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Prevalence of Alcohol Impairment and Odds of a Driver Injury or Fatality in On-Road Farm Equipment Crashes

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Abstract

Objective.—To estimate the prevalence of alcohol impairment in crashes involving farm equipment on public roadways and the effect of alcohol impairment on the odds of crash injury or fatality.

Methods.—On-road farm equipment crashes were collected from four Great Plains state Departments of Transportation during 2005–2010. Alcohol impairment was defined as an involved driver having blood alcohol content of ≥0.08g/100ml or a finding of alcohol-impaired as a driver contributing circumstance recorded on the police crash report. Injury or fatality was categorized as: a) no injury (no and possible injury combined), b) injury (non-incapacitating or incapacitating injury,) and c) fatality. Hierarchical multivariable logistic regression modeling, clustered on crash, was used to estimate the odds of an injury/fatality in crashes involving an alcohol-impaired driver.

Results.—During the five years under study, 3.1% (61 of 1971) of on-road farm equipment crashes involved an alcohol-impaired driver. One in twenty (5.6%) injury crashes and one in six (17.8%) fatality crashes involved an alcohol-impaired driver. The non-farm equipment driver was

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significantly more likely to be alcohol-impaired than the farm equipment driver (2.4% versus 1.1% respectively, p=0.0012). After controlling for covariates, crashes involving an alcohol-impaired driver had 3.94 (95% CI: 2.14–7.25) times the odds of an injury or fatality. In addition, the non-farm vehicle driver was at 2.49 (95% CI: 2.06–3.01) times higher odds of an injury or fatality than the farm vehicle driver. No differences in rurality of the crash site were found in the multivariable model.

Conclusion.—On-road farm equipment crashes involving alcohol result in greater odds of an injury or fatality. The risk of injury or fatality is higher among the non-farm equipment vehicle drivers who are also more likely to be alcohol-impaired. Further studies are needed to measure the impact of alcohol impairment in on-road farm equipment crashes.

Keywords

Agricultural equipment; Driving under the influence; Traffic accident; Occupational accident/injuries

INTRODUCTION

Motor vehicle crashes, a leading cause of injury and death in the US,[1] occur at 2.4 times higher rates in rural as compared to urban communities.[2] Rural settings pose a number of unique risk factors for crashing. First, rural roadways, in and of themselves, are hazardous for drivers due to poor roadway infrastructure and high travel speeds. Second, rural roadways are a common thoroughfare for farm equipment, which are slow moving vehicles that pose unique challenges to rural roadway drivers because of vehicle size and speed differentials. Third, risky drinking (defined as exceeding daily or weekly limits, or presence of an alcohol use disorder)[3] and risky driving behaviors (e.g., reduced seatbelt use, speeding)[4] are more prevalent in rural than urban/suburban areas. Each of these factors may contribute to increased rural roadway hazards. Notably, however, the National Highway Traffic Safety Administration 2014 data revealed equal (~31%) proportions of alcohol-impaired driving among rural versus urban traffic fatalities.[2]

Little is known about the role of alcohol-impaired driving among an often overlooked and understudied rural roadway use group, farm equipment operators. Previous research has suggested that 12% of farm equipment operators and 6% of those in crashes with farm equipment have a previous conviction for driving while intoxicated.[5] Alcohol-impaired crashes involve poor driver decision making and slow response to hazards.[6] This may be exacerbated when approaching farm equipment, due to a lack of experience interacting with such equipment, leading to misjudging the differences in the speed and size of farm equipment compared to passenger vehicles. Given that collisions with farm equipment are more likely to result in injury or fatality to the occupants of the other vehicle,[5,7,8] this is not just a farm safety issue, but rather a public health concern affecting all public roadway users. Because occupants of both farm and non-farm vehicles are at increased risk of injury or death when alcohol is involved in a crash, it is important to understand how alcohol impairment may affect injury and fatality risk among those involved in farm equipment crashes.

While we know about the configurations of these crashes, no study to date has examined the impact of an alcohol-impaired driver on the risk of an injury or fatality among on-road farm equipment crashes. Therefore, the objectives of this analysis were to examine the prevalence of alcohol-impaired driving among on-road farm equipment crashes, and to examine how the presence of alcohol impairment affects risk of a driver injury or fatality.

