IATSS Research 37 (2014) 130–136

Contents lists available at ScienceDirect

IATSS Research

Impacts of accident severity factors and loss values of crashes on expressways in Thailand

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ARTICLE INFO

Available online 6 August 2013

Keywords:
Accident severity
Speed
Multiple logistic regression
Expressway safety

ABSTRACT

The number of road accidents and the level of accident severity have been extensively applied as the indicators for measuring the efficiency of service provision in road network systems of each country. This research utilized accident data on expressway networks during B.E.2550 (2007) to B.E.2553 (2010) (updated data was collected), in which Expressway Authority of Thailand (EXAT) as legislatively mandated unit has taken responsibility for the execution of nine expressway routes covering distances totaling over 207 km with a record of 2194 crashes. The chief objective of the study aims to forecast the accident severity through formulating Multiple Logistic Regression Model to analyze the probability of injury accident and fatal accident in comparison with property damage only accident. Its measurement comprehensively considers statistical relationship among variables such as average speed on road section, average traffic volume per day, period of time, weather conditions, physical characteristics of accident area, and causes of accident. Together, the research question is to verify whether these variables affect the opportunity or probability of three levels of accidents and investigate impacts of accident loss values due to the reduction in crash severity measures.

1. Introduction

Road accidents are a major world economic and social problem as shown by the report of loss of lives and properties in many countries around the world. Reporting indicated the number of fatalities from road accidents per year of about 1.3 million and 50 million injuries were recorded [1] or an average of 3000 deaths/day and 30,000 injuries/day. Furthermore, its consequences have an impact on economic and social conditions in terms of health care costs of injuries and disabilities. The World Health Organization (WHO) [2] estimated the economic costs derived from road accidents reached 518 billion USD per year in high income countries and 65 billion USD per year in medium and low income countries.

In addition, Peden and Organization 2004 reported that 90% of road crash fatalities were found in the group of medium and low income countries such as Africa and southeast Asia. Thailand is one of the southeast Asian countries where there was a significant number of traffic accident problems. According to a worldwide comparison of traffic accident mortalities, it was found that Thailand ranked 70th among 178 countries in the world in the total number of deaths as calculated approximately 19.6 deaths/100,000 people [1]. The report of Department of Health, Thailand B.E.2554 (2011) illustrated that traffic accident is the second leading cause of death in Thailand, 2nd only to cancer disease, and is the primary cause of injuries [3]. The total cost of traffic accidents in Thailand for the year 2004 was estimated at 153,755 million baht [4]. Although the government has issued some policies to prevent and control accidents, the numbers of injuries and deaths have continued to increase.

The Expressway Authority of Thailand (EXAT). a division of the Ministry of Transport, takes responsibility for the management and execution of the expressways. The EXAT has a consolidated vision of expressway safety and provides regular road safety audits and black spot treatment. However, the number of accidents on the expressways is still too high as indicated from the record in B.E.2553 (2010) of 1878 crashes with 20 deaths and 573 injuries [5]. Nevertheless, road accident prediction is quite difficult because the causes of accidents are generally brought on by various factors such as road user behaviors, vehicle conditions, physical road characteristics, and the environment [6], even with the improvement of physical road conditions. Therefore, it is vital to obtain accident data to formulate a statistical model for the purpose of providing an explanation for and forecasting the probability of crashes, as well as finding the factors that might affect the accident severity. This effort will benefit the responsible authorities in well-considered black spot improvement and road safety audit consequence to prevent or reduce any damages caused by accidents.

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Peer review under responsibility of International Association of Traffic and Safety Sciences.

