Intersection Accident Severity Analysis using Ordered Probit Model

Name: **Sharad BAJRACHARYA**

Graduate School: Asian Institute of Technology, Thailand (2012)
Email: sharad333@gmail.com

Abstract: There is a need for a better consideration between the relationship of injury severity and the factors which are responsible for causing accidents to develop effective countermeasure to reduce both the rate of accidents as well as the severity of injuries caused by an accident. As intersection is a crucial part of any roadway network, which is also one of the key main locations of accidents due to the existence of several conflict points. There is a need to understand the factors which affect the accident rate and cause higher injury severity at an intersection.

Keywords: Intersection, Accident severity, Ordered Probit Model, Comparison Models

1. INTRODUCTION

Individuals, families and the country's economy have suffered great loss due to traffic accidents. Traffic accidents have been the cause of many untimely deaths, incapacitating injuries and financial loss due to both property damage and a loss in productivity resulting in adverse effects on a countries economy. Thailand, which is a heavily motorized country, has one of the best, wide spread and connected transportation systems in Asia. However the road safety and traffic accident rates have become a major concern to the country.

According to a study conducted by the Bureau of Health Policy and Plan and the Ministry of Public Health, the years of life lost from road accidents amongst the Thai population of 62 million has equaled approximately 600,000 years, The road crash epidemic has caused a significant adverse effect on the economy of Thailand due to the loss of productivity through accidental death in the last few decades. Road accidents are the second leading cause of death. Every year, about twenty two thousand people in Thailand lose their lives or are hospitalized due to road accidents. It has been estimated that the economic losses caused by this are approximately 232,000 Million Baht per annum or approximately 2.81% of the country's GDP.

The objective of this study is to understand the factors that result in road accidents at intersections and how they affect the severity of the accident. This is done by analyzing the current situation of accidental crashes at intersections, quantifying the magnitude of intersection crashes and developing a crash severity model for the identification of the most notable factors contributing to the injury severity level.

Intersections are a vital part of any road network, however there exists the highest possibility of having a multi vehicular accident at an intersection, due to the presence of numerous conflict points. From 2007-2009, 1127 road accidents have occurred at various intersections in Thailand (according to the DOH database), thus a new initiative needs to be created to reduce both the number of accidents and the severity of those accidents. The creation of a new initiative requires identification as to the various factors responsible for intersection accidents in Thailand.

The research scope was limited to reported crashes on major intersections located on Thailand's highways for the period between 2007 and 2009. The research results are limited by potential under-reporting of road accidents and study and analysis limited to high volume traffic intersections.

2. LITERATURE REVIEW

There have been numerous studies conducted in the last decade on the factors involved in vehicular accidents. (O' Donnel and Connor (1996), Kockelman and Kweon (2002), Chang and Mannering(1998, 1999), Krull et al. (2000), Khattak(2001), Zhang et al.(2000), Khattak et al. (2002), Yamamoto and Shankar (2002), Duncan et al.(1998), Shankar and Mannering(1996), Chang and Mannering(1998,1999), Dissanayake and Lu(2002), Lee and Mannering (2002), Kraus et al.(1993), Quddus et al. (2002)). In a report published by the Government Accountability office (2003), they ranked human factor to be the most dominant in causing accidents, followed by the environment and the roadway surroundings, and finally vehicle factors.

A Tri-level study which was conducted in Indiana, Treat et al, (1979) also showed similar results. This was the most noteworthy study conducted on vehicles accidents at that time. This study focused on the causation and frequency of accidents whether they are human, environment, roadway or vehicle factors.

Many statistical techniques have previously been used by researchers to analyze accident severity, amongst those techniques log-linear, logit models and probit models have proved popular and been extensively used.

Abdel-Aty (1998) used log-linear model to analyze the relations between the age of the driver and the crash characteristics. They used the crash data from 1994-1995 for the region of Florida including three severity levels; no injury, injury, and fatality. The results showed that injury severity is positively significant with age of the driver. They found those mostly middle aged drivers are likely to be in crashes, while old age driver were associated with more fatal crashes.

