FACTORS ASSOCIATED WITH RURAL RUN-OFF-ROAD AND URBAN RUN-OFF-ROAD CRASHES: A STUDY IN THE UNITED STATES

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ABSTRACT

Run-Off-Road (ROR) crash occurs when a vehicle leave the lane resulting in a collision. ROR crashes in recent years have become a major cause of serious injuries and fatalities. Data from Kansas Crash and Analysis Reporting System (KCARS) database during the period 2007 to 2011 were used in this study to examine the ROR crashes. Identification of various characteristics such as environment, roadway, driver, and vehicle as well as factors contributing to rural ROR and urban ROR crashes is important because potential countermeasures can be developed to improve roadside safety. It was found that avoidance/evasive or slow; ill, falling asleep or fatigued; or animal at the road is more common on rural roadways than urban roadways.

Keywords: Run-off-Road crashes, crash data analysis, lane departure crashes, rural/ urban nature of ROR crashes

1. INTRODUCTION

Each year ROR crashes cause serious injuries and fatalities in the world including the United States of America (U.S.A.) Data from Fatality Analysis Reporting System (FARS) illustrated that ROR crashes cause around 33% of fatalities in the U.S.A. in 2009 (FARS 2012).The statistics about single vehicle ROR crashes is alarming; FARS reported about 53% of the total traffic fatalities in the U.S.A. are due to single-vehicle ROR crashes where vehicles leave the lane due to collision with fixed objects or due to overturning. ROR crash usually involve running off the road onto the right or left shoulder and hitting a fixed object or a parked vehicle. ROR crashes also involve crossing into an opposite lane and colliding with an oncoming vehicle. Those crashes resulting in between two moving vehicles may be potentially more severe.

An estimated societal cost of $110 billion has been imposed each year due to roadside crashes (McGinnis et al. 2001). Dedicated efforts are necessary to take in order to reduce the severity and frequency of ROR crashes. The efforts that have been taken until now are mostly related to removing or relocating hazards for designing forgiving roadsides, or designing better safety features to mitigate the severity of these hazards in case these hazards cannot be removed and this has been proven successful (Mak 2010). The societal costs associated with roadside crashes must be recognized before cost-effective strategies can be developed to improve roadside safety. All elements of roadside-vehicle-driver system need to be taken into consideration while addressing the roadside safety problem (McGinnis et al. 2001). The roadside safety features in rural roadways were different than urban roadways. Therefore, identification of various driver, roadway, vehicle, and environmental characteristics associated with rural ROR crashes and urban ROR crashes are necessary, which will help to develop appropriate countermeasures.

2. LITERATURE REVIEW

Numerous studies have been conducted in recent years on roadside safety crashes. Hallmark et al. (2009) investigated different characteristics associated with large truck ROR crashes using the data from Large Truck Crash Causation Study database. While investigating roadway characteristics, it was found that large truck ROR crashes are more common in urban freeways with more than four lanes either for ROR crashes. For lane departure crashes, the most common condition was identified as no flow restrictions. ROR crashes were found to occur in dry condition, while rain was more common for multi-vehicle ROR crashes in compare to other ROR crashes. Single vehicle ROR found to be more common at nights without streetlights than the multi-vehicle ROR crashes. Among different driver related factors, it was identified fatigued as the topmost reasons for ROR crashes to occur. Distraction by either an internal or an external event prior to the crash was also responsible for a large number of ROR crashes. Aggression was more likely to be the reason of single-vehicle ROR crashes. When alcohol and drug involvement for drivers were compared, the research found out that large truck drivers were more likely to be using illegal drugs (10% to 11%) for ROR crashes than alcohol (around 1%).

Liu and Subramanian (2009) examined environment, roadway, vehicle, occupants, and drivers' performance-related factors for fatal single-vehicle ROR crashes. While investigating environment-related factors, it was found that fatal ROR crashes were more likely to take place in curved roads, rural roads, roadways with posted speed limit more than 60 mph, roadways with fewer lanes. Also, ROR crashes were more common in adverse weather conditions, and during night time. Among different driver related factors, it was found that ROR crashes were more likely to occur when drivers traveling with passengers. Male drivers, younger drivers, and alcohol impaired drivers were more likely to be involved in ROR crashes. When different vehicle-related factors considered, ROR crashes were more common for passenger cars and speeding vehicles.