Production and hosting by Elsevier

0386-1112/$ – see front matter
http://dx.doi.org/10.1016/j.iatssr.2013.07.001

According to the reviews, we found various studies relating to the accident severity factors and [7] prediction of levels of severity of crash using nested logit model. Some influential factors were indicated by the study such as environmental conditions, highway design, accident type, driver characteristics and vehicle attributes. Kelvin [8] examined factors causing accident severity of three vehicle types in Hong Kong including private vehicles, goods vehicles and motorcycles via logistic regression models. The research found that each vehicle type significantly exhibited different accident severity factors. In the case of private vehicle type, severity levels of crashes were mainly influenced by district board, gender of driver, age of vehicle, time of the accident and street light condition factors. While the accident severity factors of goods vehicles are seat belt usage and weekday occurrence. In addition, age of vehicle, day of week and time of the accident factors showed a significant relationship with accident severity levels of motorcycle type. O'Donnell and Connor and Kockelman and Kweon [9,10] analysed the traffic accident data using an ordered multiple choice model consisting of ordered logit and ordered probit models. O'Donnell and Connor [9] found that slight increases in the probabilities of fatal or serious injuries were influenced by several factors including the victim's age and vehicle speed. Other factors that may have some influence on different types of injuries include seating position, blood alcohol level, vehicle type, vehicle make and type of collision. Kockelman and Kweon [10] found that the vehicles such as pickups and sport utility vehicles were less safe than passenger cars, especially for accidents involving a single vehicle. However, for accidents with two-vehicle collisions, it was reported that there are less severe injuries for the drivers and more severe injuries for occupants. Ali [11] investigated the influence of accident factors on fatal and non-fatal accidents in Saudi Arabia. The study findings showed that accident location and cause of accident are significantly associated with a fatal accident. Accident factors used in the study include accident location, accident type, collision type, time of accident, cause of accident, age of driver at fault, vehicle type, nationality and license status. Some of the accident factor classifications of that study are used as the independent (predictor) variables in the analysis.

Based on the review of traffic safety literature in Thailand, most research on factors influencing accidents on highways have used several methods, such as application of statistical models and multi-factors to provide an illustration of accident conditions. None of the past research has specifically considered the issue of accident severity on the expressways which has well-designed and safety control systems serving as accident prevention which is the focus of this study. The analysis of factors influencing accident severity on Thai expressways was performed together with the development of a model for predicting the probability of crash severity following significant factors obtained by the analysis. Moreover, the study applied multinomial logistic regression to assess accident loss values according to the reduced accident numbers resulting from the revision of accident reduction policies and measures. The outcomes of the study would benefit the responsible agencies in identifying accident reduction interventions.

2. Methodology

2.1. Data description

This study proposes to investigate the severity of accidents on all expressways in Thailand by using secondary data obtained from the Expressway Authority of Thailand (EXAT), which has taken responsibility of collecting traffic accident data on each of the 9 expressway routes covering a total area of 207 km. The data includes time and location (e.g., accident time, accident management time, and accident location), environment (e.g., traffic lanes, weather condition, and physical characteristics of the accident location), accident severity (e.g., number of injuries or deaths and number of damaged cars), and characteristics and causes of the accident. This study gathered data from the past 3 years from B.E.2550 (2007) to B.E.2553 (2009) by classifying the severity of accidents following the accident factors as shown in Table 1.

According to Table 1, there were a total of 2194 accidents recorded in 3 categories including 1455 property damage-only accidents (66.32%), 700 injury accidents (31.90%), and 39 fatal accidents (1.78%).The average speed on the expressway section at which the accident occurred was around 70 km/h; while an average traffic volume of 3385 PCU/day was addressed. Considering the time of accidents, most accidents usually occur during the day (1106 times); however a high level of accident severity being recognized as a fatal accident always occurs at night (25 times). For weather conditions, the largest number of accidents occurs in clear weather (2013 times) and most occurred on a straight segment (1327 times). Furthermore, a greater number of crashes occur on one-lane roads (1606 times), in which inconsiderate drivers are a major cause of accidents (1910 times).

Table 1
The number of accidents disaggregated by accident severity.

