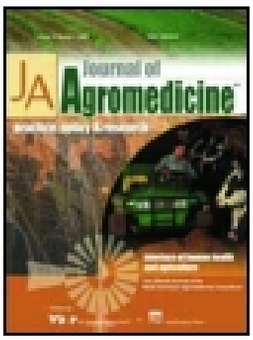

Journal of Agromedicine

ISSN: 1059-924X (Print) 1545-0813 (Online) Journal homepage: http://www.tandfonline.com/loi/wagr20

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To cite this article: Henry P. Cole EdD , Robert H. McKnight MPH ScD & Teresa A. Donovan MPH (2009) Epidemiology, Surveillance, and Prevention of Farm Tractor Overturn Fatalities, Journal of Agromedicine, 14:2, 164-171, DOI: 10.1080/10599240902805991

To link to this article: https://doi.org/10.1080/10599240902805991

Published online: 12 May 2009.

Journal of Agromedicine, 14:164–171, 2009

ISSN: 1059-924X print/1545-0813 online
DOI: 10.1080/10599240902805991

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Epidemiology, Surveillance, and Prevention of Farm Tractor Overturn Fatalities

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ABSTRACT. Census of Fatal Occupational Injuries data identify six states within or near the Appalachian mountain range that have the highest rates of agricultural tractor overturn deaths within the United States. Demographic and economic data that characterize farms in these six states were compiled from U.S. Department of Agriculture (USDA) 2002 Census of Agriculture files. Regional geological and geographic data were examined to identify topographic features within the six states. In combination, these data suggest that a majority of farms in these states are small acreage livestock operations, located on terrain with steep slopes, with annual value of sales <$10,000 a year, total equipment valued at <$20,000, with low prevalence of tractors with rollover protective structures (ROPS), and operators who work at off-farm jobs >200 days per year. Variations in these variables across the six states are examined as compared to the pooled values for all six states, and as compared to the pooled values for all U.S. farms. Surveillance methods for identifying, targeting, and implementing ROPS-promotion efforts within these states are described.

KEYWORDS. Demographics, economics, farm, fatalities, tractor-overturn

INTRODUCTION

Overturns of agricultural tractors without rollover protective structures (ROPS) are the leading cause of farm fatalities in the United States.[1] The 2004 National Agricultural Tractor Safety Initiative developed by the 10 National Institute for Occupational Safety and Health (NIOSH) regional Agricultural Safety and Health Centers is a collaborative effort to prevent these fatalities by equipping tractors with rollover protective structures (ROPS).[1] A subsequent NIOSH

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Preparation of this article was supported in part by CDC/NIOSH Cooperative Agreement 5 U50 OH007547-07, Southeast Center for Agricultural Health and Injury Prevention, University of Kentucky College of Public Health.

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analysis of Census of Fatal Occupational Injuries (CFOI) 1992–2004 data identified a cluster of six states within or near the Appalachian mountain region (Illinois, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia) with tractor overturn fatality rates >9.8/100,000 workers/year and seven adjacent states with overturn fatality rates of 5.0–9.8/100,000 (Figure 1).[2]

METHODS

Farm demographic and economic numerical data from the U.S. Department of Agriculture (USDA) 2002 Census of Agriculture Table 1, State Summary Highlights,[3] and Table 38, Machinery and Equipment on Operation,[4] were entered into Excel spreadsheets for the United States and for each of the six target states. The USDA raw numerical values for each variable for each state were then used to calculate the percentage values of selected demographic and economic variables (1) for farms pooled across the six target states compared to all U.S. farms and (2) for each of the six target states compared to all U.S. farms (see Table 1).