A study done by McLaughlin et al. (2009) investigated the effects of levels of precipitation, lighting, and roadway surface conditions in occurrence of ROR crashes. Precipitation (fog, mist, and rain) increased the occurrence of ROR crashes 2.5 times than clear conditions and snow or ice increased the likelihood by seven times than that of dry conditions. While investigating driver related factors, it was found that multiple factors were responsible for an event but distraction/inattention (40% of ROR events) was the most common contributing factor. Changes in roadway boundaries such as the start of a median, narrowing of the lane from the right, loss of a lane, or atypical roadway geometry were considered as a contributing factor in 22% of the events.

The role of ambient light in fatal single-vehicle ROR crashes was studied by Sullivan et al. (2002). There were three scenarios: pedestrian crashes at intersections, pedestrian crashes on dark, straight, high-speed roads and single-vehicle ROR crashes that were studied to see the role of light. The research identified that single-vehicle ROR crashes on dark, curved roads had little sensitivity to light in compare to first two scenarios and suggested factors other than the light level that play a dominant role in fatal single-vehicle ROR crashes. In a research to evaluate frequency and injury outcomes of ROR crashes, Benavente et al. (2006) found that ROR head-on crashes to be more severe than single-vehicle ROR crashes. The study also identified that ROR head-on crashes were higher associated costs and longer length of stay than single vehicle ROR crashes. Montella et al. (2010) in an in-depth investigation of ROR crashes in a motorway of Italy found that ROR crashes were more severe for motorcycles than any other vehicle types. The same study also investigated that crashes against roadside safety barriers tend to be less severe than crashes against ditches, walls, fore-slopes, and back-slopes.

Spainhour et al. (2008) in a study done in Florida examined human, roadway, vehicle, and environmental factors associated with ROR crashes. The analysis of the data revealed the fact that approximately 36 percent of the vehicles crossed the entire roadway and departed on the opposite side

from the initial roadway departure. Among different contributory factors, alcohol was the major one, followed by speed, inattention and fatigue/sleep. It was also found that overcorrection had a strong positive association with the presence of rumble strips, inclement weather, rural locations, incapacitated drivers, and running off the road to the left or straight and a strong negative association with male drivers, speeding, paved or curbed shoulders, wet or slippery roads, and larger vehicles. Fewer than 20 percent of fatal ROR crashes occurred where rumble strips were present; drivers were more than fifty percent were more likely to overcorrect than when they were not present.

In another research conducted by Dissanayake (2003), a sequential binary logistic regression modeling was used to identify the most important factors of ROR crashes and to estimate the severity of young driver ROR crashes. The study investigated that use of alcohol or drugs, ejection in the crash, gender, impact point of the vehicle, restraint device usage, urban/rural nature, grade/curve existence of the crash location, lighting condition, and speed were the most important factors affecting the severity of young drivers in single vehicle ROR crashes.

3. DATA AND METHODOLOGY

Crash data from 2007 to 2011 were obtained from the Kansas Department of Transportation (KDOT). This data set, KCARS database, is comprised of all police-reported crashes that occurred in Kansas, U.S.A. The police officers fill an accident report form including contributory causes and send to KDOT within ten days of the investigation for any crash which occurs on a public roadway and which results in death or injury to any person or total property damage of $1,000 or more (KDOT 2013). More details of the recording each of the variables can be found from the KDOT accident reporting manual (KDOT 2013).

The KCARS is Access based database which consists of several tables describing each crash. The definition for ROR crashes in this study was the crashes where the vehicles leaving the roadway encroach upon the median, shoulders, or beyond and either overturns, collides with fixed objects or leads to head-on crashes with other vehicles; sideswipe with opposing vehicles; or crashes where the first harmful events occur off the roadway or median-off roadway in case of divided highway sections. The tables in the KCARS database were combined and queries were made to filter all ROR crashes in order to compare rural and urban ROR crashes. From the data, it has been found that ROR crashes were approximately to 18% that of total crashes for combined crash data from 2007 to 2011. For the same time period in Kansas injury ROR crashes were found to be approximately 24% of the total injury crashes and fatal ROR crashes were 54% to that of total fatal crashes. Data were used to investigate ROR crashes, and calculating their frequencies and percentages. The next step of the research is to develop separate crash severity models for investigate the further differences.