Variables		Unit	Property damage-only	Injury accident	Fatal accident	Total
Accident occurred		Number of accidents	1,455	700	39	2194
Speed		km./hr.	70	71	76	70
Traffic volume		PCU/day	3,391	3,402	2,862	3385
Time of day	Day time	Number of accidents	769	323	14	1106
	Night time	Number of accidents	686	377	25	1088
Weather conditions	Normal	Number of accidents	1,341	637	35	2013
	Rainy	Number of accidents	114	63	4	181
Number of lane	1-lane	Number of accidents	1,112	467	27	1606
	2-lane	Number of accidents	236	178	11	425
	3-lane	Number of accidents	106	51	1	158
	4-lane	Number of accidents	1	4		5
Cause of accident	Slow driving/unusual	Number of accidents	12	5	1	18
	reckless driving	Number of accidents	1,279	601	30	1910
	Sudden lane change	Number of accidents	71	41	1	113
	Drunk	Number of accidents	17	9	3	29
	Personal diseases/driver sleepiness	Number of accidents	38	32	4	74
	Equipment failure	Number of accidents	38	12		50
Type of location	Toll station	Number of accidents	181	12	1	194
	Curve	Number of accidents	249	132	6	387
	Straight	Number of accidents	853	448	26	1327
	Intersection	Number of accidents	46	25	2	73
	Junction	Number of accidents	21	11	1	33
	Upgrade	Number of accidents	36	32	2	70
	Downgrade	Number of accidents	69	40	1	110

2.2. Variable creation

The study denoted the accident severity as a dependent variable that was classified in a type of group variable with 3 possible values: '1' = property damage only group (accidents that only damage to property is found without cases of injuries or deaths); '2' = injury accident group (accidents that list injuries but no deaths); '3' = fatal accident group (accidents that the number of deaths is recorded). In terms of independent variables, they were considered by the study through the accident data and past research on accident-related factors as illustrated in Table 2. The variables include:

– *Speed*, an average space-mean speed which was obtained from the observed mean speeds for each road segment (every road segment having on and off ramps) at different time periods that researchers purposively selected mean speed data on segments of road where accidents occurred and the time period of the accident. Previous studies [8,12,13], indicated that speed is a major accident factor because it caused a large portion of deaths, i.e. about one-third of total accidents involved fatalities. In addition, Aarts and van Schagen [40] reviewed some literature related to speed factors affecting the risk of accidents and found that an increase in speed has a greater risk of accident on collector roads than main roads, such that a 1 km/h increase in speed is associated with an average of 3% of accidental risks. And driving beyond the speed limit may cause a higher possibility of accident severity. In the case of roads with a speed limit of 120 km/h, exceeding the speed limit by 1 km/h will increase the accidental risk in injury and death levels about 1.7% and 3.3%, respectively. In this study, speed data on the road section at which the accident occurred, which is continuous data and reported in unit of km/h, was used as an independent variable for the analysis.
– *Average Annual Daily Traffic (AADT)* refers to the average daily traffic volume on road sections in which accidents occurred. Based on the previous studies of Wang et al. [43]; Jacobs [42]; Organization [41]; [14,15], traffic volume is a factor that directly affects the occurrence of accidents. Kihlberg and Tharp [14] studied the relationship between the accidents occurring and the geometric design features of rural roads, and then summarized that traffic volumes on the highway have a direct effect on accident occurrences. This meant that the greater the traffic volume, the greater chance of accident occurrences. This result is associated with the study of Jacobs (1976) that studied the rate of accidents on rural roads. The study pointed out that traffic volume directly affected the rate of accident occurrences, by which AADT data on road sections in which the accident occurred were used as an independent variable for the analysis. Data are denoted as continuous data with the unit of PCU/day.
– *Number of lanes* in the direction that the accident occurred is specified as one of the main accident factors. According to the results of Awadzi et al. [39], it was found that the number of lanes affect the reduction in driver injuries and fatalities, by which a crash on a one-lane road increases the risk of severity of injury accidents up to 81%. And if the accident occurred on a four-lane to seven-lane road, the risk of severity of crash fatalities may increase by about 23 %. Data related to the number of lanes in the direction that accident occurred, which are the type of discrete data, were used as an independent variable for the analysis and classified into 4 groups: '1' = 1-lane road; '2' = 2-lane road; '3' = 3-lane road; and '4' = 4-lane road.
– *Time of day* refers to time period in which the accident occurred. The previous studies of Ali, Wang et al. and Hıjar et al. [16,12,11] pointed out that the time of day has an effect on accident occurrence. Lin and Fearn [17] and Keall et al. [18] found that the road environment for each time period is associated with accident occurrence. The results of the study identified that driving during the midnight to dawn time period has a greater chance of accident than driving during the day-time period. In addition, Tay et al. [19] addressed that the chance of accident occurrence at night-time is 2.31 times higher than the day-time period. In this study, the time of accident data is denoted as an independent variable for the analysis, by which data have a dichotomous characteristic and were classified into 2 groups: 'group 1' is day-time period and 'group 2' is night-time period during 18:00–07:00.
– *Weather Condition* refers to the weather condition at the time of the accident. The past studies of Wang et al. [12] and Chen and Chen [12,20] identified weather condition as a major accident factor, by which rainy or foggy conditions will cause a higher chance of accident. This result is associated with the studies of Ctr et al. [21] and Robertson [22] that found accident risk factor has a direct relationship with

