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Research paper

The status of all types of rollover crashes in Northern Iran and the contributing factors

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Abstract

Introduction: There is little information about this type of traffic accident in northern Iran.

Aim: This study aimed to determine the status of rollover crashes and the factors relating them.

Material and methods: This was a retrospective analytical study. The data of this study were obtained from the reports of Traffic Police and the Department of Forensic Medicine. The data of this study included related data on vehicle damages, injuries, and fatalities of 5999 rollover crashes of motor and non-motor vehicles. All analyses were performed with Excel and SPSS v. 21 software.

Results and discussion: The probability of mortality due to rollover crashes decreases on slippery ($P < 0.001$) with age ($P < 0.001$) and at night ($P < 0.001$) and increases on road curves ($P = 0.005$) .
The probability of injuries reduced with increase with age ($P < 0.000$) and in men ($P < 0.027$), on slippery roads ($P < 0.04$), heavy vehicle ($P < 0.001$), car ($P < 0.009$), pickup trucks ($P = 0.011$), but increased on the road curves ($P < 0.001$).

Conclusions: Countermeasures include training drivers to increase their ability to control the vehicle and pay attention to the front and avoid driving in the opposite direction at the speed limit. Moreover, installing lower speed limits and installing speed cameras in high-risk areas reduce crashes. Corrective changes to the road and reduce road curve sharpness are as effective as trying to change drivers' behavior.

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1. INTRODUCTION

Traffic accidents are a major cause of death and injury in the world. According to the World Health Organization, these accidents lead to the death of 1.2 million people and the disability of 20–50 million people every year in low- and middle-income countries.[1,2]

Rollover crashes are one of the most deadly types of traffic accidents. In Europe, rollover crashes mortality is estimated to be 1 in 10 deaths, and in the United States, 1 in 3 to 4 death.[3] In Iran, every 33 minutes 1 person dies in traffic accidents. Rollover crashes with more than 30%, prevalence is the most common accidents leading to death on the country's roads. A high percentage of traffic accidents leading to death and injury occur as a result of a vehicle deviating from the route. Most of these mortalities and morbidities occur as a result of rollover and collision of vehicles with fixed roadside objects.[4,5] A rollover or overturning is a type of traffic accident in which the vehicle turns toward the roof or sideways. Rollover crashes are mainly classified into two types; off-road overturning and road surface overturning, which account for 95% and 5% of rollover crashes, respectively.[6] One of the important injured organs in rollover crashes is parts of the head, neck, and spine, which is due to the deformation of the car's roof and its effect on these areas. Studies have also reported a strong association between roof deformation and injuries to occupants.[7–9]

The rollover crashes are related to some factors including vehicle type, driver, and environmental factors. Among the most important vehicles at risk of rollover, vehicles are very heavy and often occur in maneuvers to prevent accidents at high speeds.[6] Some types of these vehicles are at risk of rollover, trucks, buses are pickup trucks, and SUVs (sport utility vehicle). The rollover crash rate for pickup trucks and SUVs is approximately five times that of other types of crashes involving this group of vehicles.[6,10,11]

Factors related to driver's behavior are also important in the formation of this type of traffic accident. Excessive speed, fatigue, and distraction of the driver cause the vehicle to deviate off the road and the driver is no longer able to control the vehicle.[12,13] Among the factors related to the drivers, speed plays a more important role and about 40% of fatal accidents are rollovers due to high speed, which mainly occurs on roads with a speed limit of 90 km/h or more.[14–16]

Among the environmental factors related to rolling over, weather condition has been investigated in the studies. The results of modeling by Kordani et al. (2017) demonstrated that the variables of rainy and foggy weather, with coefficients of 0.73 and 0.71, respectively, have the greatest effect on the occurrence of rollover. Also, the shoulder width of the road and night condition with coefficients of 0.22 and 0.18, respectively, had the least effect on the occurrence of this accidents.[13]

In northern Iran (Guilan province), few studies have been performed on rollover crashes. In particular, studies on factors affecting this type of collision in all types of motor and non-motor vehicles are rare. Therefore, the present study was necessary to identify the factors affecting rollover crashes in controlling and reducing the incidence and severity of such collisions. This can provide deep insight into this particular field of research.

2. AIM

Therefore, in the present study, the status of rollover crashes and the factors affecting them in the north of Iran between 2014 and 2017 were determined.

3. MATERIAL AND METHODS

This is a retrospective analytical study that reviewed all data of 4-year rollover crashes (2014–2017) in northern Iran. The data of this study were obtained from the reports of two reliable sources; Police Traffic Safety Department and Forensic Medicine Research Unit which included the data on damages, injuries (occupants trapped in or thrown out) and fatalities of 5999 rollover crashes in motor and non-motor vehicles (on bicycles, motorcycles, cars, pickup trucks, SUVs, light and heavy trucks). All input was used to analyze the risk factors affecting rollover crashes and determine their role.