METHODS

Study Population

This analysis is part of a larger study to examine on-road farm equipment crashes among the nine states in the Great Plains region (Iowa, Illinois, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin). Data used for this analysis are from the Department of Transportation (DOT) crash records from four of the nine Great Plains states: Iowa, Missouri, North Dakota and South Dakota for the years of 2005 through 2010. Only crashes where the alcohol-impaired status of all the drivers involved in the crash was known were included in the analysis. The driver was identified from all occupants in a vehicle based on the DOT data element called seating position as a value of '1' or 'driver'. Other states were excluded because >75% of data on alcohol use were missing.

Data Definitions

Farm equipment was defined as tractors or other self-propelled equipment of husbandry, and a crash was considered to involve farm equipment if "farm equipment" was selected as the vehicle type on the DOT crash report by law enforcement.[9–12] A crash was considered on-road if it was included in the DOT data. Data on crash characteristics (manner of collision, time of day, lighting, day of the week, weather conditions, agricultural season of the year, multiple vehicles involved), both the farm equipment and the other vehicle driver (age, gender, driver contributing circumstances, injury severity), and vehicle characteristics (farm equipment or not, vehicle action) were included in this analysis. Driver age is presented as continuous and categorical (<34, 35–44, 45–54, 55+), manner of collision was defined in seven categories (non-collision, head-on, rear-end, angle-oncoming left turn, sideswipe same direction, sideswipe opposite direction, and other). The vast majority of crashes occurred on clear weather days, therefore, weather was dichotomized to clear or not clear. Time of day was categorized into six-hour blocks (midnight-5:59am, 6am-11:59am, 12pm-5:59am, 6pm-11:59pm), and the season of the crash was grouped based on agricultural seasons in the four states analyzed (January-March for Winter, April-May for Planting, June-August for Growing, and September-December for Harvest). Between the four states, there were 22 potential driver contributing circumstances that were combined into six categories: no contributing action, disregarded traffic regulation, failed vehicle maneuver, operating in a reckless/careless/negligent/aggressive manner, operating inattentive/distracted, and other contributing action. Rurality of the crash was determined by linking the crash zip code with the Rural-Urban Commuting Area Codes (RUCA) 2.0 from the University of Washington (http://depts.washington.edu/uwruca/ruca-approx.php). Ten RUCA codes were condensed to four categories as recommended by the University of Washington: urban, large rural, small rural, isolated rural. Alcohol impairment was defined as the driver having a blood alcohol concentration of ≥0.08g/100mL or a driver contributing circumstance of alcohol-impaired

being recorded by law enforcement. Consistent with prior research,[7] a driver injury or fatality was categorized as no injury (no and possible injury combined), injury (non-incapacitating or incapacitating injury), and fatality.

Analysis

To examine differences in crash, driver and vehicle characteristics by the presence or absence of alcohol impairment, the Pearson chi-square test was used for proportions and the Student's t-test for differences in means. To delineate differences within categorical variables with greater than two-levels with a p-value<0.05, standardized residuals (se_i) greater than two are presented in the text to show which level of the variable contributes the most to the chi-square statistical significance. Hierarchical multivariable logistic regression was used to estimate the odds of an injury or fatality to a driver in a crash involving alcohol impairment. To control for the correlation among drivers involved in the same crash but in different vehicles, vehicles from the same crash were clustered in the model, using GEE modeling with a binomial distribution, logit link function, and exchangeable correlation matrix. Due to the small number of fatalities and the unadjusted odds estimates of injuries and fatalities both showing an increased odds among alcohol-impaired drivers, injuries and fatalities were combined in the multivariable model to provide more stable odds estimates. Covariates included in the multivariable model were selected based on a priori knowledge.[5,7,8] Age of the driver was included as continuous variable to reduce the number of degrees of freedom for a parsimonious model. The odds of an injury or fatality are presented by adjusted odds ratios with 95% confidence intervals.