4. RESULTS AND DISCUSSION

During 2007 to 2011, there were 43,335 ROR crashes occurred in rural Kansas roadways that accounted for 48.8% of total ROR crashes occurring in Kansas. Figure 1 shows number of ROR crashes occurred on rural Kansas roadways and urban Kansas roadways by year.

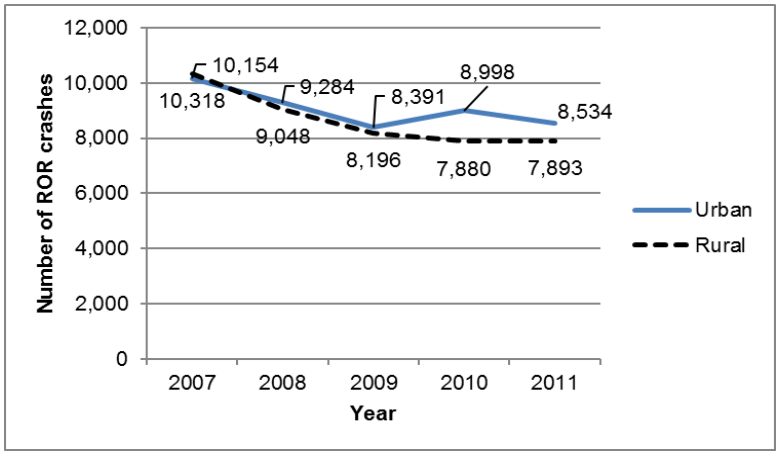

Figure 1: Rural and Urban ROR crashes by Year

Though the number of ROR crashes in rural Kansas decreased in 2011 in comparison to each of the prior four years, they continued to comprise a uniform percentage (approximately 8.5%) of total crashes. Percentages in each sub-category were calculated by taking the total number of ROR crashes as the base value. Data such as numbers of crashes and percentages for each characteristic and contributory cause were presented in tabular format. The variables were organized under driver, environmental, road, vehicle, and crash-related characteristics, and contributory causes. Information such as "unknown" and/or "other" for some of variables was not presented in the tables. Hence, the sum of the percentage for a particular variable is slightly less than 100.

The frequencies and percentages of ROR crashes for environmental-related characteristics are given in Table 1. About 37.2% of ROR crashes on rural roads occurred in the dark and approximately 39.1% of ROR crashes on urban roads occurred in the dark. The percentage of ROR crashes represented on rural roads (16.2%) during 00:00 am- 6:00 am was slightly lower than that of crashes represented urban roads (18.0%). During weekends, the percentage of ROR crashes on rural roads (32.1%) was slightly higher than that of crashes on urban roads (30.0%).

Table 1: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Environmental Related Factors

Environmental-Related Characteristics	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Light Conditions						
Daylight	27,178	59.9	26,927	62.1	54,167	61.0
Dark	17,733	39.1	16,138	37.2	33,922	38.2
Weather Conditions						
Normal conditions	32,490	71.6	30,753	71.0	63,330	71.3
Adverse conditions	12,477	27.5	12,288	28.4	24,791	27.9
Time of Crash						
6.00-12.00-Morning	11,251	24.8	11,621	26.8	22,904	25.8
12.00-18.00-Afternoon	14,571	32.1	13,605	31.4	28,209	31.8
18.00-24.00-Evening	11,364	25.1	11,094	25.6	22,485	25.3

00.00-6.00-Night	8,175	18.0	7,015	16.2	15,211	17.1
Day of Week						
Week days	31,698	69.9	29,382	67.8	61,162	68.9
Week end	13,594	30.0	13,919	32.1	27,544	31.0
Total Number of Crashes	45,361	100.0	43,335	100.0	88,809	100.0

The frequencies and percentages of ROR crashes for driver-related characteristics are given in Table 2. Higher percentage of male drivers was involved ROR crashes on rural roads compared to ROR crashes on urban rods. Also, the percentages of middle age and older drivers in ROR crashes were slightly higher when they were traveling on rural roads than traveling on urban roads. The percentage of restricted licenses holders' representation in rural ROR crashes (34.1%) was slightly higher than in urban ROR crashes (27.6%). The percentage of unrestrained drivers in rural ROR (11.9%) was higher than the drivers in urban ROR crashes (7.5%).