Table 2
Independent variables applied in the analysis.

Variables	Data characteristics	Definition
Dependent variable		
Accident severity	Dichotomous	0 = Property Damage Only 1 = Injury Accident 2 = Fatal Accident
Independent variables		
Speed	Continuous	Average speed on road section (km/h)
Average Annual Daily Traffic (AADT)	Continuous	Average Annual Daily Traffic in the unit of passenger car unit (PCU) per day
Lane	Discrete	1 = one-lane road 2 = two-lane road 3 = three-lane road 4 = four-lane road
Time of the accident	Dichotomous	0 = Time of the accident during 07:00-18:00 1 = Time of the accident during 18:00-07:00
Weather condition	Dichotomous	1 = accident occurred in normal weather condition 2 = accident occurred in rainy weather
Location	Dichotomous	1 = accident occurred on toll station 2 = accident occurred on curve 3 = accident occurred on straight way 4 = accident occurred on intersection 5 = accident occurred on junction 6 = accident occurred on upgrade 7 = accident occurred on downgrade
Cause of accident	Dichotomous	1 = accident occurred due to slow or unusual driving 2 = accident occurred due to reckless driving 3 = accident occurred due to sudden lane change 4 = accident occurred due to drunk driving 5 = accident occurred due to personal diseases or driver sleepiness 6 = accident occurred due to equipment failure

driving under unusual weather conditions (rain, fog, or wet roads), in which driving vision and road adhesion are major accident factors. In addition, Híjar et al. [16] also verified that driving under unusual weather conditions has a 5.33 times greater chance of accident than driving under normal weather conditions. Weather condition at the time of the accident, which is dichotomous data, was used by the study as an independent variable for the analysis and was categorized into 2 groups: 'group1' is normal weather condition and 'group 2' is rainy condition.