Density plots of key economic and demographic variables were accessed from the 2002 Census of Agriculture Maps and Cartographic Resources Map Index, pages 1 to 7.[5]

Because the density plots provide data at the county level, they provide visual information about the distribution of the variables across and within the six target states.[6]

RESULTS

Column 1 in Part 1 of Table 1 lists the seven demographic and economic variables extracted from the 2002 USDA data. Columns 2 and 4 list, respectively, the variable values for all U.S. farms and for the six target states pooled. Columns 3 and 5 report the corresponding percentage values. The bold values in the last column of Table 1, Part 1, reveal that the farms in these six states collectively account for only 8.39% of U.S. farmland. Yet for each of the remaining six variables listed, these six states account for 18.08% to 21.27% of the U.S. total values.

The second part of Table 1 compares the percentage of farms in each of the six states to the percentage of all U.S. farms across the four key economic variables listed in column one. The bold numbers identify those states that have high proportions of economic variables

FIGURE 1. Tractor overturn fatality rates (deaths/100,000 workers/year) in production agriculture, 1992–2004. (Compiled for NIOSH by John Myers, March 2007. Fatality rates were calculated by using CFOI data. Rates provided by the Bureau of Labor Statistics may differ.)

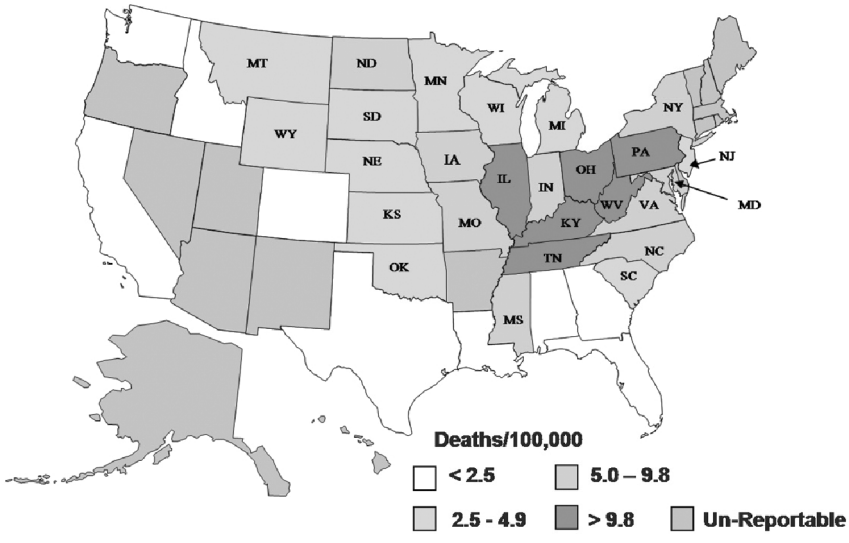


TABLE 1. Seven Key Demographic and Economic Values for the Six Target States Compared to U.S. Values

Part 1—Number and percentage of farms in the six target states pooled compared to U.S. totals

Farm variables (number)	U.S. Total	U.S. % of Total	Six State Total	Six State % of U.S. Total
Acres of farmland	938,279,056	100.00	78,749,531	**8.39**
Farms*	2,128,982	100.00	403,877	**18.97**
Tractors**	4,157,327	100.00	823,995	**19.82**
Farms <180 acres	1,401,823	65.84	298,145	**21.27**
(AVS)[$] <$10,000	1,263,052	59.33	256,642	**20.32**
Operator off-farm job >200 days/year	832,348	39.10	167,408	**20.11**
Total equipment <$20,000	974,323	47.47	176,114	**18.08**

Part 2—Number and percentage of farms by four economic variables for each of the six states compared to all U.S. farms

Variable	*IL*	**KY**	OH	PA	**TN**	**WV**	US
Number of farms	*73,027*	**86,541**	77,797	58,105	**87,595**	**20,812**	2,128,982
% Farms <180 acres	*54.31*	**77.11**	**74.76**	**79.83**	**82.71**	**72.12**	65.84
% Farms AVS <$10,000	*41.44*	**67.32**	61.23	60.94	**77.53**	**82.47**	59.33
% Operators off-farm work >200 days/year	*36.42*	**42.21**	**44.52**	37.45	**44.26**	**43.76**	39.10
% Farms with total equipment <$20,000	*33.23*	**51.00**	46.77	42.36	**66.03**	**58.46**	47.47

*U.S. farms denominator = 2,128,982.
**U.S. farm tractors denominator = 2,052,348.
[$]AVS = Annual value of sales in U.S. dollars.
Source: 2002 Census of Agriculture, Table 1, State Summary Highlights, pp. 227–235.

