Accident Analysis and Prevention 70 (2014) 8–13

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Not just a rural occurrence: Differences in agricultural equipment crash characteristics by rural–urban crash site and proximity to town

Karisa K. Harland[a,b,*], Mitchell Greenan[a], Marizen Ramirez[a]

[a] University of Iowa, College of Public Health, Department of Occupational and Environmental Health, Injury Prevention Research Center, Iowa City, IA, USA
[b] University of Iowa, Department of Emergency Medicine, Iowa City, IA, USA

ARTICLE INFO

Article history:
Received 13 December 2013
Received in revised form 18 February 2014
Accepted 19 February 2014
Available online 28 March 2014

Keywords:
Traffic accident
Agricultural equipment
Epidemiology
Occupational accidents/injuries

ABSTRACT

Purpose: Although approximately one-third of agricultural equipment-related crashes occur near town, these crashes are thought to be a rural problem. This analysis examines differences between agricultural equipment-related crashes by their urban–rural distribution and distance from a town.
Methods: Agricultural equipment crashes were collected from nine Midwest Departments of Transportation (2005–2008). Crash zip code was assigned as urban or rural (large, small and isolated) using Rural–Urban Commuting Areas. Crash proximity to a town was estimated with ArcGIS. Multivariable logistic regression was used to estimate the odds of crashing in an urban versus rural zip codes and across rural gradients. ANOVA analysis estimated mean distance (miles) from a crash site to a town.
Findings: Over four years, 4444 crashes involved agricultural equipment. About 30% of crashes occurred in urban zip codes. Urban crashes were more likely to be non-collisions (aOR = 1.69[1.24–2.30]), involve ≥2 vehicles (2 vehicles: aOR = 1.58[1.14–2.20], 3+ vehicles: aOR = 1.68[0.98–2.88]), occur in a town (aOR = 2.06[1.73–2.45]) and within one mile of a town (aOR = 1.65[1.40–1.95]) than rural crashes. The proportion of crashes within a town differed significantly across rural gradients ($P < 0.0001$). Small rural crashes, compared to isolated rural crashes, were 1.98 (95%CI[1.28–3.06]) times more likely to be non-collisions. The distance from the crash to town differed significantly by the urban-rural distribution ($P < 0.0001$).
Conclusions: Crashes with agricultural equipment are unexpectedly common in urban areas and near towns and cities. Education among all roadway users, increased visibility of agricultural equipment and the development of complete rural roads are needed to increase road safety and prevent agricultural equipment-related crashes.

1. Introduction

Crashes involving agricultural (Ag) equipment on public roads are rare occurrences, but the effects can be devastating for the Ag equipment operator as well as occupants of other vehicles involved. Two percent of crashes with Ag equipment result in a fatality while less than one percent of all other motor vehicle crashes result in fatalities (Costello et al., 2009; Traffic safety facts, 2008). Almost two-thirds (65%) of Ag equipment-related crashes involve collisions with non-Ag vehicles, and one in three crash fatalities are to occupants of the non-Ag vehicle (Gerberich et al., 1996). Although deaths are infrequent in Ag equipment-related crashes, three out of four non-fatal crashes with Ag equipment result in an injury, with the non-Ag vehicle operator being more likely to be injured (Peek-Asa et al., 2007).

Agricultural equipment, designed primarily to be operated in the field with minimal road transportation, has characteristics that make its use on the road unique and challenging. First, Ag equipment are slow moving vehicles built to endure heavy workloads and not for high speed transportation (Committee on Agricultural Safety and Health Research and Extension, 2009). Second, Ag vehicle traffic on roadways aligns with timing of agricultural tasks and varies by time of day and seasons of the year. These factors have implications for when and how crashes occur. Prior research, although sparse, has shown the most frequent manner of collision with agricultural equipment involves the equipment being struck in the rear by the non-Ag vehicle on two lane roads with speed limits of 55 miles per hour (Gerberich et al., 1996; Pinzke and Lundqvist, 2004; Gkritza et al., 2010). The incidence of Ag

* Corresponding author at: University of Iowa, Occupational and Environmental Health, 200 Newton Rd, 2188 WL, Iowa City, 52242 IA, USA. Tel.: +1 319 335 4481.
E-mail address: kari-harland@uiowa.edu (K.K. Harland).

http://dx.doi.org/10.1016/j.aap.2014.02.013
0001-4575/

crashes follows a trend consistent with exposure due to seasonal agricultural tasks, with more crashes in the crop harvesting months (Pinzke and Lundqvist, 2004; Gkritza et al., 2010). The majority of crashes with Ag equipment occur during daylight; nevertheless, those occurring at dawn/dusk or night are more likely to result in an injury than those during the day (Gerberich et al., 1996; Gkritza et al., 2010).

Agricultural equipment-related crashes occur more frequently in rural areas because Ag equipment spend more time on rural rather than urban roads (Costello et al., 2009; National Highway Transportation and Safety Association's National Center for Statistics and Analysis, 2013; Gerberich et al., 1996; Peek-Asa et al., 2007; Committee on Agricultural Safety and Health Research and Extension, 2009; Pinzke and Lundqvist, 2004; Gkritza et al., 2010). However, prior studies have not untangled some of the unique differences found within rural areas, which may differentially influence crash patterns. For example, in isolated rural communities, rural roads are more likely to have dirt and gravel surfaces with no or few traffic controls. In contrast, larger rural communities often have increased traffic density and comparatively, more paved roads and traffic controls (Ramirez et al., 2013). To our knowledge there have not been any previous studies on patterns of Ag equipment crashes in various rural environments.