– *Location* refers to the location characteristics where the accident occurred such as direct way, curve, intersection, etc. Previous research found that different locations have an effect on accident occurrence. As the study of Ali [11] illustrated that the curve characteristics are associated with accident occurrences, especially narrow curves. Generally, highway traffic accidents on curves are 3 times greater than direct way [23]. Most of the cases were caused by run-off curve crashes [24], which are associated with the study of Neumann et al. [44] that found curve radius is the main factor affecting the safety of horizontal curve design. It illustrated that horizontal curve radius with a radius less than 600 m will increase the rate of accident occurrences. Glennon [24] also found roads with limitations of sight distance due to crest curves will have a 52% higher frequency of accident occurrences than roads with vertical sag curves. In addition, the grade also has a direct impact on accident occurrences since it reduces driving visibility [25], in that accident rates and its severity will be increased by following the grade levels [26]. In addition, roads in downgrade directions cause more safety problems than upgrade directions, which is hazardous for massive truck travel, especially grade levels of more than 6% will have a greater risk of crashing [23]. Based on the aforementioned past studies, this study selected 'location characteristics where the accident occurred' as an independent variable for the analysis. Data are of dichotomous type, which are classified into 7 groups: 'group 1' = toll station entrance; 'group 2' = curve; 'group 3' = direct way; 'group 4' = intersection; 'group 5' = junction; 'group 6' = upgrade; and 'group 7' =downgrade.
– *Cause of accident* can be identified as a major accident factor derived from the driver's behavior such as driving at excessive speeds, inconsiderate driving, drunk driving or equipment failure [11,20]. According to the study results of Lapham, the Insurance Institute of Highway Safety Report, Wells, et al., McDermott and Hughes, and Leonard [27–31], drunk drivers are considered to have a greater risk of accidents than non-drinking drivers. Increase in the driver's blood alcohol concentration of every 0.02% tends to have 2 times larger number of accidents [32,33]. Moreover, they found that drivers with a blood alcohol concentration of more than 0.1 grams percent will have a 7 times higher traffic accident risk than non-drinking drivers [34]. Furthermore, drivers with risky driving behaviors — for example, braking, turning, overtaking, signaling, vehicle control, and sudden lane changes — increase the possibility of crash risk over considerate drivers. As well, a driver group concerned with health conditions, such as being fatigued from long distance driving and having little or no sleep, might cause driver drowsiness or slower driving decision. This group tends to have a greater risk of accidents than perfect-health drivers [35]. A driver group which has personal diseases (e.g., heart disease, kidney disease, pulmonary disease) also faces a higher risk of accident than perfect-health drivers [36,37]. In accordance with the above studies, this study used the cause of accident data as an independent and dichotomous variable for the analysis by which data were categorized into 6 groups: 'group 1' = slow driving/unusual; 'group 2' = reckless driving; 'group 3' = sudden lane changes; 'group 4' = drunk driving; 'group 5' = personal diseases/driver drowsiness; and 'group 6' = equipment failure.

According to the aforementioned reviews, it can be concluded that factors affecting the accident severity are speed, traffic volume, time of day, weather conditions, number of lane, cause of accident and type of location. In addition, the study used these variables in the analysis of accident severity factors on expressways via the multiple logistic regression technique. Each variable attribute used in the analysis was demonstrated in Table 2 and was obtained from the observed data in the database.

3. Procedure

It is important to understand that the goal of an analysis using logistic regression is the same as that of any model-building technique used in statistics: to find the best fit and the most parsimonious one. What distinguishes a logistic regression model from a linear regression model is the response variable. In the logistic regression model, the response variable is binary or dichotomous. The difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions. Once this difference is accounted for, the methods employed in an analysis using logistic regression follow the same general principles used in linear regression analysis. In any regression analysis the key quantity is the mean value of the response variable given the values of the independent variable [11].

The correlation analysis among variables used for a forecast of accident severity scores was carried out via the multiple logistic regression technique to find significant factors influencing accident severity levels. The multiple logistic regression is an appropriate technique when the dependent variable is categorical and the explanatory variables are continuous or categorical. It directly estimates the probability of the accident severity subject to a set of factors. Among the factors included are speed, traffic volume, time of day, weather conditions, number of lane, cause of accident, and type of location. Multinomial logistic regression estimates the odds (logit) T_{ki} of an observation i falling in a class k relative to a reference category, the equation can be written as follows.

$$T_{ki} = \alpha_k + \beta_k X_{ki} \tag{1}$$

where, α_k is a constant parameter for the accident severity category k; β_k is a vector of the estimable parameters for the accident severity category k; k representing all the three accident severity levels: property damage only, injury accident, and fatal accident; X_{ki} represents a vector of explanatory variables affecting the accident severity for i at accident severity category k (speed, traffic volume, time of day, weather conditions, number of lane, cause of accident, and type of location, etc.).