Table 2: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Driver Related Factors

Driver-Related Characteristics	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Gender						
Female	15,568	34.3	14,953	34.5	30,558	34.4
Male	26,565	58.6	27,405	63.2	54,045	60.9
Age						
Young (<24 years)	17,814	39.3	16,104	37.2	33,937	38.2
Middle Age (25-64 years)	25,284	55.7	24,561	56.7	49,931	56.2
Old (>64 years)	2,263	5.0	2,670	6.2	4,941	5.6
License Compliance						
Valid licensed	36,047	79.5	38,827	89.6	74,973	84.4
Not valid licensed	4,881	10.8	3,039	7.0	7,933	8.9
Restriction Compliance						
No restrictions on driver license	25,496	56.2	25,242	58.2	50,795	57.2
Restricted license	12,529	27.6	14,795	34.1	27,367	30.8
Safety Equipment used						
Safety belt used	33,759	74.4	33,352	77.0	67,190	75.7
Safety belt not used	3,408	7.5	5,159	11.9	8,592	9.7
Airbag						
Airbag deployed	3,535	7.8	2,658	6.1	6,218	7.0
Airbag not deployed	38,991	86.0	35,951	83.0	75,016	84.5
Alcohol/drug related						
Alcohol/drug related	5,560	12.3	4,238	9.8	9,835	11.1

No alcohol or drug	39,801	87.7	39,097	90.2	78,974	88.9
Total Number of Crashes	45,361	100.0	43,335	100.0	88,809	100.0

It is important to investigate the frequencies and percentages of ROR crashes for road-related characteristics by rural and urban nature. As shown in Table 3, higher percentage of ROR crashes were reported on black tops in rural areas compared to urban areas. Also, the percentages of ROR crashes were slightly higher when they were recorded on gravel/brick and other road surfaces in rural areas than urban areas. The percentages of ROR crashes on dry surfaces and debris surfaces in rural areas were slightly higher than that of urban areas. The percentage of rural ROR crashes (53.9%) on roadways with posted speed limit between 35 mph and 60 mph was higher than that of urban ROR crashes (39.0%). When the roadway posted speed limit was more than 60 mph, the percentage of rural ROR crashes (34.1%) was nearly twice that of urban ROR crashes (17.7%).

The frequencies and percentages of ROR crashes for vehicle-related characteristics are shown in Table 4. Automobiles had the largest share both for rural and urban ROR crashes although the percentage of urban ROR crashes involving automobiles was slightly higher than the percentage of rural ROR crashes involving automobiles. Pickup trucks and camper-rv have a slightly higher percentage for rural ROR crashes than that for urban ROR crashes. The percentage of rural truck ROR crashes were approximately twice that of urban crashes. When examining the percentages of ROR crashes by vehicle age, there distribution of rural ROR by vehicle age was close to the distribution of urban ROR crashes by vehicle age. The percentage of sole drivers involving rural ROR crashes was slightly lower than urban ROR crashes.

Table 3: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Road Related Factors

Road-Related Characteristics	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Road Surface Type						
Concrete	16,796	37.0	5,490	12.7	22,321	25.1
Black top	27,024	59.6	26,414	61.0	53,516	60.3
Gravel/brick or other	1,370	3.0	11,347	26.2	12,717	14.3
Road Surface Condition						
Dry	28,224	62.2	27,788	64.1	56,097	63.2
Wet	7,609	16.8	4,974	11.5	12,589	14.2
Debris	9,093	20.0	10,330	23.8	19,445	21.9
Road Surface Character						
Straight and level	27,923	61.6	25,250	58.3	53,228	59.9
Straight not level	8,355	18.4	10,374	23.9	18,761	21.1
Curved	8,601	19.0	7,356	17.0	15,983	18.0
Posted Speed Limit						
Less than 35 mph	19,646	43.3	5,195	12.0	24,848	28.0
35-60 mph	17,705	39.0	23,365	53.9	41,115	46.3
More than 60 mph	8,010	17.7	14,775	34.1	22,846	25.7
Total Number of Crashes	45,361	100.0	43,335	100.0	88,809	100.0