Kim (1995) also used log-linear models for the prediction of injury severity in road accidents. It was found that alcohol or drug use and non-use of seat belt caused the injury severity of crashes to increase.

A nested logit model was used by Nassar, Saccomanno, and Shortreed (1994) to predict crash severity. The models were separated into three categories: single vehicle crashes, two-vehicle crashes, and multi-vehicle crashes. The factors responsible for higher severity were found to be: crash dynamic terms, seating position, use of seat belt, condition of the vehicle, mass of the vehicle, driver condition and driver action. Road surface condition was found to be insignificant in the models, this may be due to bad weather causing drivers to decelerate and maintain a safer distance from other vehicles.

Dissanayake and Lu (2002) created the used binary logistic regression model, whose result showed that the most significant factors which causes higher injury severity in road accidents involving young drivers are: influence of drugs or alcohol, ejection in the crash, point of impact, location of crash, existence of horizontal curves or vertical grades at the location of crash, speed of the vehicles involved, and the usage of safety devices.

Lee and Chang (2002) used the nested logit model to analyze the severity for run-off road crashes in Washington. The variables used for analyzing were categorized as temporal, environmental, driver, roadway and roadside characteristics. It was concluded from the study that wet surfaces, drivers under the age of 25, drivers under the influence of alcohol and the presence of a horizontal curve all resulted in a higher incidence of injury,

O'Donnell and Connor (1996) made a comparison study between the ordered logit model and the ordered probit model to evaluate the probabilities of the 4 injury severity levels as a function of drivers attributes. Their results showed that the injury severity increased with speed, vehicle age, occupant age, female gender, blood alcohol levels over 0.08 percent, non-use of a seatbelt, collision pattern and when the vehicle used is a light-duty truck. In the comparison study, it was found that seating position was the most relevant factor (i.e. left-rear seat was most dangerous), and gender was the least relevant factor. The main distinction found in this study was the importance given to the collision pattern and crash type.

Abdel-Aty (2003) used ordered probit models for the analysis of roadway sections, signalized intersections and toll plazas to determine factors significant to severe injury crashes. In the case of a signalized intersection, the significant factor was driver violation. In the case of Roadway section, the significant factors were influence of alcohol, lighting conditions, and existence of horizontal curves. In the case of toll plaza, the equipment of vehicles with Electronic Toll Collection (ETC) was positively significant of the severity at toll plazas. This study demonstrates the resemblances and the alterations in the factors that affect injury severity in different locations.

Khattak and Targa (2004), Khattak et al. (2002, 2003) used ordered probit models to predict the injury level for crashes occurring within construction zones and involving trucks. The model was implemented to study single-vehicle truck rollovers and also to determine vehicle, roadway, driver, crash, environmental factors and the involvement of elderly drivers that play a significant role in the severity level of a road accident.

3. METHODOLOGY

The crash severity model in this study was developed to investigate the factors that affect crash severity at intersections. The dependent variable in the model is injury severity level, and the independent variables are the factors which have significant influence on the injury severity levels. The crash injury severity is a typical ordinal variable which could be categorized at four levels from the least severe level to the most severe level (shown in Table 1).

Table 1. Definition and Description of Crash Severity Level

Level	Definition	Description
0	No Injury	There is no bodily harm to the person from the crash- property damage only
1	Slight Injury	Injury which is not of any of any threat to the life of the person or his way of his living. (Eg. pain, bruises, abrasion, etc.)
2	Serious Injury	Injury which is a threat to the life of the person and his way of living. (Eg. Broken bones, head injury, etc.)
3	Fatality	An injury sustained in the crash that resulted in death immediately or post-accident.

As outlined in Figure 1, the study methodology is divided into four main steps. These are:

1) Statistical model selection, which will include a review of existing models and the selection of the most appropriate one.
2) General development of model, which will deal with the selected ordered probit model.
3) Data calibration, which will include the filtering of the vast data of the accident's in Thailand as per the DOH to the required scope of study only.
4) Application of model, which will involve case studies, which will need to be evaluated and interpreted.

