Safety Status of Farm Tractors that Operate on Public Highways in Four Rural Kentucky Counties

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ABSTRACT. *Kentucky FFA students inspected 153 farm tractors for safety features that prevent operator injuries during tractor overturns, highway collisions, runovers, and power take-off (PTO) entanglements. Tractor mean age was 23.6 years (SD = 20.9). Rollover protective structures (ROPS) were present on 50.66% of tractors, but only 33.33% of these had functional seatbelts. Loose and damaged seats were found on 30.46% of tractors. In 38.99% of cases, tractor rear-wheel fenders exposed operators to moving tractor tires, and 48.67% of tractors had dangerously worn or damaged tires. Tractors with a narrow front-end stance comprised 16.11% of the total. Only 53.06% of the tractors had starters with secure hard cover by-pass starting shields that fully covered the starter terminals, and 37.37% had fully exposed terminals with no cover. PTO master shields with all parts present and undamaged were present on only 29.27% of the tractors, and in 39.02% of cases the entire shield was missing. Only 44.67% of the tractors had properly mounted and fully functional mounting and dismounting access steps and handholds. SMV emblems were missing on 53.64% of tractors and in the proper place and condition in only 25.83% of cases. Tractors with properly mounted and fully functional head and tail lights comprised 40.94% of the sample, and tractors with no functional lights comprised 24.16%. Properly mounted, clean, and functional rearview mirrors were present on only 19.87% of the tractors, and 69.54% had no rearview mirrors. The project increased farming and non-farming students' awareness of tractor safety issues, provided empirical data about the safety status of a sample of tractors that frequently travel public highways in four rural Kentucky farming counties, and promoted dialog about these issues with adult farmers and other community members with whom the students interacted.*

Keywords. *FFA, Inspection, Safety, Tractor, Youth.*

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By age 16, students who live or work on farms typically have driven farm tractors for the previous six years, including operating tractors on public highways (Browning et al., 2001). A survey of 498 farms in Ontario, Canada, and 11 western and 12 midwestern U.S. states found that 31.1% of 1,138 farm children age 7 to 16 years were involved in tractor operation (Marlenga et al., 2001). A subsequent study using the same data found that 37.5% of children age 7 to 13 years and 62.4% of those age 14 to 16 years operated tractors $\geq$20 hp (Marlenga et al., 2004). A multi-year epidemiological study in North Carolina found that an annual average of 300 farm vehicle highway crashes accounted for less than 1% of the total 220,018 motor vehicle crashes per year. Yet the rate of farm equipment crashes per million miles driven was 5.64, a value 2.3 times higher than the statewide all-vehicle rate of 2.47. Youth who operated farm equipment were found to be at high risk for highway crashes (Costello et al., 2003). An Ohio study reported 803 farm equipment and motor vehicle crashes in that state for the four-year period 1989-1992 (Glascock et al., 1995).

During 2006 in Kentucky, 64% of motor vehicle collisions occurred in urban areas, with 56% of fatal events occurring in rural counties. A similar pattern occurred in 2007, with 60% of collisions in urban areas and 60% of fatalities in rural counties (Kentucky State Police, 2006, p. 9; Kentucky State Police, 2007, p. 9). Rural motor vehicle crash mortality rates in the U.S. are known to be 50% higher than death rates in metropolitan counties after controlling for differences in emergency medical services (Muelleman et al., 2004). During 2006 and 2007, there were 408 Kentucky public highway collisions involving farm equipment and other motor vehicles. Eleven of these collision incidents resulted in 14 fatalities, and a total of 100 non-fatal collision events resulted in a total of 140 injuries.

National motor vehicle traffic fatality rates for drivers age 16 to 20 years for the 11-year period from 1997 to 2007 are consistently about three times higher than the rates for drivers age 25 to 64 years (NHTSA, 2007). People in the younger age group comprise only 7% of U.S. drivers but account for 18% of the cost of all U.S. traffic crashes. Motor vehicle crashes for individuals age 16-20 years account for one of every five deaths in this age group (NHTSA, 2002). In 2002, a total of 7,410 persons from birth to age 20 years were killed in motor vehicle crashes, and 729,207 were non-fatally injured. Youth age 16-20 years accounted for 76% of these deaths and 65% of the non-fatal injuries (NHTSA, 2002).

This age group also may be at high risk of tractor overturn events. A 2002 random sample survey of 6,063 (8%) of Kentucky farm operations found that 14.7% of tractor operators age 16-20 years had overturned non-ROPS tractors, a value higher than for any other age category (fig. 1). The comparable values were 1.2% for those age 6-10 years, 7.0% for those age 11-15 years, and 9.4% for young adults age 21-25 years (Cole et al., 2006). The number of overturns by age category and injury outcome is reported in table 1.

