Operational Characteristics of Tractors Driven by Children on Farms in the United States and Canada

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ABSTRACT. *Farm tractors are an important source of traumatic injury for children on farms. There is, however, no documentation about the age and size of tractors that children are operating and little information about the frequency with which rollover protective structures (ROPS) are used. This study described tractors that children on farms in the U.S. and Canada were operating by age, horsepower, and the presence of ROPS, according to the age and gender of the farm children involved. As a sub-analysis of data compiled during a randomized controlled trial, a descriptive analysis was completed on work exposure data collected by telephone interview. Of the 1,113 children involved in the trial, 522 (47%) were reported to perform at least one job that involved the operation of a farm tractor, and 408 (36.7%) were operating tractors of at least 20 horsepower. The majority of these children were male. There was a wide range of ages and sizes of tractors operated. However, the majority of tractors were between 20 and 70 horsepower and manufactured after 1970. Nearly one-half of the tractors were equipped with ROPS, and these tended to be newer and larger tractors. This analysis provides new data about the broad range of tractors driven by farm children in the U.S. and Canada. The findings point to a need to re-examine the reliance on a single voluntary standard to mitigate the hazard of tractor rollovers and the need for an enhanced safety policy requiring all tractors operated by children be equipped with ROPS.*

Keywords. *Agriculture, Children, Farm, Tractors, Work, Youth.*

Farm tractors account for the majority of fatal injuries to working youth on farms in the U.S. and Canada (Castillo et al., 1999; Hard et al., 1999; Pickett et al., 1999). Tractors are also an important source of non-fatal trauma (Pickett et al., 1995, 2001) and therefore remain a leading occupational priority for childhood agricultural injury prevention efforts. To develop effective intervention strategies, a clear understanding of the nature and scope of occupational exposures to farm tractors is necessary.

Children on farms begin to operate tractors at a very young age (Aherin and Todd, 1989; Browning et al., 2001; Hawk et al., 1994; Freeman et al., 1998; Marlenga et al.,

Article was submitted for review in February 2003; approved for publication by the Journal of Agricultural Safety and Health of ASAE in September 2003.

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  ISSN 1074-7583

2001a, 2001b), and male children are much more likely to operate tractors than females (Aherin and Todd, 1989; Browning et al., 2001; Hawk et al., 1994; Marlenga et al., 2001a, 2001b). Farm tasks that involve the operation of tractors by children have been documented elsewhere (Aherin and Todd, 1989; Browning et al., 2001; Marlenga et al., 2001a, 2001b), as has the amount of time that children are driving tractors (Browning et al., 2001) and the frequency with which rollover protective structures (ROPS) are used (Aherin and Todd, 1989; Browning et al., 2001; Schulman et al., 1997). However, the existing body of literature contains no documentation on the characteristics of tractors that children are operating. This basic information is required to estimate the level of hazard associated with tractors being operated by children and the requisite levels of skill/ability needed to operate tractors safely.

In the present analysis, we examined operational characteristics of the tractors driven by children on 450 farms in the U.S. and Canada. These data were collected during the course of a multi-site, randomized controlled trial conducted in order to evaluate an enhanced approach to the dissemination of the *North American Guidelines for Children's Agricultural Tasks* (NAGCAT). Results from this trial are published elsewhere (Marlenga et al., 2002). We asked participating farm parents to report up to two tractor jobs that each child on the farm (age 7-16 years) performed most often during the summer months of July and August. Tractor exposure data were analyzed with the objectives of: (1) describing the tractors that children operated most commonly by age, horsepower, and the presence/absence of ROPS, (2) describing these operational features of tractors and whether they varied according to the age and gender of the farm children, and (3) identifying salient implications for the prevention of farm tractor injuries.

Methods

Sample

The farms and children under study were from Canada and the U.S. In Ontario, Canada, farms were identified from the Central Farm Registrar maintained by Statistics Canada and the APC Farming Database, a commercially available mailing list. In the U.S., a subset of farms with children age 7-16 years was identified from the USDA master sampling frame for a 1998 national childhood injury survey (Myers and Hendricks, 2001).