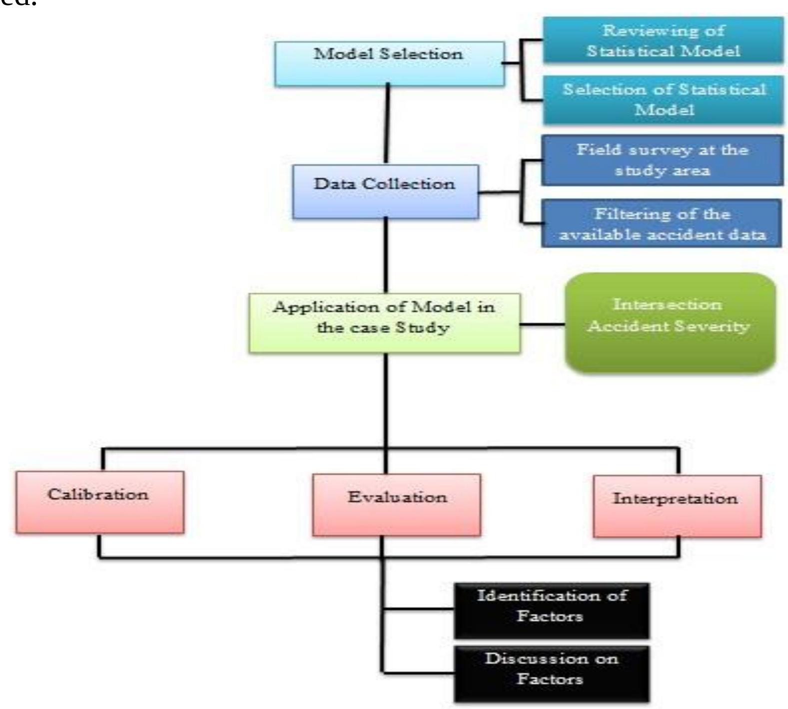

Figure1. Flowchart of Methodology

3.1 Selection of Suitable Model

By reviewing previous studies, a conclusion was reached that Multinomial models require more number of parameter estimates and neglects the data ordinarily, Nested logit models, although yielding better results, identifying the nesting structure is too complex, thus, the ordered probit model which has a relatively simple approach also recognizes the index nature of various response variables. Since in our model, the dependent variable, which is the severity index, is in an ordered format, the probit model is the best choice for this study; therefore it was selected. This selection can be backed by the literary reviews, as in the previous studies, the ordered probit model has been recognized as the most appropriate model in accident severity studies when the severity categories are of ordinal nature. There is no need to make any assumptions while applying this model, as long as the dependent variable is of ordinal nature, i.e. severity score. Order probit model has many advantages over other models which have been used in accident severity, such as:-

- It can account for both categorical and the ordinal nature of the dependent model, which is not possible in the case of multinomial or nested logit model, which can only account for the categorical nature of the dependent variable.
- The ordered probit model is also not associated with undesirable properties such as IIA or lack of closed form, which can be observed in the multinomial logit model and multinomial probit model respectively.
- The main advantage is that, when the expected value of severity is interpreted as probability in the ordered probit model, the ranges could not be outside 0 and 1, which can be seen in multiple linear regression models.

3.2 Ordered Probit Model

Ordered probit is a generalization of the popular probit analysis in the case of more than two outcomes of an ordinal dependent variable. Similarly, the popular logit method also has a counterpart ordered logit. When the dependent variable is ordinal in nature, it should not preferably be treated as nominal. Multinomial and nested logit model cannot handle ordinal dependent variable, consequently, there will be a loss of efficiency due to information being ignored. One way to deal with this problem is to use the ordered probit model instead of the multinomial logit and nested logit models. The ordered probit model discerns unequal differences between ordinal categories in the dependent variable.