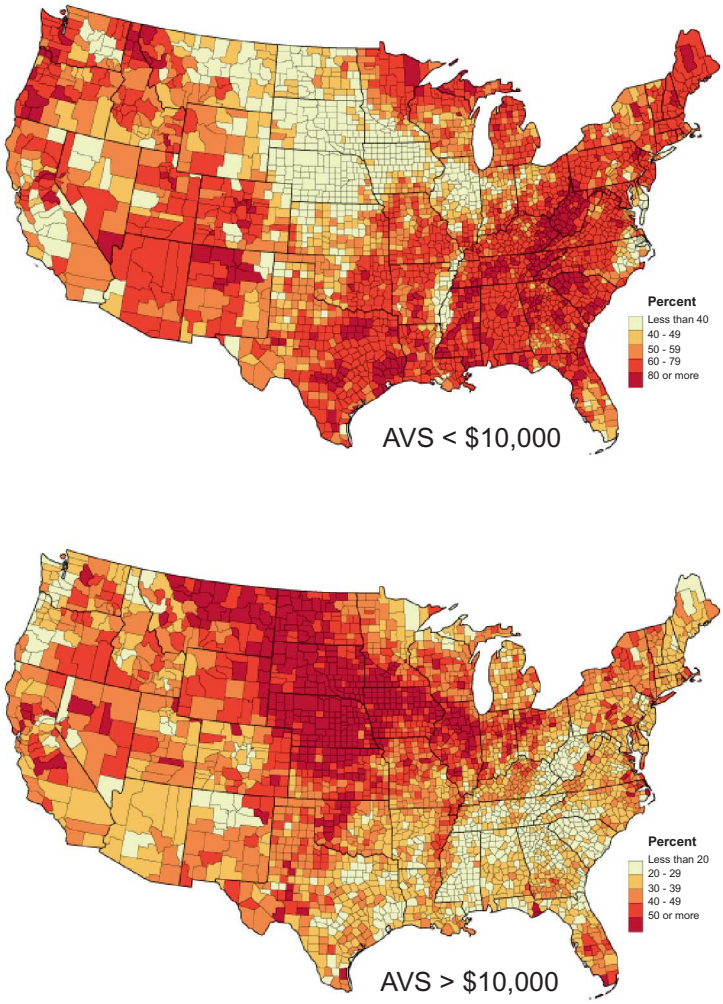
that place them at increased risk for tractor-overturn injuries: Small farms, low annual value of sales (AVS), operators who work at off-farm jobs >200 days/year, and total value of tractors and all other equipment valued <$20,000. These types of farms are at increased risk of tractor overturns because they typically (1) operate older tractors without ROPS,[7] (2) on marginal farmland with steep slopes dissected by winding and deeply entrenched streams,[8] and (3) frequently on small multiple farm plots that require tractor and farm equipment travel on narrow, winding, and hilly public roadways.[9]

The bolded values in Part 2 of Table 1 reveal that Kentucky, Tennessee, and West Virginia each have four risk factors that are substantially higher than the average values for all U.S. farms. Ohio has two of these risk factors and Pennsylvania one. Illinois is clearly an outlier. Its italicized values for all four of these variables are lower than the comparable U.S. values, and substantially lower than the values for the other five states.