Eq. (2) shows how to calculate the probability for each accident severity category. Let $P_i(k)$ as the probability of accident *i* ending in accident severity category *k*, such that

$$P_i(k) = \frac{\exp(\alpha_k + \beta_k X_{ki})}{\sum_{\forall k} \exp(\alpha_k + \beta_k X_{ki})} \tag{2}$$

In this analysis, the study determined the dependent variable as following: value '0' = property damage only; value '1' = injury accident; and value '2' = fatal accident. Hence, the application of multiple logistic regressions by this study proposes to find the influences of the independent variables that affect the probability of accident severity. In this case, parameters of the independent variables demonstrate positive values with statistical significance, which means that such variables increase the probability of greater crash severity. On the other hand, if parameters are statistically significant they are regarded as negative values, the effects are shown in the opposite direction. Parameter estimation was conducted using a maximum likelihood technique through the SPSS program for calculating 'odds ratios' (OR) to estimate the rate of probability change or the chance of accident severity occurrence when a unit change in the independent variable exists. For finding OR values, the study identified the confidence interval level (CI) of OR at a 95% confidence interval level with a stepwise logistic regression model for considering statistical significance (Hosmer David and Stanley, 1989).

4. Results

4.1. Analysis of the multinomial logistic regression model

The analysis results based on the comparison between the total accident database and the fatal accident group are illustrated in Table 3. Based on the findings, the parameter values of some independent variables were reported as statistically significant with 95% confidence level, by which the values show either positive or negative, depending on the effect of each variable. Independent variables, which are significantly associated with the accident severity, can be illustrated as follows.

According to the analysis results of the relationship between accident severity on expressways and the related factors as shown in Table 3, it can be explained that the parameters of some independent variables show significance at the 1% level or 5% level, by which their symbols are either positive or negative values relying on the impact of each variable. The study found a 'speed factor' — only one independent variable — is significantly associated with accident severity. The speed factor has a significant effect on the severity of crashes on expressways in both level of property damage only when compared to fatal accidents and level of injury accident when compared to fatal accident. The results of the parameters with negative values demonstrate that as the speed is increased, there is a greater risk of fatal accident. As well, using independent variables, specifically the speed at the road section in which the accident occurred, to find its relationship with the accident severity on expressways with the multiple logistic regression model. The results of the analysis are illustrated in Table 4.

According to the results based on the correlation analysis of crash severity as shown in Table 3, the model can be written as follows;

$$P(\text{property damage only}) = \frac{1}{1 + e^{-(5.999 - 0.032^{*}\text{Speed})}} \tag{3}$$

$$P(\text{injury accident}) = \frac{1}{1 + e^{-(5.031 - 0.029^{*}\text{Speed})}} \tag{4}$$

$$P(\text{fatal accident}) = 1 - P(\text{property damage only}) - P(\text{injury accident}) \tag{5}$$

Based on the results, the study found that the speed factor demonstrates a significant relationship with accident severity on expressways in both the property damage-only group compared to the fatal accident group and the injury accident group compared to the fatal accident group at a significance level of 0.05. Regarding the validity test, pseudo R^2 values equal to 0.004. When considering data used for the accident severity forecast, an accuracy of 66.3% was found by the test which was accepted by the study as well. Regarding the analysis of the property damage only group compared to the fatal accident group, the results perform negative values of parameter, and thus it means an increase in speed on a road section has an effect on the probability of accident occurrence of fatal accident group larger than property damage only group with OR = 0.968 (95% CI = 0.945–0.992). So, it can be described that an increase in speed on a road section of 1 km/h will result in the probability of crashes in the property damage only group of 0.968 times lower than the fatal accident group.

