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Risk factors for the injury severity of fatigue-related traffic accidents

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Abstract. Traffic accidents caused by drivers' fatigue carry less than one percent of the whole accidents in HLJ Province during the years 2006 to 2008. However, more than forty percent of such accidents accompanied fatalities. Drivers' fatigue is usually hard to be identified and there are no valid measures that could make real-time detection for it. Accordingly, variables such as drivers' characteristics, time of accident and whether using seat belt are considered to have close association with the injury severity in fatigue-related traffic accidents. This research focuses on analyzing injury severities of traffic accidents caused by drivers' fatigue, utilizing stepwise logistic regression method. Potential risk factors such as human, environment, road, and so on, were examined. Driving year, road pavement type, road grade and alignment, terrain, time and type of the accident, streetlight condition, vehicle type, speed limit, the number of vehicles involved, and whether using seat belt are significant factors impacting the injury severity. Identifying the high risk factors influencing the injury severity of fatigue-related accidents helps prevent the occurrence of drivers' fatigue and improve road safety conditions.

Introduction

With the great development of economy and rapid increase of automobiles in China, the problem of road traffic safety is more and more serious. Fatigue-related traffic accident is one of the most popular accident types which takes away lots of lives and properties every year. The hazard of fatigue-related accidents is very great.

Utilizing both the MNL model and the LCL model, factors such as driver age, influence of alcohol or drug, seat belt usage, speed are found to be closely related to driver injury severity levels in rural single-vehicle accidents[1]. Using a stepwise logistic regression model, the district board, road type, speed limit, time of the accident, driver's gender, and vehicle type are significant factors influencing the injury severity in multiple-vehicle traffic accidents in Hong Kong[2]. In single vehicle traffic accidents, district board, gender of driver, age of vehicle, and street light conditions are significant factors determining injury severity for private vehicles[3]. Complete or partial ejection, a lack of seatbelt use, a greater number of roof inversions, far side seating position and older occupant age significantly increased the risk of all types of injuries in rollover crashes[4]. Factors such as dynamics of the accident, seating position of occupant, use of seat belts, and age of occupant involved affect the accident severity[5]. There is a study confirming that the injury risk is higher in accidents occurring between heavy cars than for accidents between lighter cars[6]. In highway accidents, there are studies proving that average daily traffic per lane, average daily truck traffic, truck percentage, interchanges per mile, the number of horizontal curves, number of grade breaks per mile, pavement friction and weather effects are significant factors affecting road accidents severity[7].

This study aims to identify contributory factors for the injury severity of fatigue-related accidents. Several factors including accident type, seatbelt use, speed limit, time, weather, streetlight condition, road condition, road type, and professional driving years of the drivers were considered. To find significant factors of the injury severity, stepwise logistic regression was used to analyze the data of traffic accidents during the years 2006~2008 in Hlj Province.

Materials and methods

The traffic data used in this study were obtained from Hlj Provincial Department of Public Security Traffic Administrative Bureau Data System. Data about time, vehicle, driver, and environment were extracted from the system. Fatigue-related accidents were picked out from the system and researched in this study. According to the casualties and property loss in the accidents, accident severity was categorized into three groups: fatal, serious and slight.

In the study, contingency tables were constructed to examine the factors distribution according to each potential factor variable, which were used to assess the association between accident severity and the factors. And also the stepwise logistic regression was used to identify significant factors affecting the injury severity of fatigue-related accidents. Factors studied in this paper include human, road, environment, accident type, safety, vehicle and site.

Results

Applying logistic regression analysis to the data of accidents caused by driver fatigue, fifteen factors are determined to have a significant association with the injury severity of the fatigue-related accidents. Detailed results are shown in Tab. 1. The period from 0:00 to 5:59 shows the highest risk for fatal accidents caused by driver fatigue, while the lowest risk period is from 6:00 to 11:59. Besides, the period from June to August has the lowest risk, while the period from December-February and the period from September-November have a higher risk. Fatal accidents caused by driver fatigue are more likely to occur on roads without good lighting at night time. Drivers with less than 2 years of driving experience are more likely to be involved in fatal accidents. Driving on the straight road segment has a lower risk for the occurrence of fatal accidents, while driving both on the horizontal curve and vertical curve segments have higher risk. There is also greater risk while driving on the road in the mountain area or hilly region than in the plain area. Driving in the bad weather days, such as rainy day, snowy days, and foggy days, has much higher risk for fatal accidents than in good days. Giving the accident type, side impact, rear-end collision and bump fixation matter have a higher risk of fatal injury while frontal impact and scrape have a lower risk. Accidents occurred on the second-class highway have much more fatal injury, on the contrast, expressway, first-class highway, third-class highway and below have less fatal injury accidents. On the aspect of speed limit, the higher speed limit, the more severe accidents are, that is above 80 km/h having the highest risk. Road without the central reserve have higher risk for the fatal accidents. If roads have bad condition, such as overflow, ice-snow covered, bumpy, the probability of fatal accidents will be higher. The involvement of heavy trucks and buses has a much higher risk of fatal injury. The number of vehicles involved in fatigue-related accidents has a great association with the injury severity. The more vehicles involved, the more severe the accident is, single vehicle, double vehicles, multiple vehicles. Drivers using seat belt have lower risk of being involved in fatal accidents than those without using seat belt.