A study by Williams et al. (2006) reported that the majority of both male and female adolescents immediately began operating motor vehicles as soon as they received an operator's license, and that the majority drove smaller and less crashworthy vehicles. New drivers age 16-19 years tend to have inadequate situational awareness that is needed to prevent motor vehicle collisions, especially when traveling with two or more adolescent passengers (Doherty et al., 1998). Young suburban and urban drivers

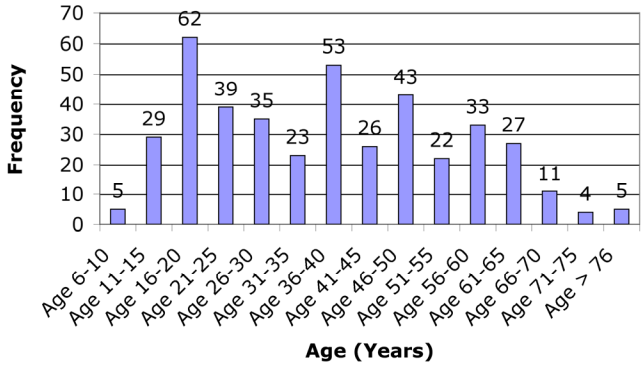

Figure 1. Age at time of non-fatal and fatal overturns of non-ROPS tractors for a random sample of 417 Kentucky tractor operators (Cole et al., 2006).

Table 1. Number of youth age 16-20 years who overturned non-ROPS tractors by age and injury outcome for a random sample of Kentucky farm operations.[a]

Age (years)	Number			
	Tractor Overturns	No or Minor Injury	Non-Fatal Injury	Fatal Injury
16	18	16	2	0
17	11	11	0	0
18	11	8	2	1
19	8	6	2	0
20	14	12	2	0
Total	62	53	8	1

[a] Includes all non-ROPS tractor overturn events for this age category during the history of a random sample of 6,063 (8%) Kentucky farms for the period 1925-2001. The data were gathered by the Kentucky Tractor Overturn Survey conducted during January and February 2002 (Cole et al., 2006).

who travel rural highways may have limited knowledge of farming practices and farm equipment and lack the experience and situational awareness necessary to anticipate, recognize, and prevent collisions with slow-moving farm machinery that frequently travels on narrow, winding, and hilly rural roads.

Aims

The project described in this article had four aims.

- Provide teachers and students with an easy-to-use visual safety inspection checklist to assess the safety status of farm tractors that operate on public highways with respect to the four National Agricultural Tractor Safety Initiative (TSI) operator safety priority areas: tractor overturns, runovers, highway collisions, and power take-off (PTO) entanglements (Swenson, 2004, pp. 4-5).
- Promote dialog about tractor inspection and safety issues with family members and other young adult and adult community members with whom the students interact as part of their FFA supervised agricultural experience, leadership, and community service programs (FFA, 2008).
- Provide empirical data about the operator safety status of a sample of tractors that travel public highways in the four agricultural counties in which the schools were located.

- Provide an opportunity for students to prepare and present their safety inspection project results within their FFA chapters, schools, and at local and regional community meetings.

Method

The sampling methods and the sample characteristics are described below, followed by an explanation of the design and administration of the study measures.

Sample

Twenty central Kentucky rural agricultural counties that were within a four-hour round-trip drive from the University of Kentucky were randomly selected from the 60-county random sample used in the 1994 to 1995 Kentucky Farm Family Health and Hazard Surveillance project (Browning et al., 2001). A University of Kentucky College of Agriculture extension safety specialist then selected four of the counties known to have outstanding FFA chapters and faculty advisors. Financial constraints limited the project effort to these four counties.

School Administrators, Teachers, and Student Recruitment

The school principals and FFA teacher-advisors were contacted by telephone and site visits arranged. The researchers then met with school administrators and the FFA teacher-advisors and FFA chapter officers to explain the (1) project aims, (2) required human subjects parental and student consent procedures and forms, (3) purpose and use of the farm tractor visual safety inspection checklist, and (4) additional instructional materials that provided background information about the frequency and characteristics of tractor and motor vehicle highway collisions and the injuries that result from the collisions. Documents containing this information were provided to each teacher and the four school administrators. After the school administrators and teachers agreed to participate in the project, a formal contract with the University and each school's FFA budget administrative officer was prepared. The contract provided a digital camera to each school's FFA program plus awards of $500 for each of two years. The students used the cameras to document their tractor safety inspections and to include photographs in their reports and presentations. The funds were used to facilitate student materials preparation and costs related to presenting the results of their tractor safety inspections at local and regional meetings. The funds also assisted the teachers' duplication, distribution, and integration of the project materials into their ongoing instruction in agriculture classes.

Subsequently, one or more of the researchers scheduled a one-hour classroom session with the FFA students and their teacher-advisors at each school during which five topics were addressed:

- The four project aims were described and discussed.
- Copies of the National Agricultural Tractor Safety Initiative (Swenson, 2004) were distributed and discussed, including the Initiative's recommendations (pp. 4-5) for preventing tractor operator injuries by (1) use of ROPS and seatbelts to prevent operator falls and ejections during overturns and collisions, (2) proper lighting and marking to prevent highway collisions, (3) starter terminal shields to prevent runovers related to by-pass starting, (4) proper shielding to prevent PTO entanglements, and (5) an additional operator safety feature that

addressed the presence of properly placed and maintained access steps and handholds to prevent operator injuries when mounting and dismounting tractors.