The ordered probit model is usually motivated in a latent (i.e., unobserved) variable framework. The general form of the model is

$$y_i^* = \mathbf{x}_i \boldsymbol{\beta} + \varepsilon_I \qquad (1)$$

Where,

y_i^* is a latent, unobservable and continuous dependent variable;
$\mathbf{x}_i$ is a row vector of observed non-random explanatory variables;
$\boldsymbol{\beta}$ is a vector of unknown parameter;
ε_I is the random error term; which is assumed to be normally distributed.

The ordered probit model can be derived from a measurement model in which a latent variable y_i^* ranging from $-\infty$ to +o is mapped to an observed ordinal variable y . The observed and coded discrete variable y_i^* is determined from the model as follows:

$$y_I = m \text{ if } \tau_{m-1} \leqslant y^* < \tau_m \qquad \text{for m = 1 to M} \qquad (2)$$

Where the threshold values τ' are unknown parameters to be estimated. The extreme categories, 1 and *M* , are defined by open-ended intervals with $\tau 0 = -\infty$ and $\tau M = \infty$.

However, researchers have recognized that the discrete measure of severity is ordinal in nature and have applied the ordered probit or ordered logit models to severity studies. The difference between the two models lies in the assumption of errors. Researchers have further indicated that the results from the ordered probit and ordered logit are similar. However, the ordered probit model is preferable because the assumption that the distribution of errors is normally distributed is more likely to be valid.

3.3 Accident Data

It is necessary to identify the factors which might affect the accident severity, to be used in the ordered probit model. Thus a data set, appropriate for the ordered probit model, has to be formed; including the general characteristics, vehicles characteristics, environmental and lighting factors, roadway features, type of accident, and collision patterns. Accident data for the present study were obtained from the department of Highway of Thailand.

After filtering the database, we can move on to the factor selection process by analyzing each group of factors as to which may be a significant factor for accident severity at intersections. Therefore, the database can be classified into eight types: general accident information, vehicle characteristics, road characteristics, probable cause, environmental Conditions, type of accident, collision pattern, and traffic control measures.

The intersections considered in this study are all signalized intersections and thus can be classified into three types, 4-legged intersections, Y & T type intersections and other intersections (which include all other types of intersections). From the database, we found that the most accidents occur at 4-legged intersections accounting for 40% accidents at intersections from 2007 to 2009, followed by other intersections with 34% accidents and then finally Y & T type intersection with nearly 36%of accidents.

4. MODEL

4.1 Model Calibration

For the model calibration, reported accident data from the DOH, Thailand from 2007 to 2009 is used in the study. During this period there were 41,660 total accidents out of which 1,127 took place at intersections. From the data, 227 people died, 425 suffered severe injury, 920 people suffered slight injury, and there were 402 cases with no injury which has been shown in figure 2 as the injury classification of intersection accidents in terms of percentage.

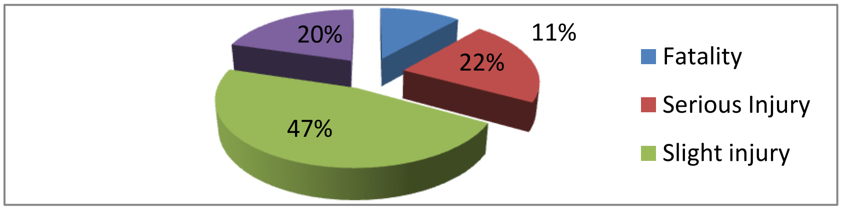

Figure 2. Injury classifications of intersection accidents (2007-2009)

The independent variables are organized into 8 groups consisting of a total of 47 factors, which are shown and explained in table 2:-

