Road traffic crashes among farm vehicle drivers in southern China: A cross-sectional survey

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ABSTRACT

Objective: The objective of this study was to identify the prevalence and potential risk factors of farm vehicle–related road traffic crashes among farm vehicle drivers in southern China.

Methods: A cross-sectional study was used to interview 1,422 farm vehicle drivers in southern China. Farm vehicle–related road traffic crashes that occurred from December 2013 to November 2014 were investigated. Data on farm vehicle–related road traffic crashes and related factors were collected by face-to-face interviews.

Results: The prevalence of farm vehicle–related road traffic crashes among the investigated drivers was 7.2%. Farm vehicle–related road traffic crashes were significantly associated with self-reported vision problem (adjusted odds ratio [AOR] = 6.48, 95% confidence interval [CI], 3.86–10.87), self-reported sleep disorders (AOR = 10.03, 95% CI, 6.28–15.99), self-reported stress (AOR = 20.47, 95% CI, 9.96–42.08), reported history of crashes (AOR = 5.40, 95% CI, 3.47–8.42), reported history of drunk driving (AOR = 5.07, 95% CI, 2.97–8.65), and reported history of fatigued driving (AOR = 5.72, 95% CI, 3.73–8.78). The number of road traffic crashes was highest in the daytime and during harvest season. In over 96% of farm vehicle–related road traffic crashes, drivers were believed to be responsible for the crash. Major crash-causing factors included improper driving, careless driving, violating of traffic signals or signs, and being in the wrong lane.

Conclusion: Findings of this study suggest that farm vehicle–related road traffic crashes have become a burgeoning public health problem in China. Programs need to be developed to prevent farm vehicle–related road traffic crashes in this emerging country.

Introduction

Agricultural production includes many both manual and mechanical operations. Along with economic development and the mechanization process, the mode of agricultural production has been shifting from manual to mechanized processing in China. The number of farm vehicles has increased rapidly from 14.76 million in 2003 to more than 22.79 million in 2013 in China (National Bureau of Statistics 2014). Farm vehicles in China are often modified by farmers to haul farm products. In addition, narrow rural roads are usually used by all kinds of vehicles or users (e.g., light and heavy vehicles, bicycles, and pedestrians; Jaarsma et al. 2003; Jaarsma and De Vries 2014). The considerable variations in speed result in high risks and delays for faster vehicles (Jaarsma et al. 2003; Jaarsma and De Vries 2014). These factors contribute to many serious farm vehicle crashes (Gerberich et al. 1996; Jaarsma and De Vries 2014). A fatality is 5 times more likely to occur when a crash involves farm vehicles on public roads than when a crash does not involve farm vehicles (Costello et al. 2009). Some studies suggested that farm vehicles and machinery-related fatalities are the leading cause of death in agriculture (Etherton et al. 1991; Waggoner et al. 2011). Traffic safety related to farm vehicles is becoming more problematic with increased use of modern farm machinery (Dutch Safety Board 2010; Jaarsma and De Vries 2014).

China is the largest agricultural country, with more than 970 million farmers (National Bureau of Statistics 2014). However, few studies on traffic safety issues related to farm vehicles among Chinese farmers have been conducted. Very little information is available regarding road traffic crashes associated with the use of farm vehicles in China. In contrast, many studies on farm vehicle–related traffic injuries have been conducted in other developing or developed countries (Carlson et al. 2005; Gerberich et al. 1996; Harland et al. 2014; Jaarsma and De Vries 2014; Karapolat et al. 2011; Waggoner et al. 2011). In addition, the role of farm vehicles in the total traffic safety problem is somewhat hidden because most national statistics, including in China, do not explicitly report farm vehicle crashes but include...
them within a general category of “other vehicles” (Bureau of Traffic Management of the Ministry of Public Security of PRC 2013; Jaarsma and De Vries 2014). Although all traffic fatalities in The Netherlands have decreased by more than 50% in the last decades, there was no decrease in fatal injuries involving farm vehicles (Jaarsma and De Vries 2014). Rapid economic development is expected to continue in China and therefore traffic safety issues related to farm vehicles are expected to increase in the future. Therefore, the aim of this study was to estimate the prevalence and characteristics of farm vehicle crashes and to study risk factors among farm vehicle drivers in a southern region of China.