- Hard copies of the *Kentucky Community Partners ROPS Notebook* (Cole et al., 2002) and the online version of the notebook were described, examined, and discussed, with emphasis on those sections of the notebook related to tractor highway collisions and tractor overturns (Cole et al., 2000). Two hard copies of the notebook were provided to each FFA program.
- Students were invited to describe and discuss their observations and experiences about tractor operator injuries and injury prevention measures during a class discussion.
- Two copies of the student assent/parental consent form were distributed to all students age <18 years, and two copies of the student consent form to all students age ≥18 years. A project researcher explained the human subject consent procedures and answered student questions. Students who chose to participate in the project were asked to take home two copies of the consent form, to discuss the project and the form with a parent or guardian, and if they agreed to participate in the project, to sign both copies of the form, keep one for themselves, and, on a specified date, return one signed copy of the form to a project researcher who would be present at the school. The students conducted their tractor safety inspections during the fall 2006 semester and the spring 2007 semester.

County Demographics

Table 2 lists the number of farms and agricultural tractors in each of the four counties as reported in the 2002 Census of Agriculture, the total number of all motor vehicle collisions in the counties during 2006 and 2007, and three categories of collision injury outcomes as reported by the Kentucky State Police.

Measures

The primary measure was the four-page Farm Tractor Visual Safety Inspection Checklist, hereafter referred to as the checklist. It was developed by Cole and Piercy. With the permission of Dr. Dennis Murphy, the checklist design and content were based in part on selected portions of the *Agricultural Safety and Health Best Management Practices* manual developed by the Pennsylvania State University Cooperative Extension Service (Legault and Murphy, undated). Pages 20, 22, and 24 of the Penn

Table 2. Number of farms, tractors, and total motor vehicle crashes and their injury outcomes for the four project counties and for the state of Kentucky.

Number of Farms and Tractors[a]			Total MV Collisions by Injury Outcome, 2006-2007[b]			
County	Farms	Tractors	Collisions	Killed	Injured	Non-Injury Property Damage
Mercer	1,087	1,073	1,027	7	329	827
Nelson	1,410	1,378	2,275	22	670	1,794
Taylor	937	909	1,352	14	364	1,096
Woodford	695	686	1,494	12	365	1,219
Total	4,129	4,046	6,148	55	1,728	4,936
Kentucky	84,319	79,213	251,805	1,777	79,830	196,538

[a] Source: USDA (2002).

[b] Sources: Kentucky State Police (2006, 2007). (Note: Values in the last three columns include all motor vehicle collisions in each of the four counties and for the state.)

State manual deal with the tractor ROPS, seats, and seatbelts, while pages 32 and 62 deal with the slow-moving vehicle emblem and the PTO master shield. The functional status of each of these features is rated on a five-point scale (1 = high to 5 = low) with a short verbal description and a black and white photograph provided for the 1, 3, and 5 ratings. The Kentucky checklist incorporates these five basic features plus seven additional safety features. In addition, the Kentucky checklist provides a more detailed verbal description for each of the five safety rating categories using a reversed scale with the highest safety status rating equal to a 5 and the lowest rating equal to a 1. A set of PowerPoint slides accompany the Kentucky checklist. Color photographs and text comments on the slides provide instructions for assigning the safety ratings for each tractor feature inspected. Through this combination of color photographs and short text statements, the PowerPoint slides provide detailed instructions for inspecting and assigning safety ratings for each of the tractor safety features addressed by the checklist. In addition, the checklist also allows field researchers to assign and record numerical rating inspection data and written comments for each one of up to four farm tractors on one copy of the form.

After its initial development the Kentucky checklist was critiqued by the members of the research project team and then revised. It was then critiqued by four additional farm safety experts from outside the University of Kentucky and by the six agriculture teachers and FFA advisors from the four participating schools. The checklist was revised based on these critiques.

Teachers and FFA students were then taught how to use the checklist by using the PowerPoint slides while inspecting one or two farm tractors that were brought to each school. Local farmers and equipment dealers provided the tractors. Following this activity, based on observations of the teachers' and students' performance and comments, the researchers made a final set of minor revisions to both the checklist and the PowerPoint slides. Students at each school then contacted local farmers (typically farm family members or friends) and used the checklist to conduct safety inspections of a non-random but representative sample of tractors used for highway travel in their counties.

Prior to conducting their tractor safety inspections and project activities, students examined and discussed the *National Agricultural Tractor Safety Initiative* (Swenson, 2004) and portions of the *Kentucky Community Partners ROPS Notebook* (Cole et al., 2002), especially those sections that include facts about tractor overturns and farm equipment and motor vehicle collisions on public highways, as well as investigative reports, short first-person stories, and newspaper articles about these types of events. Students and teachers accessed the notebook by using the hard copies provided to them and by accessing the online version available at the National Agricultural Safety Database (www.cdc.gov/nasd). This preliminary instructional activity served three purposes. First, it provided students with a broader knowledge and understanding of tractor and motor vehicle highway collisions, their precursors, injury consequences and costs, and their prevention. Second, it stimulated student interest in the tractor safety inspections. Third, it provided students with factual data and graphics that they could use as background material as they prepared their tractor safety inspection reports and presentations.