Table 2. Explanatory variables used in the model

Explanatory variables(factors in bold)		**Description of the variables**
I. General		
	1. peak hour	peak hour (0700-1100 & 1500-1900)=1; otherwise=0
	2. Holiday	Holiday=1,otherwise=0
II. Vehicle Characteristics		
	1. motorcycle	If the vehicle is a motorcycle =1, otherwise=0
	2. passenger car	If the vehicle is a car =1, otherwise=0
	3. small bus	If the vehicle is a small bus =1, otherwise=0
	4. small truck	If the vehicle is a small truck =1, otherwise=0
	5. big truck	If the vehicle is a big truck =1, otherwise=0
	6. Trailer car	If the vehicle is a trailer =1, otherwise=0
III. Road Characteristics		
1. Median		median=1, no median=0
2. No of lanes		if number of lanes on approach is 1=1, 2=2, 3=3,= >4=4
3. Type of	(a) 4-Legs Intersection	if intersection is 4 legged=1, otherwise=0
Intersection	(b) Y and T Intersection	if intersection is Y or T type=1, otherwise=0
	(c) Intersection Others	if intersection is any other (except 4legged, Y or T)=1, otherwise=0
IV. Probable Cause		
	1. Over Speed Limit	if vehicle is over speed limit=1, otherwise=0
	2. Run Pass in Front	if vehicle run pass infront=1, otherwise=0
	3. Violation of the stop sign	if vehicle violated the stop sign=1, otherwise=0
	4. Violation of traffic signal/marking	if vehicle violated the traffic signal or marking=1, otherwise=0
	5. Causes Others	any other cause=1, otherwise=0
V. Environmental Conditions		
1. Weather	(a) clear	if clear weather=1, otherwise=0
	(b) rain	if raining=1, otherwise=0
	(c) Smoke/fume	if smoke/fume =1. otherwise=0
	(d) Cloudy	if cloudy=1, otherwise=0
	(e) Weather others	if other condition=1, otherwise=0
2. Lighting	(a) day	if day time=1, night time=0
	(b) dark with light	if presence of light during dark=1, no light during dark=0
	(c) Dark without light	if dark without light=1, otherwise=0
	(d) Lighting Others	if other condition=1, otherwise=0

VI. Type of accident		
	1. M->0	if motorcycle hit object=1, otherwise=0
	2. C->C	if car hit car=1, otherwise=0
	3. C->O	if car hit object=1, otherwise=0
	4. M->M	If motorcycle hit motorcycle=1, otherwise=0
	5. Accident Others	if other type of accident=1, otherwise=0
VII. Collision pattern		
	1. cp21	head on 120-150 degree crash=1, otherwise=0
	2. cp24	turning side on=1, otherwise=0
	3. cp25	turning head on=1, otherwise=0
	4. cp27	turning rear end=1, otherwise=0
	5. cp37	rear end=1, otherwise=0
	6. cp38	out of control=1, otherwise=0
	7. cp Others	any other type of collision=1, otherwise=0
VIII. Traffic Control		
	1. Speed Limit Sign	if speed limit sign is available=1, otherwise=0
	2. Stop Sign	if stop sign is available=1, otherwise=0
	3. Other Warning Sign	if other warning sign is available=1, otherwise=0
	4. Traffic Signal	if traffic signal is available=1, otherwise=0
	5.Warning Flash Light	if warning flash light is available=1, otherwise=0
	6. Road Marking	if road marking is available=1, otherwise=0
	7. No overtaking Sign	if no overtaking sign is available=1, otherwise=0
	8. Control Others	if other traffic control sign is available=1, otherwise=0

4.2 Model Evaluation

To confirm the suitability and fitness of the model, the log likelihood ratio and the pseudo R^2 are used. But as can be seen from previous literature review of similar models, it is common to ignore such goodness of fit within order probit models because the value of log likelihood ratio index may come substantially less than 1 making it extremely difficult to tell from these values whether the model has sufficient explanatory power or not. This can be seen from the log likelihood ratio and the pseudo R^2 of the models. Even though it appears to be low, it is comparatively similar with other studies of severity models where ordered probit has been used (Kockelman and Kweon, 2002; Khattak, 2001; Ducan, Khattak and Council, 1998; Renski, Khattak and Council, 1999; Khattak et al., 2002; Quddus et al., 2002). Therefore, we can state that the results of our models are justified to explain the variation in the severity of an accident.