Table 4: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Vehicle Related Factors

Vehicle-Related Characteristics	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Vehicle Type						
Automobile	24,461	53.9	18,062	41.7	42,572	47.9
Van	2,267	5.0	2,018	4.7	4,289	4.8
Pickup-truck, camper-rv	7,200	15.9	11,593	26.8	18,809	21.2
Sport utility vehicle	7,018	15.5	6,819	15.7	13,856	15.6
Truck	1,561	3.4	3,195	7.4	4,772	5.4
Vehicle Age						
Year 4 or newer	12,005	26.5	11,617	26.8	23,651	26.6
5-9 years	17,627	38.9	16,852	38.9	34,518	38.9
10-14 years	12,566	27.7	12,048	27.8	24,646	27.8
Year 15 or older	5,967	13.2	5,490	12.7	11,477	12.9
Occupants						
Only driver	33,666	74.2	30,971	71.5	64,716	72.9
Driver and passengers	11,194	24.7	12,079	27.9	23,306	26.2
Total Number of Crashes	45,361	100	43,335	100	88,809	100

As shown in Table 5, the percentage of rural ROR fatalities was higher than urban ROR fatalities. Also, the percentages of disable injuries, injuries, or possible injuries for ROR crashes occurred in rural areas were higher than that of urban areas.

Table 5: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Crash Related Factors

Crash-Related Characteristics	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Crash Severity						
Fatal crashes	376	0.8	1,081	2.5	1,485	1.7
Injury crashes	13,180	29.1	15,651	36.1	28,878	32.5
Non-injury crashes	31,805	70.1	26,603	61.4	58,446	65.8
Driver Injury Severity						
Fatal injury	245	0.5	716	1.7	977	1.1
Disabled injury	1,177	2.6	1,965	4.5	3,154	3.6
Injury	4,980	11.0	7,147	16.5	12,150	13.7
Possible injury	4,248	9.4	4,780	11.0	9,041	10.2
Not injured	30,066	66.3	26,570	61.3	56,684	63.8
Ejection						
Ejected	1,086	2.4	1,586	3.7	2,693	3.0
Not ejected	40,200	88.6	37,857	87.4	78,138	88.0
Trapped	594	1.3	1,515	3.5	2,120	2.4
Vehicle Damage						
Not damage	695	1.5	677	1.6	1,373	1.5
Minor damage	6,276	13.8	4,886	11.3	11,169	12.6
Functional	10,477	23.1	8,311	19.2	18,801	21.2
Disabling	21,326	47.0	18,399	42.5	39,767	44.8
Destroyed	4,681	10.3	10,177	23.5	14,907	16.8
Vehicle Maneuver Before Un-stabilized Situation						
Straight-following	27,103	59.7	31,762	73.3	58,940	66.4

Turn or changing lanes	9,055	20.0	3,723	8.6	12,788	14.4
Avoiding maneuver	2,509	5.5	1,334	3.1	3,845	4.3
Stopped, parking or backing	4,056	8.9	4,848	11.2	8,924	10.0
Accident Class						
Collision with vehicle	12,966	28.6	6,420	14.8	19,425	21.9
Collision with object	29,629	65.3	26,854	62.0	56,541	63.7
Collision with animal	70	0.2	438	1.0	508	0.6
Collision with pedestrian	58	0.1	18	0.0	76	0.1
Non-collision & overturned	2,622	5.8	9,590	22.1	12,228	13.8
Manner of Collision						
Head on	8,001	17.6	2,934	6.8	10,962	12.3
Rear end	248	0.5	150	0.3	398	0.4
Angle side impact	428	0.9	247	0.6	679	0.8
Sideswipe	4,891	10.8	3,227	7.4	8,128	9.2
Backed into	55	0.1	55	0.1	110	0.1
Total Number of Crashes	45,361	100	43,335	100	88,809	100