Methods

Study design and sampling

In this cross-sectional study, farm vehicle drivers in one county in the southern part of Jiangsu Province were surveyed about farm vehicle–related road traffic crashes. The total number of farm vehicle drivers registered in the county was 3,133. A total of 1,500 participants were randomly selected from all registered farm vehicle drivers. Eligible participants included any person who lived in this rural area, owned at least one farm vehicle, and had driven farm vehicles for at least 1 year preceding the beginning of the study.

The questionnaire was developed by a research team at the Injury Prevention Research Institute, School of Public Health, Southeast University. Six graduate students from the Southeast University Injury Prevention Research Institute were trained as interviewers for this study. The research team at the Southeast University Injury Prevention Research Institute pilot-tested the survey questionnaire in a small group of the target population in the study area in August 2014. Minor changes were made before the survey questionnaire was finalized.

Data were collected by face-to-face interviews in December 2014 and January 2015. Each participant was asked about selected characteristics (e.g., gender, age, driving years, education, marital status, annual family income, vision, hearing, sleep disorders, related chronic diseases, tobacco and alcohol use, self-reported stress, current debt, and satisfied with family income), farm vehicle driving–related risk behaviors (e.g., crashes and drunk driving history, smoking, fatigue or illness when driving, taking drugs), and farm vehicle–related traffic crash characteristics (e.g., time of crash, crash pattern, and crash cause).

Informed consent was obtained from participants in accordance with ethical guidelines. The institutional review board of Southeast University reviewed and approved the study protocol.

Definition of study variables

Farm vehicles were defined as vehicles designed for agricultural use and for work carried out in the agriculture, forestry, animal husbandry, and fishery industries. These vehicles are classified as farm tractors or low-speed cargo vehicles in the motor vehicle categories in China.

Farm vehicle–related road traffic crashes were defined to include all traffic-related crashes with a farm vehicle that resulted in nonfatal injury or death to road users (drivers, motorcyclists, cyclists, passengers, pedestrians, and others) from December 2013 to November 2014.

Statistical analysis

Data were entered into EpiData 3.0 (Odense, Denmark) and analyzed with SAS 9.1 (SAS Institute, Cary, NC). First, we described the sample demographics including gender, age, driving years, education, marital status, and annual family income. Second, univariate logistic regression analyses were performed to assess the association of farm vehicle–related traffic crashes with selected characteristics and farm vehicle driving–related risk behaviors. Third, we used a priori knowledge to select gender, age, education, driving years, and annual family income as confounders. In order to control for these confounders while each of 6 driver risk behaviors (vision impairment, sleep disorders, life stress, history of crashes, drinking and driving, fatigued while driving) was examined, 6 separate multivariate logistic regression analyses were conducted. In each of 6 logistic regression models, the outcome variable was farm vehicle–related traffic crash (yes/no), and the independent variables were all confounders and farm vehicle driver risk behavior of interest. An additional analysis was conducted to test the interaction and multicollinearity of independent variables. We found no significant interaction or collinearity. Therefore, we only reported results from different models. Potential risk factors with a P value < .05 in the univariate analysis were entered into the final multivariate logistic regression model. Finally, we described the characteristics of farm vehicle–related traffic crashes with regard to time of crash, season of crash, crash pattern, and crash cause. P < .05 was considered statistically significant in our study.

Results

A total of 1,500 farm vehicle drivers participated in the study. Our face-to-face survey obtained 1,422 valid questionnaires, yielding an overall response rate of 94.8%. Reasons for nonresponse included absence from the village when the survey was conducted and incomplete questionnaires.

The mean age of farm vehicle drivers in this study was 53 years, and over 60% of drivers had an annual family income of more than 80,000 RMB. Most farm vehicle drivers were male (99.5%), were married (99.2%), had a middle school education (59.7%), and had 10–19 years of driving experience (50.9%).

The prevalence of farm vehicle–related road traffic crashes among the drivers by selected characteristics is presented in Table A1 (see Appendix, online supplement). A total of 103 crashes (7.2%) were reported. The prevalence of farm vehicle crashes among drivers who reported normal/poor vision (26.7%), normal/poor hearing (18.9%), sleep disorders (33.3%), related chronic diseases (11.3%), alcohol use (8.8%), self-reported stress (32.0%), current debt (15.4%), and dissatisfied with family income (15.8%) were significantly higher than those who did not report these conditions and behaviors (all P < .05).