During enrollment, a total of 2,500 farms from the Central Farm Registrar and 1,275 farms from the APC Farming Database were sent a letter of invitation to participate in a study to evaluate a new childhood farm safety resource (NAGCAT). Representatives from 214 Ontario farms were enrolled. Using the Canadian Census of Agriculture for comparison, participating farms were found to be representative geographically by region; however, dairy operations and larger farms were over-represented (data not shown) (Marlenga et al., 2002). In the U.S., 1,873 farms from midwestern states and 1,689 from western states were potentially eligible and invited to participate. Representatives from 11 western (N = 115 farms) and 12 midwestern states (N = 169) agreed to participate and were enrolled. Participating farms were compared to the sample frame with respect to location, acreage, and primary commodity and were found to be quite representative; however, dairy operations were somewhat over-represented in the midwestern sample (data not shown) (Marlenga et al., 2002).

A total of 498 farms participated, and 450 (90%) completed a telephone interview at 15 months post-intervention. The farms were located in Ontario, Canada

(210 farms), the midwestern U.S. (12 states, 146 farms) and the western U.S. (11 states, 94 farms). The 15-month interview was conducted during the fall of 2000 by trained interviewers in each region. It involved farm parents answering a series of questions about the tractors operated most often during July and August 2000 by each child on the farm. Responses were compiled using an open-ended format. Interviewers probed, in a structured manner, for a clear explanation about what the job entailed, how the work was done, the age of the tractor that was used, its horsepower, the presence or absence of a ROPS, and whether a power take-off (PTO) was employed during the tractor job.

Statistical Analysis

The primary data in this article relate to jobs performed by children involving tractors of at least 20 horsepower (the minimum horsepower traditionally associated with ROPS and seatbelts). For each child working on the farm, parents reported up to two tractor jobs that the child did most often during July and August. To be included in the analyses presented here, the information provided was required to include characteristics of both the child (age and gender) and the tractor (age, horsepower, and presence of ROPS). If two tractor jobs were reported for a child, the characteristics of the first reported job were used for analysis. Comparisons by job (not reported here) showed no systematic differences between the two jobs in such cases.

Analyses focus on descriptions of the children reported to use tractors and characteristics of the tractors they use. The farm sample upon which these results are based was observed to be quite representative of large regions of the U.S. and Canada (Marlenga et al., 2002) but was not designed with the evaluation of tractor characteristics as a primary aim. In addition, the tractors that parents have children use are inherently limited by the (generally) small number of tractors available to them.

Results

Table 1 describes the 450 farms by region and primary commodity, as well as the subset of farms where children were operating tractors of at least 20 horsepower. Dairy, grain, and other livestock were the leading commodities produced on these farms. The median acreage of the farm was 300 (range 2 to 30,000) acres. Table 1 further describes the children age 7-16 years by age group and gender. The majority of children working on these farms were male. A total of 522 (47%) children were reported to perform at least one job that involved the operation of a farm tractor, and 408 (36.7%) were operating tractors that were at least 20 horsepower. The remainder of this article will focus on the 408 children operating tractors of at least 20 horsepower.

There were wide ranges of ages and sizes of tractors operated by children (table 2). Approximately one-half of these tractors were equipped with ROPS, and ROPS tended to be present on newer and larger tractors (table 3). Nearly three-quarters of the tractors manufactured in 1985 or later were equipped with ROPS, while less than one-quarter of the tractors manufactured before 1970 were similarly equipped.

The demographic characteristics of the children operating tractors were seen to vary with both the age of the tractors operated (table 4) and with the tractor size (table 5). Male children and older children were more likely to be driving newer tractors and larger tractors. Irrespective of age or gender, substantial numbers of children were operating large tractors.

The presence of ROPS on tractors operated by children is further described in table 6. When considering all tractors, older children more often operated a tractor with ROPS, as did male children. However, these findings also reflect the age and

horsepower of these same tractors. As shown on the right side of table 6, the presence of ROPS is quite similar by age and gender when considering only tractors over 70 horsepower.

Table 1. Description of study sample.

	Total		Subset: Children Operating Tractors with ≥20 hp[a] (July-August 2000)	
Factor	*N*	%	*N*	%
Farms	450		258	
Primary commodity				
Dairy	111	24.7	75	29.1
Hogs	28	6.2	17	6.6
Other livestock	103	22.9	50	19.4
Poultry	9	2.0	6	2.3
Grain	107	23.8	62	24.0
Other field crops	38	8.4	18	7.0
Fruit	19	4.2	9	3.5
Vegetables	8	1.8	5	1.9
Other	27	6.0	16	6.2
Region of North America				
Ontario, Canada	210	46.7	118	45.7
Midwestern U.S.	146	32.4	87	33.7
Western U.S.	94	20.9	53	20.5
Farm children (7-16 years)	1,113		408	
Age (years)				
7-9	149	13.4	18	4.4
10-11	184	16.5	45	11.0
12-13	263	23.6	90	22.1
14	139	12.5	65	15.9
15	178	16.0	94	23.0
16	195	17.5	96	23.5
Unknown	5	0.4		
Gender				
Male	696	62.5	318	77.9
Female	417	37.5	90	22.1

[a] The subgroup of tractors with ≥20 horsepower was also required to have information on the tractor age and rollover protective structures (ROPS).