3.1. Data collection tools

The analyses were performed using only the extracted results from the data obtained from the 5-page sheet for completing the traffic accident report. The impact of different variables in these crashes such as geographical location, age of driver, geometric condition of the road, time of occurrence, type of vehicle (truck, minibus, car, etc.) was estimated separately for each rollover crash.

3.2. Statistical analyses

After sorting data, descriptive statistics of mean and standard deviation and ratio, etc. were used to calculate the frequency as well as the ratio and role of the mentioned factors. In the analytical statistics, multiple logistic regression models with dependent variables of mortality and injuries due to rollover crashes and independent variables such as road condition (slope, etc.), weather condition (rainy, sunny, etc.), and ground condition (dry, wet, etc.) were analyzed and their effects were measured. All of the analyses were performed using Excel and SPSS v. 21 software. The level of significance was $P < 0.05$.

4. RESULTS

A total of 5999 rollovers, vehicle damages, injuries, and deaths due to rollover crashes occurred in the period 2014–2017. In 5329 rollover crashes, age was recorded in which the highest number dedicated to the age group of 20–30 years ($n = 1882$; 33.90%) with a downward trend, so that in the age

group of 80–90 years, it reached 10 (0.18%) crashes. Most of these crashes (n = 5334; 92.01%) were rollovers that occurred for male drivers.

Of the 5903 rollover crashes whose cause was recorded, most of the causes were failure to control the vehicle (4263), followed by not paying attention to the front (1050), deviation (38) and failure to follow safety tips (37), respectively.

In the majority of rollover crashes (n = 2688; 45.62%), at least 1 person was injured. In 2157 rollover crashes (31.61%), there were no injuries. The highest and lowest number of rollover crashes were on straight flat roads (n = 4534, 75.57%) and in tunnels (n = 1, 0.01%). The rate of these crashes during the study period had an upward trend so it elevated from 1493 collisions in 2014 to 1508 collisions in 2017. The ratio of the number of deaths due to rollover crashes in the north of Iran equaled 7.11%. In addition, the highest number of rollover crashes on dry roads was calculated at 4725 (79.86%).

The most and least rollover crashes occurred at 1:00 p.m. (376) and 5:00 a.m. (92). According to the adjusted coefficient, the highest and lowest rates of rollover crashes on the northern roads of Iran were at 1:00 a.m. (1.91) and 8:00 a.m. (0.16)

Among all vehicle types, the highest and lowest number of rollover crashes belonged to cars (n = 4094; 69.22%) and heavy vehicles (n = 328; 5.54%), respectively. Moreover, the highest number of rollover crashes per 1000 vehicles was dedicated to motorcycles and bicycles (210.86 per 4804), while the lowest rate of rollovers belonged to pickup trucks (39.58 per 11746) (Table 1).

In determining the factors affecting mortality due to rollover crash, it was found that the probability of mortality decreases on slippery roads (IRR = 0.536; P = 0.000) with increase in age (IRR = 0.979; P = 0.000) and at night (IRR = 0.470; P = 0.000) while it increases on road curves (IRR = 1.393; P = 0.005) (Table 2).

In determining the factors affecting the injuries caused by rollover crashes, it was determined that the probability of injuries reduced with increase in age (IRR = 0.993; P = 0.000), in men (IRR = 0.890; P = 0.027), on slippery roads (IRR = 0.923; P = 0.04), in heavy vehicles (IRR = 0.23; P = 0. 0.000), cars (IRR = 0.520; P = 0.009), and pickup trucks (IRR = 0.522; P = 0.011), but increased on road curves (IRR = 1.137; P = 0. 0.000) (Table 3).

Table 1. The number of rollover crashes depending on the type of vehicle during 2014–2017 in the north of Iran.

Vehicle type	*N*	%	Cars (*N*)	Cars (in 1000 vehicles)
Not specified	14	0.23	—	—
Car	4094	69.22	97044	42.18
Motorcycles and bicycles	1013	17.12	4804	210.86
Heavy vehicles	328	5.54	2408	136.21
Pickup trucks	465	7.86	11746	39.58
Total	5914	100	116002	50.98

Table 2. Factors affecting mortality due to rollover crashes in the north of Iran during 2014–2017.

Mortality factors	IRR	Std. Err.	*z*	*P* > *z*	CI 95%	
Slippery road	0.536	0.090	–3.68	0.000	0.384	0.747
Road curves	1.393	0.163	–2.83	0.005	1.107	1.753
Night	0.470	0.050	–6.96	0.000	0.380	0.582
Age	0.979	0.005	–3.94	0.000	0.969	0.989
Male	1.241	0.272	0.98	0.326	0.806	1.910
Vehicle type						
Car	0.852	0.855	–0.16	0.874	0.119	6.091
Motorcycles and bicycles	1.211	1.219	0.19	0.849	0.168	8.710
Heavy vehicle	1.026	1.056	0.03	0.979	0.136	7.718
Pickup trucks	0.786	0.806	–0.23	0.815	0.105	5.870

Table 3. Factors affecting injuries due to rollover crash in the north of Iran during 2014–2017.