Interestingly, while Ag equipment-related crashes are generally thought to be a rural problem; two studies reported that over one in three Ag equipment crashes occurred within one mile of or in a town or city (Pinzke and Lundqvist, 2004; Gkritza et al., 2010). This suggests that Ag equipment crashes also occur in urbanized areas with greater traffic density and more exposure to passenger vehicles. With increasing urbanization, today's farmers must navigate roadways with more drivers unaccustomed to the presence of large Ag equipment on roadways. Farmers in one rural state have expressed concern over the increased traffic on rural roads and fear that drivers of passenger vehicles have not been adequately educated on the lighting and marking of Ag equipment and on how to interact with this equipment on the roadway (Luginbuhl et al., 2003). Evaluation of crashes involving Ag equipment in urban locations has not been previously conducted.

Prior research on roadway crashes involving Ag equipment has not assessed differences between urban and rural crashes, nor has research evaluated how crash patterns differ across gradients of rurality. Therefore, the objectives of this study were to: (1) determine how characteristics of Ag vehicle crashes, such as crash configuration, differ between urban versus rural zip codes and (2) among rural areas, determine how crash characteristics differ across gradients of rurality (i.e., large rural, small rural and isolated rural areas). To further understand crash proximity to towns and cities, an additional objective was to measure the average distance Ag equipment crashes occurred from town or city limits and compare the proportions of crashes across rural and urban zip codes. We hypothesize that (1) urban crashes will involve more vehicles, be more likely to occur within a town/city and will have different crash mechanisms than rural crashes, and (2) compared to isolated rural crashes, large and small rural Ag equipment crashes will also involve more vehicles and occur closer to a town or city.

2. Methods

Agricultural equipment crashes were identified from Department of Transportation (DOT) data from the nine states making up the Great Plains region (Iowa, Illinois, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin) for years 2005 through 2008. Ag equipment, for this analysis, was defined as tractors or any other self-propelled implement of husbandry (e.g. combine harvester). Within the DOT data, each state has a separate vehicle classification category for Ag equipment. This classification was used to select all crashes with Ag equipment. Crash level data extracted included manner of collision, season (month) and time when the crash occurred, crash location, and the number of vehicles (including Ag and non-Ag) involved in the crash. Because manner of collision categories differed by state, for uniform coding, we combined collision categories based on the Model Minimum Uniform Crash Criteria, (MMUCC), 4th edition (2012) to create seven categories: non-collision, head-on (front to front), rear-end (front to rear), angle, sideswipe-same direction, sideswipe-opposite direction, and other. Non-collisions include crashes with stationary objects (e.g., parked motor vehicle, trees, etc.), rollovers, ran-off road and collisions with non-motorists (e.g., pedestrian, bicyclist, animal, etc.).

To determine if the crash took place in a rural or urban zip code, ArcGIS 10.1 (ESRI 2012) was utilized to determine the location of the crash and the zip code in which the crash occurred. Two methods were used to determine where the crashes occurred. For the first method, law enforcement officers from Iowa, Illinois, Minnesota, North Dakota, South Dakota and Nebraska completing the crash report documented the *X*–*Y* coordinates of the crash. In Iowa, for example, officers have a handheld GPS device that automatically designates the coordinates of the crash location. These *X*–*Y* coordinates were then imported and projected to a UTM 15 coordinate data frame so that the crashes could be spatially located. For the second method, Wisconsin, Kansas and Missouri did not provide coordinates but instead provided the street the crash occurred on as well as the direction and distance from an intersection to the crash. Manual and automated geocoding was conducted to project where these crashes occurred. An accuracy check was then completed: all *X*–*Y* coordinates greater than one mile from an intersection, within 0.5 miles of a zip code boundary, or greater than 500 feet from a road (e.g. crash appeared to occur off-road) were manually reviewed and placed on the road segment given by the DOT location.

Zip codes were identified for each crash location after the geocoding process. Using Rural–Urban Commuting Area Codes (RUCA) 2.0 from the University of Washington (http://depts.washington.edu/uwruca/ruca-approx.php), the rurality of a zip code was approximated based on 2004 zip code boundaries. RUCA considers work commuting data from the 2000 census, proximity to an urbanized area (50,000+ population) or an urban cluster (10,000–49,999 population), and population density in its approximation of rurality. Ten RUCA codes are given to approximate rurality, for this analysis these codes were combined into four categories as recommended by the University of Washington (http://depts.washington.edu/uwruca/ruca-approx.php): urban, large rural, small rural, and isolated rural (Table 1). In addition, all rural codes (large, small and isolated) were combined to dichotomize urban versus rural zip codes.

3. Analysis

To illustrate how crashes are spatially related by rurality, a map of the nine states was created with each point representing the location of an Ag equipment-related crash. Zip codes were shaded to represent urban versus rural areas with urban being light gray and rural zip codes shaded darker gray. A portion of the map is enlarged, to display how the crash locations may differ across gradients of the rural zip codes (isolated, small, and large).

Frequencies and proportions of crashes by manner of collision, time of day, number of vehicles involved, and distance from a town were compared between urban and rural zip codes. Distance (miles) from the crash site to the boundary of the nearest incorporated place was calculated using ArcGIS. An incorporated place, using the United States Census Bureau definition, is a governmental