in preventing serious injuries in automobile overturns (Rashidy et al., 2003). The results of this study confirmed the safety value of seatbelts in combination with ROPS in Kentucky, where tractor types and models, overturn characteristics, operator and tractor ages, and farming operations were similar to other states.

Seatbelt use was found to be nearly four-fold greater on tractors that actually overturned than indicated by previous studies that included tractors whether they had overturned or not (Kelsey et al., 1996; Myers and Pana-Cryan, 2000). One possible explanation for this difference is that these studies addressed seatbelt use no matter the circumstances of tractor operation, whereas the current study suggests that seatbelt use is higher when the operator perceives the danger of an overturn.

The hazard of serious injury related to the operator wearing a seatbelt on non-ROPS tractors was confirmed. This finding supports the long-held policy of advising tractor operators not to use a seatbelt on a non-ROPS tractor (NSC, 1978; Bittner et al., 1974).

This study provided no data concerning the value of an enclosed cab to prevent injury during an overturn relative to seatbelt use on tractors equipped with a frame-type ROPS. An alternative restraint system to seatbelts was used in Sweden, where the cab restricted the movement of the operator outside of the safety zone (Springfeldt and Thorson, 1987; Springfeldt et al., 1998). Our study did not distinguish overturns between frame- and cab-type ROPS-equipped tractors.

There are no criteria for the performance of a seatbelt in the event of an overturn. Rains (2000) acknowledged that little research had been conducted on the efficacy of seatbelts on tractors. Bilancia (1969) emphasized the difference between standard automotive seatbelts and seatbelts in off-road construction equipment. On off-road equipment, seatbelts are exposed to the elements and possible contact with battery acid, hydraulic oil, and other agents that can deteriorate or cut the seatbelt webbing, and the seatbelt hardware needs to be useable when the operator wears gloves under cold conditions.

A limitation of our study results from the population sampled. Victims of overturns who were killed or permanently disabled and left farming as a result were not included in the population of farmers sampled.

Conclusion

This research suggests that the use of a seatbelt on a tractor that lacks a ROPS or with a retractable ROPS that is not deployed is a hazard in the event of an overturn. The study results confirm that a seatbelt should neither be present nor worn on a non-ROPS tractor. Conversely, this study found that a ROPS in combination with a fastened seatbelt during an overturn increased the likelihood of survival and prevented serious injury during the overturn. This article revealed that more research is needed on seatbelt use behavior and improving restraint technology.

Nonetheless, Baker (1998) observed that placing a ROPS on a tractor should be a higher priority than the presence and use of a seatbelt with a ROPS. Moreover, Myers and Pana-Cryan (2000) found that at an 8% seatbelt use rate, as observed in New York (Kelsey et al., 1996), one additional life would be saved for every 235 lives that would be saved by the ROPS alone. In addition, they found that with 100% seatbelt use, one additional life would be saved for every 21 lives saved by the ROPS alone.