Table 2. Description of tractors operated by children by age, horsepower, and presence of rollover protective structures (ROPS).

Factor	Frequency		ROPS (Row) %
	N	%	
Age of tractor (years)			
0-4	59	14.5	84.7
5-9	57	14.0	68.4
10-14	50	12.3	70.0
15-19	36	8.8	44.4
20-24	76	18.6	40.8
25-29	39	9.6	25.6
30-34	45	11.0	33.3
35-39	12	2.9	16.7
40-44	17	4.2	17.6
45-49	7	1.7	0.0
≥50	10	2.5	0.0
Horsepower			
20-29	30	7.4	30.0
30-39	28	6.9	14.3
40-49	37	9.1	37.8
50-59	72	17.6	34.7
60-69	64	15.7	37.5
70-79	41	10.0	61.0
80-89	31	7.6	61.3
90-99	22	5.4	59.1
100-139	50	12.3	74.0
140-199	22	5.4	90.9
≥200	11	2.7	100.0
Total	408	100	49.3

Table 3. Percentage of tractors with rollover protective structures (ROPS) operated by children by tractor age and horsepower.

	20 to 70 hp		71 to 120 hp		>120 hp		Combined	
	N	% ROPS	*N*	% ROPS	*N*	% ROPS	*N*	% ROPS
1985 and newer	108	63.0	52	84.6	24	79.2	184	71.2
1970-1984	98	17.3	39	48.7	25	84.0	162	35.2
Pre-1970	50	12.0	8	62.5	4	50.0	62	21.0
Combined	256	35.5	99	68.7	53	79.2	408	49.3

Table 4. Age and gender of children operating tractors by age of tractor.

	Age of Tractor						
	1985 and Newer		1970-1984		Pre-1970		
Factor	*N*	%	*N*	%	*N*	%	Total
Age of child (years)							
7-11	23	36.5	27	42.9	13	20.6	63
12-13	38	42.2	38	42.2	14	15.6	90
14	28	43.1	29	44.6	8	12.3	65
15	50	53.2	26	27.7	18	19.1	94
16	45	46.9	42	43.8	9	9.4	96
Gender							
Male	155	48.7	118	37.1	45	14.2	318
Female	29	32.2	44	48.9	17	18.9	90

Table 5. Age and gender of children operating tractors by horsepower of tractor.

	Horsepower of Tractor						
	20 to 70 hp		71 to 120 hp		>120 hp		
Factor	*N*	%	*N*	%	*N*	%	Total
Age of child (years)							
7-11	39	61.9	16	25.4	8	12.7	63
12-13	60	66.7	17	18.9	13	14.4	90
14	47	72.3	14	21.5	4	6.2	65
15	57	60.6	27	28.7	10	10.6	94
16	53	55.2	25	26.0	18	18.8	96
Gender							
Male	190	59.7	84	26.4	44	13.8	318
Female	66	73.3	15	16.7	9	10.0	90

Table 6. Age and gender of children operating tractors by presence of rollover protective structures (ROPS)

	All Tractors		Tractors >70 horsepower	
Factor	*N*	% with ROPS	*N*	% with ROPS
Age of child (years)				
7-11	63	41.3	24	70.8
12-13	90	46.7	30	70.0
14	65	49.2	18	61.1
15	94	52.1	37	81.1
16	96	54.2	43	72.1
Gender				
Male	318	53.8	128	72.7
Female	90	33.3	24	70.8

Discussion

This study involved a secondary analysis of data collected during a randomized controlled trial. Our findings show that there is great variability in the types of tractors assigned to children of different ages. Males are clearly more frequently exposed to farm tractor work. In addition, there is variability in the use of ROPS by age of tractor (ROPS more frequent on newer tractors) and size of tractor (ROPS more frequent on larger tractors). Our data (tables 2 and 3) suggest that the presence of ROPS on tractors has risen substantially since the adoption of the 1985 ASAE voluntary standard for inclusion of ROPS as standard equipment on all tractors over 20 horsepower manufactured in the U.S. and Canada (*ASAE Standards*, 1985), yet less than half of the tractors operated by children in our study were equipped with ROPS.