As well, the analysis results of the injury accident group compared to the fatal accident group show the same direction by which negative values of the parameter are admissible with OR = 0.971 (95% CI = 0.948–0.995). This result means that an increase in speed on the road section of 1 km/h will result in the probability of crashes in the injury accident group of 0.971 times lower than the fatal accident group.

4.2. Analysis of accident loss values

Table 5 depicts a summary of accident loss values classified by three levels of crash severity (average accident loss values (THB) per time) based on the study of Thongchim et al. [4]).

According to the data of accident loss values, researchers adopted the results from a correlation analysis between crash severity on expressways and speed factors in Table 4 in order to examine the potential impact of changes in policies by related authorities. According to the study's expectancy, the measures related to reduction in accident severity on expressways through speed control may decrease vehicle speed as a major cause of accidents; for example, the enforcement of speed limits on expressways in which four-wheel passenger cars were rigorously mandated with a maximum speed of 120 km/hr.

Table 3
The relationship between the accident severity on expressway and related factors.

Independent variables	Property damage only compared to fatal accident					Injury accident compared to fatal accident				
	B	Sig.	OR	95% CI		B	Sig.	OR	95% CI	
				Lower	Upper				Lower	Upper
Constant	30.986	0.940				28.993	0.944			
Speed	−0.043	0.016	0.958	0.925	0.992	−0.032	0.073	0.968	0.935	1.003
AADT	0.000	0.558	1.000	1.000	1.000	0.000	0.827	1.000	1.000	1.000
Lane	0.085	0.761	1.089	0.629	1.885	0.247	0.382	1.280	0.737	2.222
Day-time	0.584	0.103	1.793	0.888	3.619	0.329	0.363	1.390	0.684	2.827
Night-time										
Toll station	0.961	0.503	2.614	0.157	43.443	−1.149	0.432	0.317	0.018	5.584
Curve	−0.830	0.451	0.436	0.050	3.773	−0.838	0.449	0.433	0.049	3.784
straight	−0.828	0.425	0.437	0.057	3.337	−0.894	0.391	0.409	0.053	3.153
Intersection	−1.304	0.300	0.271	0.023	3.196	−1.414	0.265	0.243	0.020	2.916
Junction	−1.825	0.210	0.161	0.009	2.791	−1.821	0.216	0.162	0.009	2.891
Upgrade	−1.443	0.251	0.236	0.020	2.770	−1.013	0.421	0.363	0.031	4.289
Downgrade										
Normal	−11.536	0.000	0.000	0.000	0.000	−11.629	0.000	0.000	0.000	.000
Rainy	−11.751	0.000	0.000	0.000	0.000	−11.826	0.000	0.000	0.000	0.000
Slow driving/unusual	−13.363	0.974	0.000	0.000		−13.079	0.974	0.000	0.000	
Reckless driving	−11.955	0.977	0.000	0.000		−11.476	0.978	0.000	0.000	
Sudden change lane	−11.517	0.978	0.000	0.000		−10.784	0.979	0.000	0.000	
Drunk	−13.711	0.973	0.000	0.000		−13.249	0.974	0.000	0.000	
Personal diseases/driver sleepiness	−13.246	0.974	0.000	0.000		−12.212	0.976	0.000	0.000	
equipment failure										
−2 Log Likelihood	1408.137									
Pseudo R^2	0.063									

Table 4
The relationship between the accident severity on expressway and speed factor.

Independent variables	Property damage only compared to fatal accident					Injury accident compared to fatal accident				
	B	Sig.	OR	95% CI		*B*	Sig.	OR	95% CI	
				Lower	Upper				Lower	Upper
Constant	5.999	0.000				5.031	0.000			
Speed	−0.032	0.009	0.968	0.945	0.992	−0.029	0.020	0.971	0.948	0.995
−2 Log Likelihood	189.971									
Pseudo R^2	0.004									

Henceforth, the raised question was to what extent the accident loss values can be reduced due to such measures. The study determined the speed values in each range to compare the accident probabilities classified by its severity and loss values as demonstrated in Table 6. The findings found that the trends of crash severity have been continuously increasing, especially the in speed range between 120 and 150 km/hr. Moreover, fatal accident rates tend to be increased by 3.56% resulting in the greater amount of accident loss values as counted approximately 583,363 THB/time. Additionally, an accident occurring at a speed of 200 km/hr is more likely to potentially cause the significant number of fatal accident rates about 0.47% higher than injury accidents and property damage only. As a consequence, the accident loss values are relatively high, estimated to be about 1,623,889 THB/time.