Mortality factors	IRR	Std. Err.	*z*	*P* > *z*	CI 95%	
Slippery road	0.923	0.035	–2.05	0.04	0.855	0.996
Road curves	1.137	0.039	3.73	0.000	1.063	1.217
Night	0.992	0.030	–0.26	0.795	0.935	1.052
Age	0.993	0.001	–4.71	0.000	0.991	0.996
Male	0.890	0.046	–2.21	0.027	0.804	0.986
Vehicle type						
Car	0.520	0.130	–2.6	0.009	0.318	0.852
Motorcycles & bicycles	0.668	0.168	–1.59	0.111	0.407	1.096
Heavy vehicle	0.237	0.063	–5.36	0.000	0.140	0.401
Pickup trucks	0.522	0.133	–2.53	0.011	0.316	0.863

5. DISCUSSION

In the present study, a significant number of rollover crashes have been reported in the north of Iran, resulting in injuries and deaths. Cost of treatment of injured patients might be high in rollover crashes because the injury and disability is high in these patients and they might need rehabilitations and home care.[17–19] Findings of the study on the age groups of people involved in rollover crashes unveiled that the highest number of accidents occurred for the age group of 20–30 years which has a downward trend so that it reaches the lowest level in the age group of 80–90 years. Studies in line with the findings of the present study report that young drivers were more likely to have rollover crashes than other age groups.[20–22] Therefore, with the increase in age, driver-related factors such as failure to control the vehicle and lack of attention to the front, and unauthorized speed due to reduced excitement and improved driving skills decrease. As people age, they become more conservative and avoid speeding and driving at night to prevent injuries. The extra experience of driving under dangerous situations also increases the driver's readiness to control the vehicle.

Findings from the study exhibited that 92% of rollover crashes occurred for male drivers. The results of some other

studies were in line with the findings of the present study. For example, based on a study, young and middle-aged men were involved in more rollover crashes than the same-age women.[21] In addition, men suffered more severe injuries in rollover crashes than women.[16] In the present study, men were more incapable of controlling the vehicle and not paying attention to the front (probably due to the use of cell phones), and driving fast. Women were less prone to dangerous situations (e.g. when driving in the dark and rainy conditions) and dangerous driving (low attention to the front and high speed) due to their cautious personality traits.

In the present study, most of the accidents occurred due to the failure of the drivers to control the vehicle and lack of attention to the front. Speeding and wrong direction were the next important causes. The results of one estimation also revealed that the car rollover was significantly associated with six variables of not driving in a single lane, violating the speed limit, driving in rural roads and SUVs with not driving in a single lane, unavoidable measures, vehicle age, and rural areas.[23] In another study, analysis of subscales of driver's behavior showed that a driver with higher offensive scores is more likely to drive faster in road curves, and an improved speed model can prevent the dangers of turning and road curves.[24] Also in an Iranian study, careless driving and abnormal driver behavior increased the likelihood of more severe consequences when driving at a speed of 40i80 km/h in rollover crashes. Speed and obstruction of vision lead to more severe consequences when the road lighting conditions are not sufficient.[16] These findings provide in-depth insights into the nature of causation and the factors affecting the severity of driver's injury in rollover accident.[5,23]

Therefore, rollovers are mostly associated with driver-related factors such as failure to control the vehicle, lack of attention to the front, speeding, and driving in the opposite direction. In previous studies, driver-related factors such as the failure of the driver to turn properly in the curves,[23] the driver's distraction,[25] fatigue and drowsiness,[26] and alcohol and drug use[23] have been repeatedly emphasized. Among these causes, unauthorized speed is the most important factor in rollover crashes.[15,25,27]

The findings of the present study suggested that in most rollovers, at least one person is injured and the ratio of the number of deaths to crashes was equal to 7.11% in 5815 rollovers in the north of Iran. In 2016, in China, 5036 rollovers occurred which constituted only 2.68% of the total motor vehicle accidents, being responsible for 5.64% of total fatal crashes.[28] The results of some other studies were in line with the findings of the present study. For example, a study reported that significantly more deaths and injuries occurred in rollover crashes. The severity of the driver's injury increases with rollover.[29] Another found that, the injuries of upper extremity fractures were more than the lower extremity ones and fatal head and face injuries were observed in about 10% of the cases.[30] A study by Roberts found that most fatal severe injuries in rollover crashes were in head and neck due to head-neck contact with the roof during the motor vehicle accidents. It concluded that in rollovers, occupants suffered fatal injuries due to more severe vehicle damage. Passengers are also more likely to be thrown out, which increases fatalities due to rollover.[8] It can be concluded that in rollover crashes, usually the vehicle's structure cannot properly protect the occupants and they may suffer fatal head and neck injuries due to further damage to the vehicle's roof as a result of colliding with trees or any similar object.[31] Also, passengers are more likely to be thrown out,[25] which increases the number of deaths due to rollover accidents.