Results

The study results are presented in two parts: the students' demographic and tractor driving characteristics first, followed by the results of their tractor safety inspections.

Student Characteristics

Table 3 lists the number, gender, and percentage of FFA students in each of the four county high schools that were involved in the project and the numbers of tractors inspected by the students. The students' gender distribution and the numbers of tractors inspected varied widely across counties. For example, Nelson County with 61 students, 43 of whom were female, accounted for only 22 (14.4%) of the tractor inspections. Yet Taylor County, with 22 students, of whom only three were female, accounted for 69 (45.1%) of the tractor inspections.

A majority of the 119 students completed and turned in a one-page form that collected information about their age, gender, farming experience, tractor driving experience, and farm tractor highway operation. The items included on this form were developed and validated in a series of earlier studies conducted as part of the NIOSH-funded Kentucky Community Partners for Healthy Farming ROPS project (Cole et al., 2002).

Table 4 presents data from the 9th, 10th, 11th, and 12th grade students who answered four demographic questions. Because of missing data, the totals for each variable sum to less than the 119 students who conducted the tractor inspections. The primary reasons for the missing data were incomplete forms. The unit of analysis for table 4 and for the remaining results reported is the pooled four-county data. This is consistent with the study's informed consent and human subjects procedures to protect the anonymity of the farmers whose tractors were inspected. Table 5 provides the age distribution of students who reported that they did or did not have a motor vehicle operator's license.

Table 4 reveals that, of those who responded, 56.2% of students lived or worked on farms, 34.8% had a driver's license, 46.0% reported driving farm tractors, and 56.4%

Table 3. Number and percentage of students by Kentucky county high school, gender, and number of tractors inspected.[a]

County	Male	Female	Combined	Tractors Inspected
Mercer	19 (29.2)	0 (0.0)	19 (16.0)	35 (22.9)
Nelson	18 (27.7)	43 (79.6)	61 (50.3)	22 (14.4)
Taylor	19 (29.2)	3 (5.6)	22 (18.5)	69 (45.1)
Woodford	9 (13.8)	8 (14.8)	17 (14.3)	27 (17.6)
Total	65	54	119	153

[a] Values in parentheses in cells are the percentage of column totals.

Table 4. Students' farm experience, operator's license status, and tractor driving experience.[a]

Student Characteristic	Yes	No	Total
Live or work on a farm	54 (56.2%)	42 (43.8%)	96
Have a driver's license	31 (34.8%)	58 (65.2%)	89
Drive farm tractors	40 (46.0%)	47 (54.0%)	87
Drive tractors on highways	22 (56.4%)	17 (43.6%)	39

[a] The number of students in the last column varies because of missing data. Note that of the 40 students who reported that they drove tractors, 22 reported that they operated tractors on public highways, 17 reported they did not, and one did not reply.

Table 5. Age distribution of students with and without a driver's license.[a]

	Student Age (Years)					
	14	15	16	17	18	Pooled
Licensed	0 (0.0%)	0 (0.0%)	8 (50.0%)	15 (100.0%)	8 (88.9%)	31 (34.8%)
Not licensed	22 (100.0%)	27 (100.0%)	8 (50.0%)	0 (0.0%)	1 (11.1%)	58 (65.2%)
Total	22	27	16	15	9	89

[a] Percentages represent the proportion of licensed and unlicensed students in each age group.

of those who drove tractors also operated them on public highways. Table 5 reveals that, of those who responded, no students age 14 and 15 years were licensed drivers, 50% of all 16-year-olds were licensed drivers, and 100% of those age 17 years had a driver's license. Eight of the nine 18-year-olds (88.9%) were licensed drivers.

Tractor Inspection Results

The students' Farm Tractor Visual Safety Inspection Checklist data are presented in four major categories. The first category includes tractor demographics including manufacturer and year manufactured. The second category addresses tractor safety features related to preventing a tractor operator from being injured by being ejected or falling from the operator's compartment during collisions and/or overturns while operating a moving tractor on public highways or elsewhere. The third category includes tractor lighting and reflective marking, safety features that make farm equipment more visible to other motor vehicle operators. The fourth category includes safety features that prevent injuries to operators when they are on the ground preparing to start a tractor or to inspect, connect, operate, or disconnect machinery attached to the tractor PTO, and also while they are mounting or dismounting a tractor. Although 153 tractors were inspected, student inspectors sometimes failed to record a specific tractor feature either because the information was not available or because it was not assigned a rating. Therefore, the number of tractors (denominator) inspected for each feature is reported.

Consistent with procedures for the protection of human subjects, the checklist was restricted to a visual inspection to prevent students from starting and operating tractors during inspections (even though many of the students regularly drove tractors). Thus, tractor braking, steering, and hydraulic systems were not included in the checklist.

Tractor Demographics

The mean age of the 91 tractors for which manufacture year was known was 23.6 years (mean manufacture year 1982) with a standard deviation of 20.9 years. The tractor's median age was 21 years with a range of 71 years. As is evident from figure 2, a tri-modal age distribution accounted for 94% of these tractors (16% in 1947-1956, 35% in 1972-1991, and 43% in 1996-2006). The distribution of tractor brands is presented in figure 3.