Consistent with other studies, we found that children are operating tractors at a young age and that male children are more often operating tractors than female children. However, to our knowledge, this is the first published report in the peer-reviewed literature to describe the ages and sizes of tractors operated by children.

Several reports document the percentages of children driving ROPS-equipped tractors. These percentages varied from 10.5% to 50% (Aherin and Todd, 1989; Browning et al., 2001; Schulman et al., 1997). In the absence of information on the ages and sizes of tractors, it is difficult to compare these findings with our own, due to the strong association we identified between ages and sizes of tractors and the presence of ROPS.

The underlying reasons for the patterns observed in this study are multi-faceted. Speculatively, many parents are likely to make decisions about which tractor a child will use for farm work based on the size and age of the child, the size of the tractor, and the job to be done rather than whether or not the tractor is equipped with safety features such as ROPS. For example, our findings suggest that younger tractor operators are differentially assigned to work on smaller tractors that are less likely to be equipped with ROPS. Further, the cost of retrofitting a tractor with ROPS or replacing an older tractor may be a factor in parents' decision-making regarding safety. An income gradient has been demonstrated with respect to children operating tractors that were ROPS equipped (Browning et al., 2001). Farmers with lower incomes had fewer children operating tractors equipped with ROPS.

We do not have a complete tractor inventory for the farms in our study and therefore cannot verify or refute selective utilization. However, one report in the literature examined tractor ownership on farms in the U.S. in 1993 and made a 10-year projection of the numbers of tractors, the age of tractors, and the percent of tractors with ROPS that would be on farms in 2003 (Myers and Snyder, 1995). These investigators projected a percentage of tractors with ROPS that is virtually the same as the percentage of children we observed using tractors with ROPS (49% vs. 49.3%). However, the investigators projected a substantially lower percentage of newer tractors than we observed among children using tractors (20% vs. 41% for tractors 0-14 years old).

Our findings have implications for the study and prevention of tractor injuries involving children. More comprehensive exposure data are required in order to describe the exact conditions of childhood tractor operation and typical durations of these tractor work exposures. Ongoing surveillance of tractors and associated safety features is warranted, in addition to ongoing surveillance of children and the tractor work that they are performing. Further, there is need for enhanced safety policies that challenge the acceptability of permitting children to operate farm tractors that are not equipped with ROPS. These policies should also articulate the minimum ages and associated developmental abilities required for tractor operation.

Strengths and Limitations

This study represents a novel analysis using a large and geographically diverse sample of farm children, and it addresses an important injury prevention priority. However, several limitations must be acknowledged. This study was based on data from farm parents who volunteered to participate in a randomized controlled trial and thus may not provide a fully representative sample. Furthermore, the study was not designed with the evaluation of tractor characteristics as a primary aim and may not be large enough to adequately represent the true mix of tractors used by boys and girls of various ages. We expect that our findings may overestimate the presence of ROPS on farm tractors, as farms that volunteered are more likely to take safety precautions than non-participants.

There is a seasonal bias to our data that warrants recognition. We asked parents about the children's "most common tractor jobs during July and August" because: (1) these are the most active times for fieldwork for most farm operations and farm children, (2) it provided a focused time period to promote accuracy of recall, and (3) we wanted to focus on tractor jobs where children had the most exposure. Therefore our findings reflect a predominance of cutting, raking, baling, and transporting hay. Different ages and sizes of tractors may be used for spring tillage and planting, as well as fall harvesting, and we did not capture these tractor operations in our study.

Conclusion

Regardless of the reasons behind parental decision-making surrounding the assignment of children to farm tractor work, substantial numbers of children are put at risk (50% in our study), and there is also differential exposure to risk by age and gender of the children involved. Despite the apparent positive impact of the 1985 ASAE standard, these data show that relying only on a single voluntary system is insufficient to protect many farm children from the hazard of tractor overturns. It may be time to adopt and/or legislate the standard suggested by the American Academy of Pediatrics (2001) in their policy statement, "Prevention of Agricultural Injuries Among Children and Adolescents" and reinforced by the recommendations of NAGCAT (Lee and Marlenga, 1999). Both suggest that children should be restricted from operating any tractor that is not equipped with ROPS and a seatbelt.