RESULTS

Crash Characteristics

From 2005 through 2010, there were 1971 farm equipment crashes involving 3601 vehicles (1,984 farm equipment, 1,617 non-farm vehicles) in four Great Plains states (Iowa, Missouri, North Dakota and South Dakota). Overall, 3.1% (61 of 1971) of on-road farm equipment crashes involved an alcohol-impaired driver. The proportion of alcohol-impaired driver crashes differed significantly by state (North Dakota [6.1%], South Dakota [5.8%], Missouri [2.5%], Iowa [2.4%], p=0.0096). About one in six (17.8%) fatal crashes involved an alcohol-impaired driver and one in twenty (5.6%) crashes that resulted in an injury had an alcohol-impaired driver involved (Table 1). Among alcohol-impaired crashes, 10% were head-on and 33.3% were rear-end crashes (se_i=*2.78*) compared to 4.8% and 18.9% among non-alcohol-impaired crashes respectively (p=0.3) (Table 2). Over 42% of alcohol-impaired crashes occurred between 6:00pm and 11:59pm while only 5.6% of non-alcohol-impaired crashes occurred during these times (se_i =11.3, p<.0001). In addition, over half (52.4%) of alcohol-impaired crashes occurred in the dark (9.8% dark with street lights [se_i=*6.36*] and 42.6% dark without street lights [se_i=*7.25*]) compared to 12.4% of non-impaired crashes occurring under the same conditions. Alcohol-impaired crashes occurred more frequently on Friday (29.5%, se_i=3.07) than non-alcohol-impaired crashes (15.0% Friday, (p=0.03). When comparing urban to rural (large, small and isolated combined), 87.9% of alcohol-involved crashes occurred in rural zip codes while only 75.0% of non-alcohol-impaired crashes occurred in rural zip codes (p=0.02, data not shown).

Driver and Vehicle Characteristics

The presence of alcohol impairment differed significantly by farm equipment versus non-farm equipment. The non-farm equipment driver was significantly more likely to be alcohol-impaired than the farm equipment driver (2.4% versus 1.1% respectively, p=0.0012). The alcohol-impaired crashes (n=61) involved 62 impaired drivers: 21 farm equipment drivers, 39 non-farm equipment drivers and a crash involving both an impaired farm equipment and non-farm equipment driver. The impaired non-farm equipment driver's vehicle action (e.g., heading straight, turning) did not differ significantly from the impaired farm equipment drivers vehicle action (data not shown, p=0.20). Alcohol-impaired non-farm equipment drivers most frequently rear-ended the farm equipment while alcohol-impaired farm equipment drivers were more often involved in a non-collision (e.g., ran off road) (Figure 1, p<.0001).

Table 2 summarizes variables significantly associated with alcohol-impairment. A detailed table is provided in Appendix Table 1. Alcohol-impaired crashes occurred more frequently among 35–44 year olds than non-impaired crashes (27.9% vs 14.8% respectively, $se_i=2.84$, p=0.03) (Appendix Table 1). Among driver contributing circumstance, 23.2% of alcohol-impaired crashes were due to operating in an inattentive or distracted manner compared to 5.6% of non-impaired crashes ($se_i=5.63$, p<.0001). A higher proportion of alcohol-impaired crashes resulted in non-incapacitating (17.0%, $se_i=2.34$,), incapacitating (15.3%, $se_i=4.83$) and fatal (11.9%, $se_i=7.72$) injuries compared to non-impaired crashes (8.4%, 3.4%, 1.0%, respectively) (p<.0001). Among the 3601 drivers in the data, 21.9% (n=789) were missing data on occupant protection (data not shown). Of those with missing occupant protection, 62% were the farm equipment driver and 38% were the non-farm equipment driver. Among those with data on occupant protection, over 86% of farm equipment driver used no protection while only 13% of non-farm equipment drivers were unrestrained (p<.0001). The driver was unrestrained in 66% of crashes involving alcohol impairment compared to only 47% of those with no alcohol impairment (p=0.04) and 53% of injury/fatality crashes had an unrestrained driver compared to 46% of crashes with no injury/fatality (p=0.0016).

Adjusted Odds of Injury or Fatality

Alcohol impairment is strongly associated with crash injury severity. In unadjusted analyses, alcohol-impaired crashes had odds of an injury 4.85 (95% CI=2.2.66–8.83) times that for non-impaired crashes and odds of a fatality 19.2(95% CI=7.84–46.8) times that for non-impaired crashes. To increase stability of odds estimates, injuries and fatalities were combined for the multivariable modeling. After controlling for driver age, manner of collision, rurality of the crash, and state, the odds of an injury or fatality for alcohol-impaired drivers were 3.94 (95% CI=2.14–7.25) times as high as that for non-alcohol-impaired drivers and the odds of being injured or fatally injured for the non-farm equipment driver were 2.49 (95% CI=2.06–3.01) times as high as that for the farm equipment drivers (Table 3).