Features that Protect Operators on Moving Tractors

Presence and use of properly maintained ROPS, seats, seatbelts, rear wheel fenders, a wide front-wheel stance versus a narrow stance, and tractor tires combine to protect operators of moving tractors. During overturns and collisions, the ROPS, seatbelt, and tractor seat protect the operator from being ejected from the tractor. In the absence of a fastened seatbelt, properly maintained seats with backs and armrests help prevent the

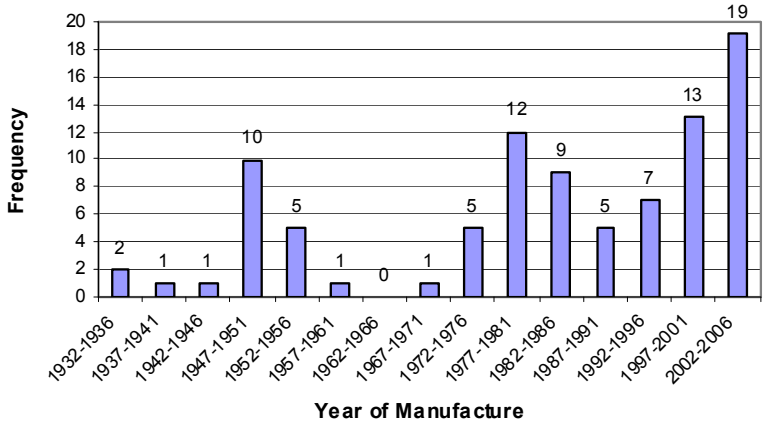

Figure 2. Year of tractor manufacture in five-year intervals (*n* = 91).

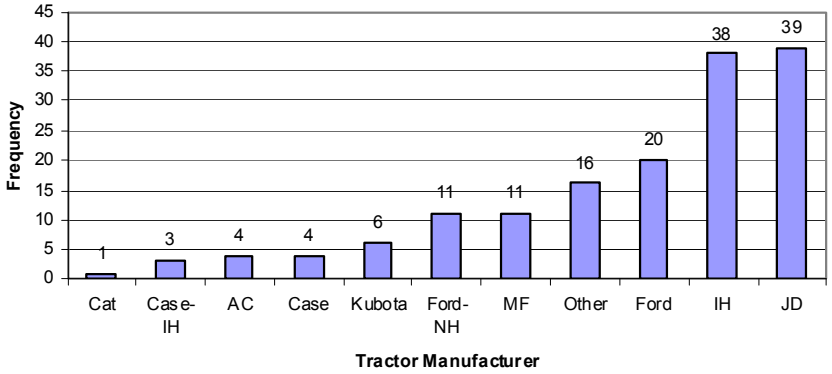

Figure 3. Distribution of tractor brands for the 153 tractors inspected: Cat = Caterpillar, Case-IH = Case-International Harvester, AC = Allis Chalmers, Ford-NH = Ford-New Holland, MF = Massey Ferguson, Other = a collection of older tractors such as David Brown, White, Oliver and unknown manufacturers, as well as tractors produced overseas (in England, Japan, India, or Germany), IH = International Harvester, and JD = John Deere.

operator from being knocked or tossed off a moving tractor and run over. Examples include the operator being struck by a low-hanging tree branch while mowing a pasture or being tossed from the seat when a moving tractor abruptly lurches violently but does not overturn after striking a hole, stump, or other obstacle while plowing, disking, or mowing (Murphy, 1992, p. 22). Likewise, properly designed and well maintained rear wheel fenders also help protect operators, or portions of their bodies, from being tossed into contact with the tops and sides of the moving rear tractor tires during such events. Once in contact with the moving tractor tire cleats, an operator can be pulled from the tractor seat and operator platform and be run over or otherwise injured. Fenders that fully protect the operator from the tops and sides of moving tractor wheels and tires also prevent operators from being struck by objects that become entangled in the tractor tire cleats. Observations of tractor rear-wheel fender design across a wide range of years reveals an incremental progression from small and incomplete fenders that expose the operator to potential contact with large sections of

moving tractor wheels and tires to fenders that fully shield the operator from exposure to the tops and sides of the wheels and tire cleats. This progression is consistent with general machine guarding design principles that strive to prevent any portion of a worker's body from coming into contact with moving machinery components.

A wide front-end stance provides a tractor with greater stability and less risk of overturning. Properly maintained tractor tires help prevent loss of control, collisions, and overturns, which can result from a sudden tire failure while operating a tractor on a highway (Murphy, 1992).