The prevalence of farm vehicle crashes by risky behaviors is shown in Table 1. The prevalence of farm vehicle crashes among drivers who reported a history of crashes (21.4%), smoking while driving (11.8%), drunk driving (24.2%), making or receiving calls while driving (12.7%), fatigued driving (21.3%),
or driving while ill (17.5%) were significantly higher compared to those who did not report these behaviors (all P < .001).

Table 2 presents the multivariate logistic regression models. The results indicated that farm vehicle crashes were significantly more likely to occur among drivers with the following characteristics: self-reported vision (normal/poor vs. good, adjusted odds ratio [AOR] = 6.48, 95% confidence interval [CI], 3.86–10.87), self-reported sleep disorders (sometimes/always vs. never, AOR = 10.03, 95% CI, 6.28–15.99), self-reported stress (always vs. self-reportedsleepdisorders(sometimes/alwaysvs.never,AOR5.72,95%CI,3.73–8.78)), and reported history of fatigued driving (yes vs. no, AOR = 5.40, 95% CI, 3.47–8.42), reported history of crashes(%) OR(95%CI)

| Reporting history of crashes | OR (95% CI) | P value |
|------------------------------|-------------|---------|
| Yes                          | 5.06 (3.29–7.80) | <.001   |
| No                           | Reference   |         |

Reporting history of smoked while driving

| Yes                          | 2.13 (1.40–3.25) | <.001   |
| No                           | Reference        |         |

Reporting history of drunk driving

| Yes                          | 4.92 (2.90–8.36)  | <.001   |
| No                           | Reference         |         |

Reporting history of making or receiving a call while driving

| Yes                          | 2.58 (1.72–3.85)  | <.001   |
| No                           | Reference         |         |

Reporting history of fatigued driving

| Yes                          | 5.45 (3.58–8.31)  | <.001   |
| No                           | Reference         |         |

Reporting history of driving while ill

| Yes                          | 3.33 (2.07–5.34)  | <.001   |
| No                           | Reference         |         |

Reporting history of taking drugs before driving or while driving

| Yes                          | 1.57 (0.85–2.90)  | .148    |
| No                           | Reference         |         |

Table 3. Characteristics of road traffic crashes involving agricultural vehicles.

| Crash cause                      | n  | %   |
|----------------------------------|----|-----|
| Time of crash                    |    |     |
| Daytime (6:00 a.m.–6:00 p.m.)    | 96 | 93.2|
| Nighttime (12:00 a.m.–6:00 a.m., 6:00 p.m.–12:00 a.m.) | 7 | 6.8 |
| Month of crash                   |    |     |
| January–March                    | 20 | 19.4|
| April–June                       | 34 | 33.0|
| July–September                   | 32 | 31.1|
| October–December                 | 17 | 16.5|
| Crash pattern                    |    |     |
| Frontal crash                    | 11 | 10.7|
| Side-to-side crash               | 31 | 30.1|
| Rear-end crash                   | 21 | 20.4|
| Vehicle with object or person crash | 16 | 15.5|
| Other                            | 24 | 23.3|
| Crash cause                      |    |     |
| Improper driving                 | 19 | 18.4|
| Careless driving                 | 18 | 17.5|
| Violating traffic signals or signs | 16 | 15.5|
| Wrong lane                       | 13 | 12.6|
| Excessive speed                  | 3  | 2.9 |
| Fatigue while driving            | 2  | 1.9 |
| Alcohol use while driving        | 1  | 1.0 |
| Other behaviors affecting safety | 27 | 26.2|
| Road factors                     | 2  | 1.9 |
| Vehicle factors                  | 2  | 1.9 |

Road traffic crashes by time of crash, month of crash, crash patterns, and crash causes are presented in Table 3. Most crashes occurred during the daytime (93.2%). Approximately 65% of farm vehicle crashes occurred in April–September. The most common crash patterns were a side-to-side crash (30.1%), rear-end crash (20.4%), and collision with an object or person (15.5%). In over 96% of road traffic crashes, farm vehicle drivers were believed to be responsible for the crash, with the underlying causative factors of improper driving (18.4%), careless driving (17.5%), violating traffic signals or signs (15.5%), being in the wrong lane (12.6%), and other behaviors affecting safety (26.2%). The road and vehicle factors accounted for 1.9% of these crashes.