4.3 Intersection Accident Severity

The final result of statistical analysis using Order Probit Model for the accident severity in intersections of Thailand from the available database is shown in Table 3 below:-

Table 3. Ordered Probit Model for Accident Severity

Iteration 0:	Log likelihood =	-1493.3484				
Iteration 1:	Log likelihood =	-1196.6707				
Iteration 2:	Log likelihood =	-1192.1920				
Iteration 3:	Log likelihood =	-1192.1754				
Iteration 4:	Log likelihood =	-1192.1754				
				Number of Obs =		1127
Ordered Probit Regression				LR Chi^2 (13) =		602.35
				Prob> Chi^2		0.0000
Log likelihood = -1192.1754				Pseudo R^2		0.2017
OPM	**Coef.**	**Std. Err.**	**z**	**P>[z]**	**[95% conf. Interval]**	
Motorcycle	1.0032520	.0797981	12.57	0.000	.8468506	1.159653
Passenger car	-.3642053	.0770166	-4.73	0.000	-.515155	-.2132556
Big truck	.3427091	.1079013	3.18	0.001	.1312264	.5541918
No of lane	-.2793679	.0377646	-7.40	0.000	-.353385	-.2053507
Russ pass infront	.1619847	.0804498	2.01	0.044	.0043059	.3196635
Day	-.3097344	.0822730	-3.76	0.000	-.4709864	-.1484824
MM	-.4381299	.1320048	-3.32	0.001	-.6968545	-.1794053
Cp24	-.4931966	.1959406	-2.52	0.012	-.8772331	-.1091601
Cp37	-.8662968	.0977531	-8.86	0.000	-1.057889	-.6747042
Traffic signal	.4239824	.0830306	5.11	0.000	.2612454	.5867194
Warning Flash	.3079213	.0923541	3.33	0.001	.1269105	.4889321
/cut1	-.9026315	.1259295			-1.149449	-.6558143
/cut2	.2552228	.1243654			.0114711	.4989745
/cut3	.961071	.1273487			.711472	1.21067

Out of 47 variables, only 11 were found to be statistically significant and are represented in Table 3. In the following section the impact of each significant variable on the accident severity level is interpreted.

Vehicle Characteristics: There are three factors in this group that are found to be statistically significant, they are motorcycle, passenger cars and big trucks. Among these three, motorcycle has the highest coefficient followed by big truck and passenger car having a negative coefficient. This shows that the occupants of **motorcycles** are more vulnerable to high accident severity in a road accident when compared with passenger car occupants for several reasons; the main factor is a lack of safety features such as outer shell, seatbelts or airbags on a motorcycle. The vehicle is both smaller and weighs considerably less than a passenger car which results in less force absorbed by the vehicle and proportionately higher force being absorbed by the occupant. Even in minor collisions, motorcycle occupants can easily lose control and suffer serious injury.

Accidents that involve **big trucks** results in higher injury severity for the occupant of the opposing vehicle as the size and mass of the big truck are far greater than any other type of vehicle. The collision therefore has a greater impact on the opposing vehicle as it would typically be smaller in every aspect. Therefore we can conclude that big trucks are more likely to be involved in a road accident resulting in higher injury severity.

Passenger cars are most commonly used vehicle for commuting. As the main purpose of a passenger car is for the movement of people, many safety features including air bags, seatbelts, and steel frame have been installed as mandatory features. Also there have been numerous studies, copious research, crash tests and product advancement focused on protecting the occupants of a passenger car. This is to ensure occupants of the passenger car avoid suffering severe injuries, where possible, when involved in an accident. The model shows that the passenger car is the safest of the vehicle types when involved in a road accident, as it has a negative coefficient, meaning that occupants of the passenger would suffer from the least injury severity in a road accident when compared with other vehicle types.