ROPS Status

Students inspected the ROPS status of 152 tractors. Tractors equipped with commercial certified ROPS comprised 50.66% of the total, and those without such protection comprised 49.34%. The percentage of ROPS-equipped tractors in this sample is higher than Kentucky's estimated current 38% ROPS prevalence rate. This estimate is based on two large random sample surveys of Kentucky farms conducted in 1997 and again in 2000 as part of a ROPS promotion educational and social marketing campaign. A non-intervention control county was found to have a ROPS prevalence rate of 30% in 2000 with an annual ROPS-equipped tractor increment of 1.4% from 1997. Assuming the same annual increment of ROPS-equipped tractors in other Kentucky counties for the six years between 2000 and 2006 suggests an 8.4% increase in ROPS-equipped tractors that when added to the 2000 prevalence rate of 30% provides an estimate of 38.4% of ROPS-equipped tractors by 2006, or roughly 39% by the middle of 2007 (Myers et al., 2004). The 50.66% of ROPS-equipped tractors found in this study is likely a bias that resulted from instructing students to restrict their inspections to tractors that were used for highway travel.

Of those tractors with ROPS, 37% had a ROPS when purchased. An additional 1.97% (3 tractors) had commercial ROPS that had been modified (cut, re-welded, or drilled through) or homemade roll bars. Of the 50.66% of tractors with intact commercial ROPS, 21.71% had two-post ROPS and 28.95% cab-frame-type ROPS. However, 3.95% of the cab-frame-type ROPS tractors had doors that would not latch and/or were missing doors and windows. As a result, only 25.00% of the cab-frame tractors with four-post ROPS systems were completely intact and functional.

Seatbelt Status and Condition

A total of 153 tractors were inspected for their seatbelt status. Properly anchored seatbelts were in good condition, fully intact, functional, and equipped with retractors on 31.37% of the ROPS-equipped tractors. An additional 1.96% of the ROPS tractors had fully intact and functional seatbelts but without retractors. An additional 5.88% of ROPS tractors had non-retractable but properly anchored seatbelts, but the belts were twisted, oily, dirty, difficult to reach, and probably not used. An additional 1.31% had seatbelts with broken anchors or buckles. No seatbelt was present on 14.38% of the ROPS-equipped tractors, presumably having been removed.

Of the 49.34% of non-ROPS tractors, 45.10% had no seatbelts, a proper safety practice. However, 4.24% of the non-ROPS tractors were improperly equipped with a seat belt, a condition that greatly increases the likelihood of severe or fatal injury to the operator during an overturn.

Seat Type and Condition

The condition of the tractor seat was reported for 151 of the 153 tractors inspected. As noted earlier, even without a buckled seatbelt, a firmly anchored tractor seat with a back and armrests in good condition can help to protect the operator from falling from or being ejected from the tractor's operator compartment and run over. Seats equipped with backs and armrests were present on 68.87% of the tractors. However, 26.49% of these seats were in poor condition because of missing, crushed, or torn seat cushions and loose or damaged seat backs and armrests. Only 42.38% of the tractors had firmly anchored seats with backs and armrests that were undamaged, conditions that provide operators with support and stability that help prevent falls and ejections. Twisted, rusted, loose, and damaged seats were observed on 30.46% of the tractors, with older-type pan seats with no backs or armrests accounting for 78.40% of these damaged seats. Overall, pan seats were present on 23.8% of the 151 tractors. In addition, one tractor (0.65%) had a makeshift seat.

Rear Wheel Fenders

The presence and condition of rear wheel fenders were reported for 150 tractors. Fully intact and firmly secured rear wheel fenders that provide the operator with complete protection from the tops and sides of the tires were observed for 62.00% of these tractors. Securely mounted fenders in good condition that covered the tire tops, but that did not provide full side protection to the operator's lower legs and feet, were found on 10.00% of the tractors. In 1.33% of cases, the tractor fenders were the small fan type, leaving the entire top of the tractor tires exposed as well as exposing the operator's lower legs and feet to large mid-sections of the wheels and tires on both sides of the operator's platform. Another 16.00% of the tractors had fenders that were loose, bent, rusted, broken, or combinations of these four characteristics. Rear wheel fenders were missing on 10.67% of the tractors.

Tractor Tires

Tire condition was recorded for 150 tractors. Tires with little wear, square cleats, no cuts or dry rot cracks, and with only superficial small cuts and abrasions, were observed on 40.00% of the tractors. Tires with moderate wear, with well-defined cleats at the center of the tire and rounded cleat ends and a few cuts and abrasions, were found on 11.33% of the tractors. Tires with wear patterns including shallow, worn cleats still visible at the center of the tire and heavily worn and rounded cleat ends, usually accompanied by multiple cuts and abrasions and small dry rot cracks, were observed on 36.00% of the tractors. Badly worn tires with little tread and cleats barely visible at the center of the tire, with heavily rounded cleat ends, and with multiple dry rot cracks, cuts, and abrasions, were observed on 3.33% of the tractors. Tires that were very badly worn, with no tread visible at the center of the tire and with only nub-end remnants of the tire cleats, when combined with badly damage tires with deep dry rot cracks and cuts (sometimes exposing the inner tube) and multiple abrasions, were observed on 9.33% of the tractors.

Front Wheel Stance

Narrow (tricycle type) versus wide front-wheel stance was recorded for 149 tractors. Tractors with wide front-end stance accounted for 83.89% of the total, and tractors with narrow front-end stance for 16.11%.