Discussion

This study was a descriptive study of road traffic crashes among farm vehicle drivers in southern China. Our study indicated that 7.2% of drivers in the study area who drove a farm vehicle in the past year suffered road traffic crashes. We also found that the risk of farm vehicle–related road traffic crashes was significantly associated with factors such as poor vision, sleep disorders, stress of daily life, driver-reported history of crashes, driver-reported history of drunk driving, and driver-reported history of fatigued driving. The rapid mechanization of agriculture taking place in China means that farm vehicle–related road traffic crashes may soon become a greater societal and public safety problem than before in the absence of appropriate road traffic injury prevention measures.

In our study, there was no association between self-reported annual family income and farm vehicle traffic crashes in multivariate analysis. Our result was consistent with a previous Chinese study where income level was not significantly related to occupational injuries among agricultural machinery operators (Simpson et al. 2004). However, our results were inconsistent with a study that reported higher income as a risk factor for occupational injuries among agricultural machinery operators.
factor for serious injury among farm workers in Finland (Risto et al. 2009). Income may reflect the size of the operation and exposure time to agricultural injury (Risto et al. 2009). Previous studies also indicated that life stress has an effect on ability to focus during work (Simpson et al. 2004). Our finding that farmers reporting higher life stress at increased risk of injury (Risto et al. 2009). In our study, the prevalence of road traffic crashes among farm vehicle drivers who reported a history of crashes was more than 4 times that among drivers who did not report history of crashes. One study showed that crash involvement was associated with a short time interval before the next crash (Hamed et al. 1998).

Drivers who reported drinking alcohol were at an elevated risk of farm vehicle crashes than those with a zero blood alcohol concentration (BAC) and that this risk increased rapidly with BAC (Peden et al. 2004). A previous study found that young and inexperienced drivers with an elevated BAC were at higher risk of traffic crashes than persons with zero or lower blood alcohol concentrations (Shults et al. 2001). Our study suggested that drivers who reported a history of drunk driving were more likely to have farm vehicle traffic crashes. This finding was consistent with previous studies that identified drunk driving as a major contributor to road crashes (Peden et al. 2004; Shults et al. 2001).

The use of cellular phones can adversely affect driver behavior with regard to physical as well as perceptual and decision-making tasks (Peden et al. 2004). A recent study found that a greater reported frequency of cell phone use while driving is associated with a broader pattern of behaviors that are likely to increase the overall risk of crashes (Zhao et al. 2013). In our study, however, there was no association between drivers reporting a history of cell phone use while driving and farm vehicle traffic crashes in multivariate analysis. This is in contrast to several international studies of cell phone use while driving as a traffic crash risk factor (Brusque and Alauzet 2008; Violanti 1997; Zhao et al. 2013).

Fatigue or sleepiness is associated with a range of factors, including long-distance driving, sleep deprivation, and the disruption of circadian rhythms (Connor et al. 2002; Peden et al. 2004). Results in our study suggest that the prevalence of farm vehicle crashes among drivers who report sleep disorders and fatigue were significantly higher than among those who did not report these conditions and behaviors. A population-based study in New Zealand found that factors that substantially increased the risk of a fatal crash or a crash with serious injuries included driving while feeling sleepy, driving after less than 5 h of sleep in the preceding 24 h, and driving between 2:00 and 5:00 a.m. (Connor et al. 2002; Peden et al. 2004). In addition, peak levels of driver fatigue-related traffic crashes at night are often 10 times higher than daytime levels (Peden et al. 2004). Driver fatigue has been identified in some studies as a causal factor in rural crashes through its association with distance traveled (Siskind et al. 2011). It is considered that a reduction in all 3 of these behaviors could reduce the incidence of traffic crashes involving injury by up to 19% (Connor et al. 2002).