Road Characteristics: One factor in this group is found to be statistically significant, i.e. Number of lanes. From the results shown in Table 3, **Number of Lanes** has a negative coefficient which means that as the number of lanes in the roadway increases the severity of injury in accident decreases. As the number of lanes increases it allows more space for vehicles to maneuver and avoid collision with other vehicles as well as nearby objects thus decreasing the chance of accidents. As the space increases, there is less possibility of two vehicle accidents, as the vehicles have the ability to move to different lanes. Higher lane numbers also allows space and time for the driver to recover from an accident so as to avoid severe injury due to multiple collisions.

Probable Cause: One factor in this group is found to be statistically significant, i.e. **Run in pass in front of.** Run in pass in front of is a way of illegally overtaking the vehicle which is in front of the subject vehicle. When the driver of the subject vehicle tries to overtake the vehicle in front illegally, it often takes the other vehicle by surprise as the driver is not expecting an overtaking maneuver. This will affect the concentration of the driver of the vehicle in front which may result in the vehicle losing control and crashing subsequent road accident. Furthermore, while overtaking a vehicle in front, the driver behind will not be able to clearly see the road ahead as the view may be obscured by the vehicle in front. Therefore any obstacles, objects, or oncoming vehicles on the road may take the subject drive by surprise resulting in a lack of time and space to maneuver away from said object concluding in a potential road accident, thus the Run in pass in front of maneuver results in accidents with a higher injury severity.

Environmental Condition: From Table 3 it is found that three factors in this group are statistically significant, i.e. rain, day and dry.

From the result, in table 3 we found that **day** time is a significant factor in accident severity but having a negative coefficient, which means that during the daytime an accident is less likely to have a higher injury severity. In the presence of light the ability to view visible road, road geometry and the obstacles present in the surroundings offers the driver a better chance to avoid mishaps from occurring than during the night when the driver has to rely on headlights and street lights to see the road. Therefore the high visibility during the day results in a longer available reaction time for the driver meaning injury severity is significantly decreased as shown by the negative coefficient. Conversely **night** has an adverse effect on injury severity due to a lack of visibility and potential driver drowsiness.

Type of accident: M->M: From Table 3, it is found that a motorcycle hitting another motorcycle is a significant factor in the accident severity with a negative coefficient. This means that the severity of injury is less where there is a collision between two motorcycles due to their smaller size and lower mass the severity of the impact force mainly depends on the speed of the motorcycle. Since the crash takes place at an intersection, which is naturally a deceleration area of the road the impact force is significantly decreased resulting in lower injury severity.

Collision Pattern: From Table 3, it is found that two factors in this group are found to be statistically significant; cp24 (turning head to side crash), and cp37 (rear end crash).

Both of the collision patterns have negative coefficients, turning head to side crash having the largest negative coefficient, followed by rear end crash.

Rear end crash occurs mainly due to the speed differential of the vehicle in front and the vehicle following. The vehicle following often cannot stop in time before the vehicle ahead thus causing a rear end collision and often shunting the vehicle in front into the moving intersection, thus causing a chance of higher injury severity to the occupants.

A **turning head to side crash** at an intersection is often assumed to be of higher injury severity because the impact of a head to side collision is generally greater than head to rear collision along with possibly less collapsible space on the side of the vehicle. Furthermore, occupants on a side crash are less protected than in a head on crash, who may be cushioned by seat belts and air bags. But as shown from the results of this study, this is not the case and rear end crashes often cause higher injury severity than a turning head to side crash.

Traffic Control: From table 3, it is found that there are two factors from this group which are significant to the severity of accidents at intersections; traffic signal and warning flash lights.

Traffic Signals are a medium to divide the flow of traffic in the different directions of the intersection. However regardless of the presence of traffic signals a combination of misplacement resulting in lack of visibility to the oncoming traffic and a disregard for traffic signals can result in confusion or misdirection. The reliance on traffic signals at an intersection often results in a lack of awareness from other vehicles and can lead the vehicle into the intersection where there is traffic crossing due to obscurity of the traffic signal or a disregard for said signal, resulting in an accident which produces severe injury to the occupants.