4.3. Discussions

The purpose of this research is to study the factors affecting accident severity on expressways by using accident data of the past three years from B.E.2550 (2007) to B.E.2553 (2010). The multiple logistic regression technique was applied by the study for finding factors and their statistical relationships on the severity of crashes, which were categorized into 3 groups: property damage only; injury accident; and fatal accident. The fatal accident group was used as a database for the basis of comparison. Tentative factors, applied as independent variables in order to examine their relationships on the severity of accidents, were considered through accident data and various research addressing factors affecting the accident severity. So, 7 factors were obtained: average speed; average annual daily traffic; number of lanes; time of the accident; weather conditions; location; and causes of accident. According to the analysis, the findings indicated the speed factor has a significant effect on both the property damage only group (OR = 0.968, 95% CI = 0.945–0.992) and the injury group (OR = 0.971, 95% CI = 0.948–0.995) when compared to the fatal accident group. The study found that an increase in speed on a road section may pose a greater chance of accident severity as fatal accident than the other groups, and increasing the speed twice tends to increase the accident loss values nine times; thus associating with the study of Vägverket [45] that speed will accelerate the crash severity, wherein speed increased by 10% will result in more severity in crashes up to 21% and 46% of fatal accident. In addition, the study also found that speed tends to increase the chance of accident occurrences, in that 3.5 times of higher speeds must spend 8 times of time spent in decision-making to stop the vehicle [38].

The analysis of the study applied the multiple logistic regression method to formulate an equation which demonstrates the relationship between dependent variables and independent variables for predicting the chance related to the occurrence of the concerned events. Such a relationship found by the analysis does not show a mutual correlation and association in terms of linear form, so that it results in obtaining factors that affect the severity on expressway accident closing to the real situation. In addition, limitation of the study would be addressed that data from previous years were obtained without recording of some data types, consequently some factors that might be associated with the severity of expressway crashes are not included by the analysis of this study such as seat-belt use by drivers, road surface, and driver skills.

Table 5
Accident loss values categorized by crash severity levels.

Level of severity	Estimated values of an average traffic accident loss (THB/time)
Fatal accident	3,397,457.00
Injury accident	78,262.00
Property damage	30,871

Table 6
Accident probabilities classified by speed levels.

Speed (km/hr)	Accident probabilities Property damage-only	Accident probabilities Injury accident	Accident probabilities Fatal accident	Estimated accident loss values(THB)
90	0.647	0.325	0.029	143,336
100	0.633	0.328	0.039	177,375
120	0.6	0.33	0.07	281,908
150	0.525	0.315	0.16	583,363
200	0.312	0.218	0.47	1,623,889

5. Conclusion

This research focuses on finding factors that affect the accident severity on expressways with the aim of providing benefits to the responsible authorities for issuing accident prevention policies or measures that are effective to alleviate or protect unexpected losses from accidents. The findings verified that speed on a road section is the only factor influencing the severity of crashes on expressway with significance; hence speed limits on expressways should be mandated for drivers by carrying out rigorous inspections of expressway-speed under the regulations. As well, increasing awareness of accident severity caused by driving at excessive speeds should be promoted by authorities to potentially reduce the risks and levels of accident severity. In addition, the study suggests that further research should focus more on the issue of identification of speed limit design in accordance with roadway geometric features for driver safety on expressways to efficiently tackle the accident severity problems. Hence forward, this research can be applied for finding how to decrease the accident loss values by means of policy intervention relating to accident reduction measures from related agencies.

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