The 2002 Census of Agriculture Cartographic Maps[5] provided information about the distribution of economic and demographic factors within these states' counties. For example, the top portion of Figure 2 reveals that 60% or more of nearly all counties in Kentucky and Tennessee have annual value of sales (AVS) <$10,000 and that a majority of counties in Pennsylvania also fall into this category. However, in Ohio, Illinois, and Indiana, this is the case only for those counties that are located along the western edge of the Appalachian mountain range.[8] In West Virginia, the most mountainous of the states in the region, 80% of counties have AVS <$10,000. The same pattern occurs in Pennsylvania, Virginia, North Carolina, and Tennessee for those counties located in central Appalachian mountain regions. The density plots in the lower portion of Figure 2 that identify those counties with AVS >$10,000 are the obverse of those in the upper portion.

Cartographic density maps for additional economic variables for the six states and their counties compared to other U.S. states and counties follow the same general pattern shown in Figure 1.[5] These maps reveal the (1) low proportion of farmers in specific counties within

FIGURE 2. Farms by state and county with annual value of sales <$10,000 and >$10,000. (*Source:* 2002 Census of Agriculture Maps and Cartographic Resources, map numbers 02-M009 and 02-M010. Available at http://www.nass.usda.gov/research/atlass02/.)



the six states that receive government payments, (2) high proportion of farm operators whose primary occupation is something other than farming, (3) high proportion of farm production income spent on equipment maintenance and repair, (4) high proportion of farms operated by full- as opposed to part-owners, and (5) the very high proportion (>75%) of farm acres harvested for forage. (USDA defines forage as grass, hay, silage, and green chopped vegetation.). This last characteristic is consistent with the predominance of beef cattle farming within these counties.[9] This type of agriculture requires frequent rotary mowing (bush hogging) of steep and difficult terrain to maintain pastures. In addition, farm tractors operate equipment used to till, seed, and harvest hay, corn, and silage, work that also occurs on steep slopes cut by deep winding ravines and streams.[8,9]

Data from 2002 Census of Agriculture tables and cartographic maps reveal that the distribution of the economic and demographic risk factors for older non-ROPS tractors is not uniform across or within these states. Nearly all counties in West Virginia, Kentucky, and Tennessee have large numbers of farms with low AVS.

The counties within these states with the highest risk factors for non-ROPS tractor overturn fatalities are located within the central portion of the Appalachian mountain chain that runs from the northeast to the southwest and has elevations of 2000 to 5000 feet, with local reliefs of 1600 feet and sometimes 3200 feet.[8,9] These mountainous areas consist of two basic types of landforms: (1) multiple over layering thrust faults that produce a series of steep escarpments and narrow V shaped valleys, and (2) large uplifted fault blocks and arches that are dissected by extensive networks of streams.[8,10] The result is a rugged terrain of hills and valleys with steep slopes.[9,10]

The geologic formations to the west of these mountains consist of highland plateaus and escarpments with elevations from 1000 to 2000 feet that also are deeply dissected by entrenched and winding rivers and their tributary streams. This creates reliefs of 200 to 500 feet.[8] In addition, five large regions of central and southern Kentucky's relatively flat to rolling farmland lie over thick limestone beds that contain one of the world's largest networks of underground caves and an abundance of small and large surface sink holes that connect to the caves. This pattern is referred to as karst topography. The karsts or sink holes have steeply sloped sides and often small limestone ledges or cliffs along the sides of larger sinks.[11,12] Thus, portions of relatively flat farmland with deeply entrenched streams and karst topography pose difficult steep slope challenges when operating farm equipment. West Virginia, Tennessee, and Ohio also have similar farmland regions.[11,12] In all six states, those areas with the most difficult terrain of entrenched streams, karsts, and steep slopes are the typically the most eroded, least expensive, and marginal farmland areas where small and limited resource farms tend to be located.[9]

DISCUSSION

Although the distribution of tractor overturn fatality rates for the states shown in Figure 1 is informative, it is unlikely that these fatalities are uniformly distributed within states. Rather, it is reasonable to suspect that high overturn fatality and injury rates within these states are associated with farms located in counties that have demographic, economic, and topographic characteristics like those described in Table 1 and the USDA cartographic maps.[5] These include small acreage farms located in difficult terrain,[9] with low AVS, low farm equipment value, a high prevalence of older non-ROPS tractors, and operators with primary occupations other than farming.[7]

Farming counties in other states that share these characteristics also may experience high rates of tractor overturn fatalities and injuries.[7] For example, a recent study used data from the NIOSH Occupational Injury Surveillance of Production Agriculture 2001 and 2004 national surveys to identify the prevalence of ROPS-equipped tractors. For all U.S. farms pooled the prevalence of ROPS tractors is 51%, but for limited resource farms with part-time operators with annual value of sales <$10,000, only 34%.