Operator Tractor Runover, Entanglement, and Fall Prevention Features

When a faulty tractor ignition switch fails to engage the starter, rather than make repairs, farmers sometimes stand at the side of the tractor engine between the front and rear wheels. They then lift or remove the starter motor terminals shield and place a screwdriver blade or other conductor across the terminals. This activates the starter motor and starts the tractor engine. If the operator has forgotten to take the tractor out of gear, then the tractor immediately and rapidly moves ahead or backward and runs over the operator when the engine starts. Properly shielded starter motor terminals prevent by-pass starting injuries.

Dismounted operators who are inspecting or working around rotating drivelines can become entangled in the tractor PTO, resulting in severe or fatal injuries. A proper and well maintained master shield around the rotating PTO prevents entanglement injuries.

Many tractor-related injuries result from operators falling as they mount or dismount tractors. Older farmers in particular are at high risk for these types of injuries (Browning et al., 1998). Properly placed and well maintained access steps and handholds prevent falls and injuries.

Tractor Starter Terminal Shield

A total of 147 tractors were inspected for presence and condition of starter terminal shields and by-pass warning decals. Of the total tractors inspected, 36.73% had starter terminals that were fully shielded by a secured hard cover with clearly legible warning decals, or with starter terminals positioned to be inaccessible, a feature of some newer tractors. An additional 16.33% had terminals with secured hard covers but with degraded by-pass starting warning labels that were difficult to read. Soft rubber terminal covers (that can be pried up with a screwdriver) with clearly legible warning decals were present on 4.08% of the tractors. An additional 7.48% of the tractors had soft rubber terminal covers but had illegible or missing warning decals. For 37.37% of the tractors, the starter terminals were fully exposed with no terminal cover.

Tractor PTO Master Shield

Inspection for presence and condition of the PTO master shield was recorded for only 123 tractors. The missing data likely are related to the inappropriate inclusion of a PTO stub shaft shield feature along with the other five master shield features listed for this item. Stub shields were used on older tractors but are rarely present on older or newer tractors. Apparently the inclusion of this feature created confusion. Of the 149 tractors inspected, 26 (17.45%) were reported as having a stub shield. It is not clear what this rating means. However, students properly evaluated the remaining 123 tractors for the presence and condition of master shield components. Thus, the data reported are for these 123 tractors.

Tractors with master shields with all parts present and undamaged were observed on 29.27% of the 123 tractors. Tractors with master shields with all parts present, but with one or more parts bent, were found in 11.38% of the inspections. In 12.20% of the cases, all master shield components were present but were bent, cracked, loose, and provided little entanglement protection, particularly from the sides of the PTO. In 8.13% of the cases, key parts of the master shield were missing. In 39.02% of cases, the entire master shield was missing.

Tractor Access Steps and Handholds

A total of 150 tractors were inspected for presence and condition of access steps and handholds. Only 44.67% of the tractors inspected had access steps and handholds that were properly placed, fully intact, clean, and in good condition. In 15.33% of the cases, access steps and handholds were present and in good condition, but very muddy or greasy. Access steps were missing, bent, broken, placed too high, or obstructed on 17.33% of these tractors. A common obstruction was the presence of a front-end loader or other attachment with its support arms mounted on the tractor rear-wheel axle housing. Functional access steps but no handholds were observed on 13.33% of the tractors. In 9.33% of the cases, both access steps and handholds were present but bent, broken loose, rusted, or some combination of each of these four features.

Visual, Lighting, and Reflective Marking Safety System Features

Components of this system, when present and fully functional, make farm tractors and equipment more visible to other motor vehicle operators and facilitate the tractor operator's vision while driving on public roads, especially during periods of heavy traffic, low light, or bad weather. The combined effect is to lower the risk of highway collisions.

Standards for tractor lighting and marking vary widely across states. In addition, only 14 states have laws that regulate youth operation of farm tractors. The majority of states, including Kentucky, have no laws limiting the age of tractor drivers (Doty and Marlenga, 2006). Kentucky statutes allow unlicensed motor vehicle operators to operate farm tractors on public highways to transport farm equipment or products, provided the tractors and equipment do not exceed a width of 102 inches (KRS 189.2225; Kentucky Revised Statutes, 2008).

The American Society of Agricultural and Biological Engineers (*ASABE Standards*, 2008) has detailed tractor lighting and marking requirements with which all current U.S. tractor manufacturers comply. These include two properly functioning and mounted headlights, two red tail lamps, a minimum of two amber flashing lights visible from both front and rear, and turn signal lights with the one in the direction of the turn flashing and the one on the opposite side remaining steady. In addition, all tractors must have a properly positioned rear-mounted, clean, reflective slow-moving vehicle (SMV) emblem. Most late-model tractors have all these features. Tractors capable of highway speeds $\geq$25 mph must have two red stop lights as well (*ASABE Standards*, 2008).