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References

- ASAE Standards. 1967. S383: Roll-over protective structures (ROPS) for wheeled agricultural tractors. St Joseph, Mich.: ASAE.
- Baker, L. D. 1998. ROPS and seatbelts: Keeping the order right. *J. Agric. Safety and Health* 4(4): 203.
- Berge, O. J., and R. C. Swanson. 1967. A protective frame can save your life. *Hoard's Dairyman* (Oct.): 1143, 1154.
- Bilancia, R. A. 1969. Seat belts for construction equipment. SAE No. 690568. In *Proc. National Farm, Construction, and Industrial Machinery Meeting*, 1-5. Warrendale, Pa.: Society of Automotive Engineers.
- Bittner, R. H. C. Bolton, R. E. Childers, H. J. Doss, H. A. Hughes, L. K. Pickett, R. H. Wilkinson, C. Hausmann, T. Paige, and R. Parker. 1974. *Fundamentals of Machine Operations: Agricultural Machinery Safety*. Moline, Ill.: John Deere Service Publications.
- Bittner, R. H. C. Bolton, R. E. Childers, H. J. Doss, H. A. Hughes, L. K. Pickett, R. H. Wilkinson, C. Hausmann, T. Paige, and R. Parker. 1994. *Farm and Ranch Safety Management*. Moline, Ill.: John Deere Service Publications.
- Browning, S. R., S. C. Westneat, H. Truszczynska, D. Reed, and R. McKnight. 1999. Farm tractor safety in Kentucky, 1995. *Public Health Rep.* 114(1): 53-59.
- Cole, H. P., and S. Westneat. 2003. The Kentucky State University and University of Kentucky on-site farm tractor survey: Preliminary results. Unpublished report dated April 14. Lexington, Ky.: University of Kentucky, Department of Preventive Medicine and Environmental Health, Southeast Center for Agricultural Health and Injury Prevention.
- Cole, H. P., S. Westneat, and S. Browning. 1998. Results of a pre-intervention survey of principal farm operators' demographics, beliefs, and practices related to farm tractor ROPS, seat belts, and extra riders. Unpublished report. Lexington, Ky.: University of Kentucky, Department of Preventive Medicine and Environmental Health, Southeast Center for Agricultural Health and Injury Prevention.
- Cole, H. P., S. C. Westneat, and M. L. Myers. 2004. Frequency and severity of operator injuries during overturns of farm tractors without ROPS. Paper No. 04-02. Presented at the 2004 Conference of the National Institute for Farm Safety.
- Johannessen, H. G. 1985. Historical perspectives on seat belt restraint systems. In *Seat Belts: The Development of an Essential Safety Feature*, 42-50. D. C. Viano, ed. Warrendale, Pa.: Society of Automotive Engineers.
- Kelsey, T. W., J. J. May, and P. L. Jenkins. 1996. Farm tractors and the use of seat belts and roll-over protective structures. *American J. Ind. Med.* 30(4): 447-451.
- Lamouria, L. H., C. Lorensen, and R. R. Parks. 1964. Design criteria for a driver safety frame. *Trans ASAE* 7(6): 418-419.
- Legault, M. L., and D. J. Murphy, 2000. Evaluation of the Agricultural Safety and Health Best Management Practices manual. *J. Agric. Safety and Health* 6(2): 141-153.
- Lehtola, C. J., S. J. Marley, and S. W. Melvin. 1994. A study of five years of tractor-related fatalities in Iowa. *Applied Eng. in Agric.* 10(5): 627-632.
- Lhotka, D. C. 1964. The seat belt story. *Traffic Safety* 64(11): 22-25, 34-35.
- Myers, M. L. 1998. NIOSH perspective on tractor-related hazards. *J. Agric. Safety and Health* 4(4): 205-230.
- Myers, M. L. 2000. Prevention effectiveness of roll-over protective structures, part I: Strategy evolution. *J. Agric. Safety and Health* 6(1): 29-40.
- Myers, M. L., and R. Pana-Cryan. 2000. Prevention effectiveness of roll-over protective structures, part II: Decision analysis. *J. Agric. Safety and Health* 6(1): 41-55.
- NSC. 1978. Tractor operation and roll-over protective structures. Data Sheet I-622-78. Chicago, Ill.: National Safety Council.
- Pratt, S. G., and D. L. Hard. 1998. Injury risk factors associated with agricultural workplace fatalities. *J. Agric. Safety and Health* Special issue 1: 29-38.
- Rashidy, M., B. Deshpande, T. J. Gunasekar, R. Morris, R. A. Munson, J. A. Lindberg, and L. Summers. 2003. Analytical evaluation of an advanced integrated safety seat design in frontal, rear, side, and rollover crashes. In *Seat belts: The Development of an Essential*

- Safety Feature*, 852-863. D. C. Viano, ed. Warrendale, Pa.: Society of Automotive Engineers.
- Rains, G. C. 2000. Initial rollover effectiveness evaluation of an alternative seat belt design for agricultural tractors. *J. Agric. Safety and Health* 6(1): 13-27.
- SAE. 1955. SAE recommended practice: Motor-vehicle seat belt assemblies. Report of Motor Vehicle Seat Belt Committee, November 1955. Warrendale, Pa.: Society of Automotive Engineers.
- Skromme, A. B. 1986. History of rollover protection for farm tractors. Presented at the dedication ceremony of a Historic Milestone in Agricultural Engineering, "Rollover Protection for Farm Tractors," Waterloo, Iowa, 25 September 1986.
- Springfeldt, B., and J. Thorson. 1987. Mitigation of personal injuries caused by overturning of farming tractors. In *Proc. 31st Annual Conf., AAAM*, 229-236. Barrington, Ill.: American Association for the Advancement of Automotive Medicine.
- 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.
- USDA. 1997. Census of Agriculture: Kentucky State and County Data, AC97-A-17. Volume 1, Geographic Area Series, Part 17. Washington, D.C.: USDA National Agricultural Statistics Service.
- Zink, C. L. 1963. Anti-roll bars: Can they reduce tractor fatalities? *Agric. Eng.* 44(6): 308.