Based on the information reported in this paper, four types of surveillance activities may be critical for advancing the National Agricultural Tractor Safety Initiative.

A first surveillance activity is to gather and combine farm demographic, economic, and topographic data. This begins with examining USDA Census of Agriculture county-level data and profiles to identify specific regions within states with high proportions of limited resource farms with economic risk factors for tractor overturn injuries. U.S. Geological Survey maps for the same counties can then be examined to determine the prevalence and location of topographic risk factors for tractor overturns. U.S. Census population data can be used to determine the total number and proportion of county residents employed in agricultural and nonagricultural industries and occupations, as well as stratified by age category, household income, educational level, home ownership rates, and other economic variables.

A second surveillance activity is to identify fatal, nonfatal injury, and noninjury tractor overturn events within the counties identified in the previous step. It is important to collect data for three types of tractor overturn injury outcomes to provide robust estimates of the prevalence of

overturns and their injury outcomes. For example, a Kentucky population-based study identified 443 non-ROPS tractor overturn events, 5.4% of which resulted in fatalities, 24.2% in nonfatal injuries (14.5% that were serious injuries), and 70.4% no or minor injuries. The comparable values for overturns of 92 ROPS-equipped tractors were 1.1% fatalities, 20.6% nonfatal injuries (only 4.3% that were serious injuries), and 78.3% with no or minor injuries.[13] The only ROPS tractor overturn fatality was to an unbelted operator who was ejected from the tractor during a roadway incident. Non-ROPS tractors accounted for 80.76% of the total overturns. This is related to two factors: (1) the large proportion of older non-ROPS tractors operating in Kentucky over the many years in which the reported overturns occurred; (2) the estimated statewide 38% of ROPS-equipped tractors at the time of the January 2001 survey.

Information about tractor overturn events can be collected from county agricultural extension and Farm Bureau offices, county and regional newspaper articles and archives, county and regional hospital emergency department records, and death certificates. Additional sources include local county fire departments and emergency medical services, county coroner offices, and sheriffs and other law enforcement officials. Members of these groups typically are involved in extrication, care and transportation of injured operators, and investigations of these incidents. Representatives from service and supply businesses that are in frequent contact with farmers usually are aware of both fatal and nonfatal tractor overturn events among the farms they serve.[14]

A third type of surveillance activity involves identifying and enlisting the help of county and regional stakeholders who may have an interest in preventing tractor overturn injuries to farmers and farm family members. For example, a successful randomized community trials ROPS-promotion project in Kentucky identified and enlisted a wide array of local stakeholders as advocates and activists for promoting farmers' obtaining ROPS-equipped tractors. Partners included county Farm Bureau and extension office leaders, and human resource and safety officers from local manufacturing plants who vigorously promoted adoption of ROPS among their workers, approximately 80% of whom were part-time farmers or farm family members.[15] Other partners included farm equipment and farm supply dealers, fire departments and local emergency medical services, county and regional hospitals, health service centers, health care providers, veterinarians, farm producer organizations, local newspapers, and radio stations.[14] These groups assisted with identifying and documenting fatal, nonfatal, and noninjury tractor overturns; developing, field testing, and disseminating a series of social marketing messages and educational materials that promoted ROPS and seatbelts;[16] raising and awarding local incentive funds to farmers for purchase of ROPS retrofit kits; and documenting the numbers of ROPS retrofits purchased prior to and during the 3-year intervention.[17]

A fourth type of surveillance involves locating potential funding sources for incentive funds to assist farmers to retrofit unguarded tractors with ROPS and seatbelts or to replace them with newer ROPS-equipped tractors. Prior studies in New York, Kentucky, and Virginia have shown that various combinations of incentive funds, social marketing messages, and community-based educational efforts are essential to increasing the number of farmers who install ROPS on unprotected tractors.