In a sub-analysis of only drivers with available occupant restraint data, the adjusted odds of injury/fatality was calculated for alcohol impairment and non-farm equipment driver, controlling for all covariates in Table 3 and for restraint use type, including none. The

adjusted odds for alcohol impairment [aOR=3.82 (2.06–7.08)] and non-farm equipment driver [aOR=2.51 (1.20–3.15)] did not differ significantly in this model compared to that presented in Table 3.

DISCUSSION

Overall, about 3% of farm crashes in Iowa, Missouri, North Dakota, and South Dakota involve alcohol-impaired driving. As expected, fatalities and injuries were more likely when alcohol was present. Notably, however, alcohol-involved fatalities (17.8%) are much less frequent among on-road farm equipment crashes when compared to national reports for all roadway fatalities (22%), bicycle-involved (24%) and motorcycle-involved crashes (29%).[13] In this study, a number of other factors, such as age, time of day, and day of week, were shown to be associated with larger proportions of alcohol involvement in roadway crashes and fatalities.

Not surprisingly, greater proportions of alcohol-impaired crashes occur at night. Using data from 2006, the last year with data on alcohol-impaired non-fatal crashes, the National Highway Traffic Safety Administration (NHTSA) reported that alcohol was involved in greater than 50% of fatality and 25% of injury crashes occurring between 9 pm and 6 am.[14] In unadjusted analyses, this study found Fridays, but not Saturdays or Sundays, to have a higher proportion of alcohol-impaired crashes than other days of the week. For 2014, NHTSA reported greater proportions of alcohol involvement in fatal crashes on weekends among all age drivers.[13] In addition, previous studies have found weekday daytime crashes were significantly less likely to involve alcohol compared to weekend nighttime crashes (0.4 vs 1.5%).[13,15]

When examining age of the drivers involved in on-road farm equipment crashes, we found age to be evenly distributed among alcohol-impaired crashes. The distribution of alcohol impairment by age in our analysis is older than that found among all fatal crashes reported by NHTSA in 2014 (26.6% <34, 24% 35–44, 20.3% 45–54 and 12% 55+ years) with a higher proportion of those 55 or older found to be alcohol-impaired in farm equipment crashes. The differences in the proportions could be due to our analysis including injuries and fatalities while national data only examines alcohol impairment among fatal crashes. In addition, the older average age among alcohol-impaired farm equipment crashes in our analysis may be due to the average age of US farmers being older than the average age of US licensed drivers (58.3 years in farmers, 44 years in the US licensed population).[16,17]

We found no statistically significant difference in alcohol impairment by number of vehicles in the crash (3.8% single vehicle, 2.9% multiple vehicles). This differs from the Shyhalla et al[18] study of passenger vehicles which found a higher proportion of alcohol impairment among single vehicle versus two-vehicle crashes (10.7% single, 1.4% two-vehicle). A single vehicle crash in this analysis involved only a single piece of farm equipment (versus Shyhalla being a passenger vehicle[18]), and our results suggest that the non-farm equipment driver is most often alcohol-impaired. This may lead to the multiple vehicle crashes having a similar proportion of alcohol impairment as single vehicle crashes. Of note, intoxicated driving can result in more aggressive driving, as was found in our study (Table 2).[19] Given

the higher proportion of impairment in the non-farm equipment driver, the impaired drivers may have been more aggressive when passing and approaching farm equipment.

As found in previous studies, those in the non-farm equipment vehicle were more likely to be injured or a fatality.[5,7,8] In our study, those in the non-farm vehicle were over twice as likely to be injured or fatality injured after controlling for alcohol use, manner of collision, rurality of crash, state and age. Non-farm vehicles are at a distinct disadvantage in crashes with farm equipment due to the overwhelming energy transfer from the larger, heavier farm equipment to the smaller, lighter passenger vehicle. This stresses the importance of education for all road users on interacting with farm equipment on the roadway as when a crash occurs they are more likely to receive an injury.

This study has several limitations. This is a secondary analysis of Department of Transportation farm equipment related crashes obtained through police reports. Less severe crashes resulting in minor property damage or no injuries are less likely to be reported to police, particularly if it is a single vehicle crash.[20,21] This analysis is limited in its generalizability as only four states were examined. Nationwide, approximately 70% of all fatally injured drivers and 27% of surviving drivers are tested for alcohol impairment.[22] For the states included in this analysis, the prevalence of known blood alcohol level among fatally injured drivers ranges from 28–87% (IA=28.5, MO=80.5, ND=86.8, SD= 80.9) and surviving drivers from 26–85%. (IA=26.2, MO=57.9, ND=26.0, SD=85.2).[22] Among these states, all but Iowa have mandatory blood alcohol content testing for fatally-injured drivers.[22] Increased testing of fatally-injured drivers could result in a detection bias of alcohol impairment explaining some of the results of this analysis, although an increased odds of alcohol impairment was also found among non-fatally-injured drivers.