Findings of the study on the time series of rollovers in the north of Iran exhibited that the rate of rollover crashes during the study period had an upward trend. In other studies, rollover crashes had a statistically increasing trend,[32,33] but this is the reason for neglecting these types of crashes and the need to pay more attention to them.[33]

In the present study, the highest number of rollover crashes occurred in flat straight road conditions and road curves, respectively. Since in northern Iran, the roads are mostly flat and without curves, the number of rollovers and any type of traffic accidents is higher at these levels. However, if the number of the toll road was controlled, more accurate results could be obtained.

In the present study, about 80% of rollover crashes occurred on dry land. In the study of Padmanaban (2008), 90% of overturning accidents occurred on dry roads.[34] In an Iranian study, the occurrence of rollovers was more in rainy and foggy weather.[13] However, the likelihood of rollover crashes increased on dry days in our study probably because of the more days with dry weather during the study period. On the other hand, some similar studies have shown that drivers are more cautious in rainy weather and wet roads than on dry roads, and as a result, the number of rollovers was lower on these days.[34,35] However, in a study on multi-vehicle accidents, when the road was wet, the vehicle was more unstable and more likely to roll over.[36] Due to the lack of any control variable, it was not possible to investigate the effect of road wetness and dryness on rollover accidents in this study.

In the present study, the highest number of rollovers per number of traffic was at 1:00 a.m. and in the dark and the lowest was at 8:00 a.m. In a study by Roy and Dissanayake (2011), the probability of rollover in the dark air at midnight at 3:00 a.m. was higher.[37] Most of these collisions likely occur at 1:00 a.m. due to the driver's fatigue and drowsiness and darkness.

In the present study, the highest number of rollovers in 1000 vehicles is dedicated to motorcycles/bicycles and heavy vehicles. Some other studies emphasize more rollover of heavy vehicles and worse static stability factor of heavy than light vehicles.[36]

Also in a new study, the risk of rollover of light trucks such as minibuses and heavy vehicles such as trucks is higher than personal cars.[38] Trucks, pickup trucks, and SUVs which have a higher center of gravity can be unstable during driving and are more prone to rollover.

In determining the factors affecting mortality due to roll over, it was found that the probability of mortality with slippery surfaces decreases with age and at night while it increases in road curves. A similar study found that the possibility of serious and fatal injuries in rollover crashes

increase on rough terrain and blacktop road surface and rural roads, and the outcome of the injury severity in rollover crashes can vary due to regional differences.[25]

It was also found that the probability of injuries decreases with age, being a man, on slippery roads with heavy vehicles, cars, and pickup trucks, but increases in road curves. In one study, the risk of rollovers was high in heavy vehicle drivers who were under the age of 21 and exposed to alcohol, illegal drugs, fatigue, or other medical conditions. The three factors that had no lasting effect on the risk of rollover in vehicle collisions were undivided highways, driver's gender, and adverse environmental conditions.[27] But in another rollover study, male drivers had less severe damage in personal cars and SUVs.[25]

Estimated results of a study on the effect of age groups on single-vehicle crashes showed that the effects of alcohol and fatigue increase the risk of fatal crashes in young and old drivers and the use of seat belts reduces this risk in middle-aged and old drivers. Road safety features including guardrail can significantly reduce the risk of fatalities among young and middle-aged drivers, and driving at night without proper lighting increases the risk of fatal crashes for them.[39] This study recommends the need to enforce the laws related to driving under the influence of alcohol and using seat belts, shaping educational campaigns on driving, and the installation of guardrails on curved roads.[40]

These findings provide transportation agencies with in-depth insights into the causal nature and determinants of mortality and injuries due to rollover crashes to determine appropriate responsive measures and reduce driver's injuries in single-vehicle rollover crashes.

One of the limitations of the present study was that to determine the adjusted coefficient of accidents in terms of traffic on the roads in northern Iran, traffic was considered on only one road. Other limitations were the lack of coordination between the police in recording data, incomplete and mist data.

5. CONCLUSIONS

In mortality and human injuries due to rollover crashes, road-related factors such as road curves, and the type of vehicle such as heavy vehicle are just as effective as driver demographic factors.

Conflict of interest

Authors declare no conflict of interest.

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Ethics

Protocol of the study was approved by ethic committee, vice-chancellery for research and technology, Guilan University of Medical Science (IR.GUMS.REC.1397.099).

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