Higher percentage of ROR crashes involving drivers ejected or trapped in rural areas than those in urban areas. The percentage of vehicle destroyed at the time of ROR crashes occurred in rural areas slightly higher than twice that of crashes occurred in urban areas. The percentages of ROR crashes occurred driving on straight-following roadways in rural areas were higher than that of urban areas. The percentage of rural ROR crashes occurred when attempting to turn or lane changing was lower that urban ROR crashes that of urban areas this may due to low complexity in rural areas. Also, when the vehicle maneuver was stopping, parking or backing, higher percentage of rural ROR crashes were reported than urban ROR crashes. When examining the percentages of ROR crashes by accident class, approximately 22.1% of rural ROR crashes were non-collision or overturn crashes which were higher than that of urban ROR crashes 5.8%. A higher percentage of urban ROR crashes were related to collision with a vehicle than that of rural ROR crashes. About 17.6% of urban ROR crashes was head-on crashes, that was higher than the percentage of rural head-on ROR crashes (6.8%).

Contributory causes for rural and urban ROR crashes were also investigated using Kansas crash data. Since a single cause is rarely to blame for a traffic crash, many factors have been considered. Driver-related contributory causes involve the condition of or actions taken by the driver of the vehicle, while environmental, road or vehicle-related contributory causes involve the environmental, road or vehicle conditions at the time of crash. The frequencies and percentages of ROR crashes for contributory causes are shown in Table 6. The contributory causes were reported according to the opinion of the accident investigating officer. Driving fast was the top-ranked driver contributory cause in rural ROR crashes(22.2%), followed by inattention (18.9%), and avoidance/evasive or slow (8.3%), and improper actions taking by the driver (8.3%). Driving fast and inattention were also the most frequent contributory causes in urban ROR crashes.

Table 6: ROR Crash Frequencies and Percentages by Urban/Rural Nature: Contributory Causes

Contributory Causes	Number of ROR Crashes					
	Urban		Rural		Total	
	Number	%	Number	%	Number	%
Driver Action Related						
Driving fast	11,800	26.0	9,613	22.2	21,426	24.1
Avoidance/ evasive or slow	3,098	6.8	3,581	8.3	6,694	7.5
Improper action	3,080	6.8	2,017	4.7	5,116	5.8
Aggressive driving	3,543	7.8	1,509	3.5	5,057	5.7

Disregarded traffic signs/signals	3,056	6.7	1,457	3.4	4,529	5.1
Turning or lane changing	2,731	6.0	784	1.8	3,522	4.0
Failure to yield right of way	3,304	7.3	708	1.6	4,014	4.5
Driver Condition Related						
Alcohol impaired	5,736	12.6	3,755	8.7	9,515	10.7
Ill, falling asleep or fatigued	2,413	5.3	2,981	6.9	5,407	6.1
Driver Distractions Related						
Inattention	9,891	21.8	8,201	18.9	18,118	20.4
In vehicle distraction	1,556	3.4	1,599	3.7	3,160	3.6
Total Crashes Occurred Due to Driver Factors	35,645	78.6	26,322	60.7	62,046	69.9
Environmental Related						
Animal	4,194	9.2	5,062	11.7	9,267	10.4
Weather related	335	0.7	1,744	4.0	2,081	2.3
Vision obstruction	293	0.6	253	0.6	550	0.6
Total Crashes Occurred Due to Environmental Factors	4,793	10.6	6,991	16.1	11,801	13.3
Total Crashes Occurred Due to Vehicle Factors	1,177	2.6	1,055	2.4	2,234	2.5
Total Crashes Occurred Due to Road Factors	7,285	16.1	6,283	14.5	13,576	15.3
Total Number of Crashes	45,361	100	43,335	100	88,809	100

The percentages of urban ROR crashes due to driving fast, improper action, aggressive driving, disregarding traffic signs/signals, turning or lane changing, and failure to yield right of way were higher than that of rural ROR crashes. The percentage of total urban ROR crashes occurred due to driver contributory causes was higher than that of rural ROR crashes. The most frequent environmental-related contributory causes was animal at the road and its percentage for rural ROR crashes (11.7%) was slightly higher than that of urban ROR crashes (9.2%). The percentage of total rural ROR crashes (16.1%) occurred due to environmental contributory causes was higher than that of urban ROR crashes (10.6%). On the other hand, the percentage of total rural ROR crashes (14.5%) occurred due to vehicle contributory causes was slightly lower than that of urban ROR crashes (16.1%).