Discussion

This study analyzed all of the vehicle accidents occurring during the 3-year period from 2006 to 2008 in Hlj province. Data of fatigue-related traffic accidents were extracted in order to find the high risk factors affecting the injury severity of such accidents. On the basis of the results obtained in previous section, time of the accident was identified to be an important factor which could increase the risk of fatal accidents. In particular, the period from 0:00 to 5:59 has the highest risk for

such fatal accidents. This is because during this period people should have enough sleep, according to the physiological rhythm of people, but they have to be in the car rather than in the bed. So, drivers during this period are easy to become sleepy. It is too late to take any measures before the accident occurs while the vehicle is still with high speed. Thus, it will be very severe once the accident happens. Besides, night-time driving without good street lighting is another high risk factor. The first reason is that in this condition drivers need to always keep their eyes wide open in order to avoid accidents or not get lost, which will make them tired quickly. And the second is that the darkness will reduce the right judgement of drivers due to decreased vision. Drivers with less than 2-years of driving experience have the highest risk for the fatal fatigue-related accidents. Due to lack of operational experience, inexperienced drivers are prone to be nervous and take the wrong measures when they are in face with dangerous conditions, which will increase the probability of fatal accidents.

Tab. 1 Adjusted odds ratios in stepwise logistic regression analysis

Factors	O.R.	Factors	O.R.
Time of the accidents		Accident type	
0:00-5:59	2.109	side impact	1.029
Month		rear-end collision	1.402
December-February	1.281	bump fixation matter	2.107
September-November	1.010	Others	2.199
Streetlight condition		Road cross section	
no lighting at night time	2.991	without the central reserve	1.552
Road alignments		Road grade	
Horizontal curve	1.638	second-class highway	1.042
vertical curve	6.541	Road condition	
Terrain		Overflow	1.520
hilly region	1.620	Ice-snow covered	2.153
mountain area	2.269	Bumpy	1.316
Weather		No seatbelt use	3.547
Rainy	1.020	Speed limit (km/h)	
Snowy	1.515	41-80	1.025
Foggy	1.516	⩾80	2.742
Driving years		Vehicle type	
⩽2	3.081	Buses	1.221
Number of vehicles involved		Heavy truck	3.450
double vehicles	1.635		
multiple vehicles	3.705		

The results also show that people driving both on the horizontal curve road segment and on the vertical curve road segment have much more risk for fatal accidents than on the straight road segment, especially the vertical curve road segment having the highest risk. This is probably because drivers on the vertical curve or the horizontal curve road segment do not have good sight distance. Their declining alertness will exacerbate the bad condition, which could result in serious accidents. Another condition is that driving on the roads in the hilly region or mountain area is prone to be involved in fatal accidents. As we can see, vehicles will usually roll violently and do great harm to passengers' lives.

Vehicle type is also an important risk factor for fatigue-related accidents involving buses or heavy trucks exhibiting much higher risk of fatal accidents. This is because much more people will be involved in an accident once there is a bus to be involved in, which will increase the probably for fatal or serious injury. And besides, heavy trucks are at greatest risk than any other kinds of vehicles because they all have great masses and are hard to be braked. Once they collide with smaller vehicles, they usually maintain undamaged, while other vehicles yield serious deformation, reducing the survival chances of drivers. The number of vehicles involved in the accident is also another risk factor affecting the injury severity. The more vehicles involved in an accident, the more people to be involved which in turn increases fatal injury occurrence.

The results also show speed and road type to be important factors. Higher speed limits on road imply higher speeds of vehicles on road. So, it is more probable that fatal accidents happen on road with high speed limits. However, expressways do not have the highest risk for fatal accidents, but the second-class highways do. This is probably because second-class highways in HLJ account for the most proportion of all roads, and traffic volumes on these roads are usually heavy. Besides, expressways usually have favorable safety facilities, such as guardrail and median strip, keeping drivers away from serious accidents. That is also why accidents occurred on the roads with the central reserve have lower risk of fatal injury. As we know, the function of seatbelts is to protect drivers away from serious injuries. So, drivers involved in an accident without seatbelt use have much more probability of fatal injury.

The weather of the accidents seems to be related with the occurrence of fatal of severe fatigue-related accidents. There may be more fatal accidents in bad weather days, such as rainy, foggy, or snowy days. This is most largely because that bad weathers increase the difficulties of driving and severity of accidents. The same condition applies to driving on the of roads with bad conditions, such as overflow, ice-snow covered, increasing the wet traction of roads. As we know, the period from December to February in HLJ is winter, coldest and most snow and ice on the roads, which will lead to greater number of accidents, and increase the probability of fatal accidents. Side impact, rear-end collision, and bump fixation matter have much higher of fatal injury. This is probably because of the collision point of vehicles. The side and back of vehicles are the most fragile, once vehicles collide with each other at these parts, the consequences will usually be serious.

Although fatigue-related accidents account for less proportion of all accidents, the severity of them is much higher. Because once the drivers get asleep when they drive at a high speed, they don’t even have any time to take measures before the vehicles collide with each other. More and more efforts have been done to prevent fatigue-related accidents and keep drivers away from dangers. Identifying the high risk factors of fatal fatigue-related accidents helps prevent the occurrence of drivers’ fatigue and improve road safety conditions.

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