Our study found that the most traffic crashes involving farm vehicle frequencies occurred during the day. Many road traffic crashes occur in safe driving circumstances, such as sunny weather, flat and straight roads, paved roads, and other favorable traffic conditions (Zhang et al. 2013). However, traffic crashes at night were more likely to result in injury (Jaarsma and De Vries 2014). In recent years, the proportion of fatal traffic crashes involving farm vehicles at night has increased (Jaarsma and De Vries 2014). Farm vehicle-related traffic crashes often occur during the harvest (Jaarsma and De Vries 2014). Results of our study found that about two thirds of all road traffic crashes occurred in April–September. This association with agricultural activities was also found in The Netherlands and the United States (Jaarsma and De Vries 2014). The seasonal trend could reflect the length of time driving and tight work schedules of farm vehicle drivers during harvest.

Many developing countries have mixed lane use for road traffic, such as pedestrians, hand carts, bicycles, motorcycles, vans, cars, trucks, and buses (Peden et al. 2004). Therefore, drivers may be more likely to have side-to-side crashes because traffic flows are not divided in many regions in China. Drivers may also be more likely to have single motor vehicle crashes with objects or pedestrians because roadsides do not have guardrails or there is no separate space earmarked for them. Our study suggested that more than 30% of farm vehicle traffic crashes occurred in side-to-side crashes, more than 20% occurred in rear-end crashes, more than 15% occurred in farm vehicle crashes with an object or a person, and more than 10% occurred in frontal crashes.

Comparing causes of traffic crashes suggested human behavioral, vehicle and road factors as the main cause, with a smaller contribution of environmental factors (El-Sadig et al. 2002; Lyznicki et al. 1998; Zhang et al. 2013). Our study suggested that farm vehicle drivers who reported risky behaviors might have accounted for 96.2% of traffic crashes. Common risk factors contributing to traffic crashes include improper driving, followed by careless driving, violating traffic signals or signs, and driving in the wrong lane. Identifying major risk factors for farm vehicle traffic crashes could guide preventive measures and enforcement of traffic laws in China.

Farm vehicle-related traffic crashes are complex social phenomena. According to other researchers, a combination of 3 road traffic system components (driver, vehicle, and road infrastructure) may contribute to improving road traffic safety related to farm vehicles (Dutch Safety Board 2010; Jaarsma and De Vries 2014). Farm vehicle driver education is an important process for safeguarding drivers of both farm vehicles and other motor vehicles (Jaarsma and De Vries 2014). Education targeting farm vehicle driver is needed to teach them to focus more on increasing safety knowledge and decreasing risky behaviors. Drivers should also be better aware of the maintenance of farm vehicles. A safe farm vehicles design is also needed. The absence of safety features in older farm vehicles indicates an important limitation in China, such as safety belts, rearview mirrors, tail lamps, brake lamps, etc. For instance, better farm vehicle lamps are advised so that other drivers can easily identify farm vehicles at any time of the day or night. Finally, a comprehensive set of
measures related to road infrastructure improvement should be considered. These measures vary from improving lighting and signal and traffic signs with rural road characteristics adapted to farm vehicles. Due to differences in economic development in the region, different road infrastructure solutions should be developed for different regions.

There are some limitations to be considered when interpreting the results of our study. First, information on farm vehicle-related road traffic crashes in the past 12 months was collected through a cross-sectional survey. Recall bias might have caused underestimation of crash prevalence and reporting errors regarding crash characteristics. In addition, farm vehicle-related road traffic crashes might be underestimated because social desirability bias with regard to reporting on driving while fatigued, drunk driving, etc. Second, the sample in our study was solicited from only one county in southern China and the sample size was relatively small. The results of this study cannot be extrapolated to all farm vehicles in China. The small sample size might have caused some unreliable results. Future studies should consider a larger sample size and a diverse geographic study population. Third, because this study was cross-sectional, it was not possible to determine causal relationships between risk factors and farm vehicle-related road traffic crashes.

In summary, this epidemiological study shows that farm vehicle–related road traffic crashes are serious in China. Traffic safety issues related to farm vehicles are expected to increase in the future as the dimensions of modern agricultural machinery continue to expand. Our study indicates that driver’s health status, risk behaviors while driving, and crash characteristics were associated with farm vehicle traffic crashes in China. Drivers reporting a history of behavioral factors was the principal cause of farm vehicle traffic crashes. Further studies are needed to develop interventions for the prevention of farm vehicle–related road traffic injuries among farm vehicle drivers in China.

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