Overall, the prevalence of alcohol impairment in crashes involving farm equipment is less than three percent. In farm equipment crashes, the odds of an injury or fatality increases with alcohol impairment and among the driver of the non-farm equipment. Increased education of all road users on interacting with farm equipment on the roadway and continued interventions to decrease alcohol-impaired driving are needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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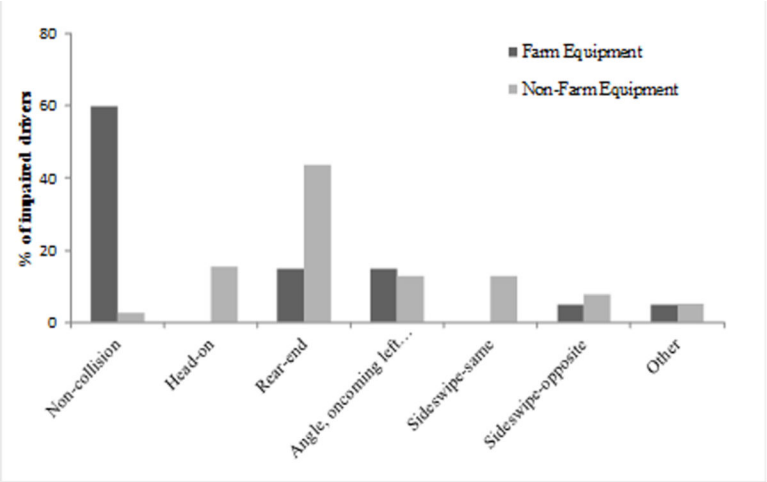

Figure 1.
On-road farm equipment crash mechanism by vehicle driver impaired.

Table 1.

Crash by whether any driver was alcohol impaired, four Great Plains states, 2005–2010 (n=1971).

	Driver Alcohol Impaired		
	No	Yes	
	N (row %)	N (row %)	p-value
Crash Characteristics			
All Crashes	1910 (96.9)	61 (3.1)	
State			0.0096
IA	998 (97.6)	25 (2.4)	
MO	577 (97.5)	15 (2.5)	
ND	155 (93.4)	10 (6.1)	
SD	180 (94.2)	11 (5.8)	
Crash Severity			<.0001
Property Damage	1235 (98.8)	15 (1.2)	
Injury	638 (94.4)	38 (5.6)	
Fatal	37 (82.2)	8 (17.8)	

Table 2.

Crash, vehicle and person characteristics significantly associated with whether any driver was alcohol impaired, four Great Plains states, 2005–2010.

	p-value
Crash Characteristics	
Manner of Collision	0.03
Lighting	<.0001
Time of day	<.0001
Day of Week	0.03
Driver and Vehicle Characteristics	
Driver Age	0.03
Farm Equipment	0.0017

Table 3.

Adjusted odds of an injury/fatality among farm equipment related on-road crashes, four Great Plains states, 2005–2010.

	aOR	(95% CI)
Age	1.01	(0.999–1.01)
Farm equipment driver		
No	2.49	(2.06–3.01)
Yes	1.00	(ref)
Driver alcohol-impaired		
Yes	3.94	(2.14–7.25)
No	1.00	(ref)
Manner of collision		
Non-collision	1.00	(ref)
Head-on	0.78	(0.49–1.23)
Rear-end	0.50	(0.35–0.71)
Angle, oncoming left turn	0.38	(0.26–0.56)
Sideswipe, same direction	0.13	(0.08–0.19)
Sideswipe, opposite direction	0.26	(0.16–0.41)
Other	0.29	(0.17–0.47)
Rurality of crash		
Urban	1.00	(ref)
Large rural	1.07	(0.74–1.55)
Small rural	1.09	(0.78–1.52)
Isolated rural	1.14	(0.85–1.54)
State		
IA	1.00	(ref)
MO	1.96	(1.27–3.00)
ND	0.95	(0.60–1.48)
SD	0.72	(0.38–1.36)