Acknowledgements

The authors thank the primary advisors of the *North American Guidelines for Children's Agricultural Tasks* (NAGCAT). Dr. William Steinke was initially a co-investigator on this project but withdrew for personal reasons. We thank Jim Linneman for assistance with database management and quality assurance; Kathi Hartle, Juanita Herr, Debbie Hilgemann, Deb Kempf (Marshfield), and Deborah Emerton (Ontario) for data collection efforts; and Tracy Jakobi for administrative support. We also thank the Marshfield Clinic Research Foundation for its support through the assistance of Alice Stargardt in the preparation of this manuscript.

This research was sponsored by the Centers for Disease Control and Prevention R01 CCR515576-03 and the Ontario Ministry of Health and Long-term Care, via a Career Scientist Award to Dr. William Pickett.

References

Aherin, R. A., and C. M. Todd. 1989. Accident risk taking behavior and injury experience of farm youth. ASAE Paper No. 895530. St. Joseph, Mich.: ASAE.

American Academy of Pediatrics. 2001. Prevention of agricultural injuries among children and adolescents. *Pediatrics* 108(4): 1016-1019.

ASAE Standards, 32nd ed. 1985. S318.10: Tractor roll-over protection. St. Joseph, Mich.: ASAE.

Browning, S. R., S. C. Westneat, and R. Szeluga. 2001. Tractor driving among Kentucky farm youth: Results from the farm family health and hazard surveillance project. *J. Agric. Safety and Health* 7(3): 155-167.

Castillo, D. N., N. Adekoya, and J. R. Myers. 1999. Fatal work-related injuries in the agricultural production and services sector among youth in the United States, 1992-96. *J. Agromedicine* 6(3): 27-41.

Freeman, S. A., S. D. Whitman, and R. L. Tormoehlen. 1998. Baseline childhood farm safety data for Indiana. *J. Agric. Safety and Health* 4(2): 119-130.

Hard, D., J. Myers, K. Snyder, V. Casini, L. Morton, R. Cianfrocco, and J. Fields. 1999. Young workers at risk when working in agricultural production. *American J. Ind. Med.* Suppl. 1: 31-33.

Hawk, C., K. J. Donham, and J. Gay. 1994. Pediatric exposure to agricultural machinery: Implications for primary prevention. *J. Agromedicine* 1(1): 57-74.

Lee, B., and B. Marlenga, eds. 1999. *Professional Resource Manual: North American Guidelines for Children's Agricultural Tasks.* Marshfield, Wisc.: Marshfield Clinic.

Marlenga, B., W. Pickett, and R. L. Berg. 2001a. Agricultural work activities reported for children and youth on 498 North American farms. *J. Agric. Safety and Health* 7(4): 241-252.

Marlenga, B., W. Pickett, and R. L. Berg. 2001b. Assignment of work involving farm tractors to children on North American farms. *American J. Ind. Med.* 40(1): 15-22.

Marlenga, B., W. Pickett, and R. L. Berg. 2002. Evaluation of an enhanced approach to the dissemination of the North American Guidelines for Children's Agricultural Tasks: A randomized controlled trial. *Prev. Med.* 35(2): 150-159.

Myers, J. R., and K. J. Hendricks. 2001. Injuries among youth on farms in the United States, 1998. DHHS (NIOSH) Publication No. 2001-154. Cincinnati, Ohio: National Institute for Occupational Safety and Health.

Myers, J. R., and K. A. Snyder. 1995. Roll-over protective structure use and the cost of retrofitting tractors in the United States, 1993. *J. Agric. Safety and Health* 1(3): 185-197.

Pickett, W., R. J. Brison, and J. R. Hoey. 1995. Fatal and hospitalized agricultural machinery injuries to children in Ontario, Canada. *Injury Prev.* 1(2): 97-102.

Pickett, W., L. Hartling, R. J. Brison, and J. R. Guernsey. 1999. Fatal work-related farm injuries in Canada, 1991-1995. Canadian Agricultural Injury Surveillance Program. *CMAJ* 160(13): 1843-1848.

Pickett, W., L. Hartling, H. Dimich-Ward, J. R. Guernsey, L. Hagel, D. C. Voaklander, and R. J. Brison. 2001. Surveillance of hospitalized farm injuries in Canada. *Injury Prev.* 7(2): 123-128.

Schulman, M. D., C. T. Evensen, C. W. Runyan, L. R. Cohen, and K. A. Dunn. 1997. Farm work is dangerous for teens: Agricultural hazards and injuries among North Carolina teens. *J. Rural Health* 13(4): 295-305.