5. SUMMARY AND CONCLUSION

This study compare the characteristics and contributory causes of rural ROR crashes and urban ROR crashes using crash data. The variables which have greater association with rural ROR crashes compared with urban ROR crashes were identified. Higher percentage of rural ROR crashes were reported during driving on day light condition, adverse weather condition, morning (6:00 am to 12:00 am) hours, or weekends. Also, male drivers or middle age drivers were likely to involve in rural ROR crashes compared to urban ROR crashes. When considered on roadway characteristics, higher percentage of rural ROR crashes were reported on gravel/brick road surface, dry road surfaces, debris road surfaces, driving on straight not level road surfaces, or posted speed more than 35 mph compared to urban ROR crashes. Pick-up trucks, camper-rv, trucks were more likely to involve rural ROR crashes compared to urban ROR crashes. Higher percentage of rural ROR crashes were reported vehicle maneuver was straight-following or non-collision and overturn than urban ROR. When considered with contributory causes for ROR crashes, avoidance/evasive or slow, ill, falling asleep or fatigued, or animal at the road is more common on rural roadways than urban roadways. These results will help to develop appropriate countermeasures in preventing ROR crashes.

6. REFERENCES

Benavente, M., H. A. Rothenberg, and M. A. Knodler Jr., 2006. *Evaluation of Frequency and Injury Outcomes of Lane Departure Crashes,* in 2006 ITE Annual Meeting and Exhibit Compendium of Technical Papers.

Dissanayake, S., 2003. *Young Drivers and Runoff Road Crashes.* Proceedings of the 2003 Mid-Continent Transportation Research Symposium, Iowa.

Fatality Accident Report System (FARS), 2012. National Highway Traffic Safety Administration, U.S. Department of Transportation.http://wwwfars.nhtsa.dot.gov/Main/index.aspx. Accessed June 14, 2012.

Hallmark, S. L., Y.Y. Hsu, T. H. Maze, T. J. McDonald, and E. J. Fitzsimmons, 2009. *Investigating Factors Contributing to Large Truck Lane Departure Crashes Using the Federal Motor Carrier Safety Administration's Large Truck Crash Causation Study (LTCCS) Database*. Center for Transportation Research and Education, Iowa State University.

Kansas Department of Transportation, 2013. *Kansas Motor Vehicle Accident Report Coding Manual, Strategic Highway Safety Plan,* http://www.ksdot.org/burtransplan/prodinfo/lawinfo/2012_Motor_Vehicle_Coding_Manual_v1_web.pdf, Accessed March 3, 2013.

Liu, C., and R. Subramanian, 2009. *Factors Related to Fatal Single-vehicle Run-off-road Crashes*, Report No. DOT-HS-811-232, U.S. Department of Transportation.

Mak, K. K., 2010. *Identification of vehicular impact conditions associated with serious run-off-road crashes,* Report No. 665, Transportation Research Board of the National Academies.

McGinnis, R. G., M. J. Davis, and E. A. Hathaway, 2001. *Longitudinal Analysis of Fatal Run-off-road Crashes, 1975 to 1997*, in Transportation Research Record of the National Academies: Journal of the Transportation Research Board, vol. 1746, no. 1, pp.47-58.

McLaughlin, S. B., J. M. Hankey, S. G. Klauer, and T. A. Dingus, 2009. *Contributing Factors to Run-off-road Crashes and Near-crashes*, Report No. DOT-HS-811-079, U.S. Department of Transporation.

Montella, A., and M. Pernetti, 2010. *In-depth Investigation of Run-off-the-road Crashes on the Motorway Naples-Candela,* Proceedings of the 4th International symposium on highway geometric design, pp. 2-5.

Spainhour, L. K., and A. Mishra, 2008. Analysis of Fatal Run-Off-The-Road Crashes Involving Overcorrection. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2069, TRB, National Research Council, Washington, D.C., pp. 1-8.

Sullivan, J. M., and M. J. Flannagan, 2002. The Role of Ambient Light Level in Fatal Crashes: Inferences from Daylight Saving Time Transitions," *Accident Analysis and Prevention*, vol 34, no. 4, pp.487-498.