During both day and night operation, all Kentucky tractors traveling on public highways must have an SMV emblem that is maintained in a clean and reflective condition and mounted at the rear center of the tractor with the bottom of the emblem three feet or more above the road (KRS 189.820; Kentucky Revised Statutes, 2008). However, as in many other states, lighting requirements for tractors are less stringent. All motor vehicles including tractors must have two head lamps, with one on each side of the vehicle (KRS 189.040; Kentucky Revised Statutes, 2008), and two red rear lights unless the vehicle was originally equipped with one such light (KRS 189.050; Kentucky Revised Statutes, 2008). When in operation between sunset and sunrise, all motor vehicles are to have forward and rear turn signals, but hand signals are allowed for older equipment not equipped with turn signals (KRS 189.380; Kentucky Revised Statutes, 2008). Two mirrors are required, one on the left side of the vehicle, and one

in the center or on the right side of the vehicle (KRS 189.130; Kentucky Revised Statutes, 2008).

Slow-Moving Vehicle Emblem

A total of 151 tractors were inspected for presence and condition of their SMV emblems. Bright, clean, and properly mounted emblems were observed on 25.83% of the tractors. Clean but faded and improperly positioned emblems were found on 15.23% of the tractors. An additional 5.30% of the tractors had non-functional emblems that were dirty, faded, wrongly placed, insecurely mounted, broken, or combinations of these conditions. The SMV emblem was missing on 53.64% of the tractors.

Lighting

A total of 149 inspections were recorded for tractor headlights and taillights. Tractors with properly mounted, undamaged, clean, and fully functional head and tail lights comprised 40.94% of the sample. An additional 14.09% had lights that were intact and functional, but that were obstructed with mud and dirt. Lights that worked but that had cracked and broken lenses were observed on 6.04% of the tractors. One or more burned out or inoperable lights were observed on 14.77% of the tractors whose remaining lights were operable. Tractors with no operable headlights and taillights comprised 24.16% of the sample.

A total of 150 tractors were inspected for presence and condition of warning flashers and turn signals. In 32.00% of the cases, all flasher and turn signal lights were present and functioned correctly. An additional 8.00% of the tractors had flashers and turn signals that worked but lights that were loose or with cracked and broken lenses. Another 4.67% had operational flashers and turn signals but with damaged switches and frayed wires. Functional warning flashers but no turn signals were observed on 14.67% of the tractors. The remaining 40.66% of the tractors had no functional warning flashers or turn signals, 35.33% because they did not include this equipment and 5.34% of which were equipped with flashers or turn signals that did not work.

Mirrors

A total of 151 tractors were inspected for presence and condition of rearview mirrors. Rearview mirrors that were properly mounted, clean, and functional were found on only 19.87% of the tractors. Mirrors that were functional but dirty and/or difficult to adjust were found on 4.64% of the tractors. In 5.96% of the cases, mirrors were ineffective because they were broken or their mounting structures were bent or broken. A large majority (69.54%) of the tractors had no rearview mirrors.

Discussion

The project limitations and its potential impact are discussed in this section.

Limitations

The county high schools were not randomly selected. Rather, four schools that were known to have effective FFA programs were selected from a larger random sample of Kentucky rural county high schools. Thus, the study results may be not be generalizable to other counties and states. However, the tractors inspected and the results of the inspections are likely representative of tractors that travel public highways in these counties. The results also suggest that a large proportion of these tractors have

safety feature deficiencies that increase the risk of tractor operator injuries, as well as injuries to occupants of other motor vehicles, during highway travel.

Another limitation is that, because human subjects protection procedures prohibited students from starting and operating tractors, the checklist omitted inspection of tractor steering, braking, and hydraulic systems, all three of which are critical for preventing loss of control that can result in overturns and highway collisions. Given that some of the teachers have now incorporated the use of the checklist with their annual agriculture tractor safety and tractor driving programs, the checklist needs to be revised to include these features. It also needs to be revised to correct the "stub shield" problem that confounded the inspection results for the tractor PTO master shield.

Potential Impact

Interventions aimed at educating rural youth about the risks of highway collisions between farm tractors and other motor vehicles have the potential to lower these types of injury events. Nearly all rural high school students presently drive or will in the near future be driving motor vehicles on highways shared by farm equipment. Many students with farming backgrounds also operate farm equipment on rural highways. Efforts that promote increased awareness of collision hazards between farm equipment and other motor vehicles, and the inspection of farm tractor features related to safe highway travel, may be beneficial to this at-risk population in two ways. First, the students involved may acquire attitudes and knowledge that help them to prevent such events. Second, this population is the next generation of farm community adults, parents, and community leaders. Targeting FFA students in rural agricultural counties for such interventions may be particularly relevant because FFA chapters emphasize preparing both farming and non-farming youth for community leadership and service roles (FFA, 2008).

Based on observations of students, the students' project reports, and teachers' judgments, the project activities increased students' awareness of highway safety issues related to the presence of farm equipment and other motor vehicles traveling along rural highways, particularly for students not familiar with farming and tractors. Second, the project promoted dialog about these tractor safety issues with adult farmers and other community members. Third, it provided empirical data about the safety status of a non-random but representative sample of tractors that regularly travel public highways in four rural Kentucky agricultural counties. Fourth, it provided the teachers and future students with a worthwhile community service project.

Students presented their tractor safety inspection findings as poster and oral presentations both within their schools and at community and at regional events that included Agricultural Council Meetings whose membership include farmers, farm business, farm service organizations, health professionals, and agricultural extension program personnel. Students also presented their findings at community-wide safety day camps.

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