A project in New York State used a carefully developed ROPS retrofit social marketing campaign[18] in combination with $200,000 in incentive funds. Two years into the project, 538 farmers had retrofitted their tractors with ROPS and seatbelts with the help of rebates that paid for 70% of the cost of the ROPS, including shipping and installation.[19]

For 14 years, Virginia Farm Bureau conducted a statewide ROPS promotion and educational campaign with initial incentive fund awards of $100 and thereafter of $200. To date this effort has resulted in 394 ROPS retrofits.[20] A Kentucky community partners' ROPS promotion, social marketing, and educational campaign targeted two counties. One county raised a total of $750 and the second county a total of $2750 in local ROPS incentive funds. Both counties advertised these funds in local media and awarded them through public drawings during the last

2 years of the 3-year project. The combined effect of the educational, social marketing, and incentive fund drawings resulted in 81 ROPS retrofits of tractors in the two counties, even though only 17 farmers received an incentive award. Farm equipment dealer records revealed that in the year prior to the intervention, only four ROPS retrofits occurred in the two counties.[14]

Finding sources of incentive funds to assist farmers to obtain ROPS retrofit kits or to replace older unprotected tractors with newer ROPS-equipped tractors is challenging. Little attention has been directed to potential sources of philanthropic and private funding including for-profit corporations and non-profit foundations. The Web sites of major corporations can be searched under terms such as "community involvement," "global philanthropy," or "corporate contributions." Companies' corporate responsibility and review documents can be downloaded and examined. Most major private enterprises have similar information on their Web pages, including annual financial reports.

Information about foundations may be found through sources such as the Foundation Center (http://www.foundationcenter.org/), the Grantsmanship Center (http://www.tgci.com/), the Chronicle of Philanthropy (http://philanthropy.com/), the Philanthropy Roundtable (http://www.philanthropyroundtable.org/index.asp), and GuideStar (http://www.guidestar.org/). Regional sources of information should not be overlooked: e.g., Southeastern Council of Foundations (http://www.secf.org/s_secf/index.asp), Community Foundation of Central Georgia (http://www.cfcga.org/aboutus/aboutus_pages/communityfoundations.html).

Knowing prospective donors, their missions, policies, and history of charitable giving is essential. Proposals must be in keeping with the granting agency's goals, cogent, and convincing. One way to accomplish this is to gather the data from the first three surveillance activities described above and then organize and present this information in brief, factually accurate, and persuasive combinations of discourse and graphics. The presentations must clearly identify the problem, the at-risk target populations, their plights and needs, and the humanitarian and economic benefits of directing resources to address the needs and ameliorate the problem.

LIMITATIONS

Illinois, one of the six states with high rates of tractor overturn fatalities as reported by CFOI data (see Figure 1), has a profile of USDA economic variable values *not* related to increased risk of tractor overturns (see Table 1, Part 2). This anomaly may result from the aggregation of CFOI data at the state level. U.S. topographic maps reveal that southern Illinois is heavily dissected by a network of entrenched streams.[8] This region may have a concentration of limited resource farmers with older non-ROPS tractors resulting in high rates of overturn fatalities. Similar situations may exist in other states.

The USDA data in Table 1 reveal that while farms in the six states account for only about 8.4% of all U.S. farmland, collectively they account for nearly a fifth of all U.S. farms and farm tractors, and more than a fifth of small farms, with low AVS, and a large number of farm operators who work nearly full time at off-farm jobs. In combination, these data suggest the greatest burden of U.S. tractor overturn deaths lies within the six-state region. Surveillance and intervention efforts that target specific counties in these states that have large numbers of farms with risk factors for tractor overturn injuries and fatalities may lower the national burden of these preventable injuries.

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