Warning flash light is a device used to warn the drivers of vehicles about an oncoming danger however the flash light can potentially cause a disturbance in the drivers vision, resulting in a loss of concentration or even at times temporarily blurred vision due to the high intensity flashing lights.

5. CONCLUSION

In conclusion this research study has identified the main factors responsible for accident severity in Thailand using the ordered probit model. In Thailand there is a need to promote safe driving below the designated speed dependent on the conditions and location and to strictly follow rules and regulations to avoid unnecessary tragedies.

The type of vehicle which accounts for the greatest injury severity when involved in a road accident has been found to be motorcycles, due to unavailability of various safety features or protection from any type of collision followed by the big truck due to its big size and heavy mass causing greater impact force resulting in higher injury in the opposing vehicle. The most severe accident occurs when there is a collision between a big truck and a motorcycle, in this type of accident the motorcycle occupant usually suffers from severe injuries or fatality. A suggestion to reduce the severity of injury involved in motorcycle vs. truck road accidents would be to provide separate lanes for motorcycles and heavy vehicles so as to reduce the conflict points at an intersection. This would not only reduce the injury severity but also reduce the accident rate as well.

The most significant probable cause for the occurrence of severe accident is when a vehicle following passes in front of the vehicle in front of it illegally. This is due to a combination of distraction of the front vehicle driver and an obscurity of any potential oncoming obstacles, vehicles or objects for the driver of the overtaking vehicle.

A secondary cause for the occurrence of severity accidents is low visibility and night time drowsiness of the driver and therefore delayed reaction of the driver to any objects or impeding collision with other vehicles. There is a significantly reduced severity during the day when there is presence of light on the road, resulting in higher visibility and making the obstacles, objects, on coming vehicles distinctly visible from a safer distance, resulting in more time to complete any action that can be taken to avoid accidents.

Among the factors considered in collision types for intersections, turning side on and rear end collisions seem to have the greatest injury severity to the occupants of the vehicles. But, common collision like right angle crash seems to be less severe as compared to the aforementioned accidents. To minimize theses collision crashes, innovative design .and proper placement of roadside objects and installment of clearly visible delineated intersection ahead signs in both major and minor roads are necessary. Also a crash recovery area should be allocated at intersections as to provide some space for safety.

Additionally information from local residents and law enforcement suggests that there is a huge problem of commuters avoiding and not cooperating with the traffic control devices and signal. So installing traffic feature such as red light cameras, monitors and the resultant persecution of violators of traffic signals and signs at major intersections of Thailand's highways should be implemented.

REFERENCES

Abdel-aty, M. A., Chen, C., and Schott, J. R. (1998) An assessment of the effect of driver age on traffic accident involvement using log-linear models. *Accident Analysis and Prevention, 30(6)*, 851–861.

Abdel-Aty, M., (2003). Analysis of driver injury severity levels at multiple locations using ordered probit model. J. Safety Res. 34 (5), 597–603.

Chang L.-Y. and Mannering, (1998). Predicting Vehicle Occupancies from Accident Data – an Accident Severity approach. *Transportation Research Record*, *1635*, pp.93-103.

Dissanayake, S., and Lu, J. (2002) Analysis of Severity of Young Driver Crashes- Sequential Binary Logistic Regression Modeling. *Transportation Research Record*, *1784*, pp. 108-114. 2002.

Duncan, C.S., Khattak, A.J. and Council, (1998) F., M. Applying the Ordered Probit Model to Injury Severity in Truck- Passenger Car Rear- end Collisions. *Transportation Research Record, 1635*, pp. 63-71.

Khattak, A.J., M. D. Pawlovich, R.R. Souleyrette, and S.L. Hallmark. (2002*)* Factors Related to More Severe Older Driver Traffic Crash Injuries, *Journal of Transportation Engineering*, Vol. 128, No. 3, pp 243-249,

Khattak, A.J., Shneider, R.J., &Targa F. (2003) Risk factors in large truck rollovers and injury severity: analysis of single-vehicle collisions. *82nd Annual Meeting of the Transportation Research Boards, TRB paper number 03-2331*

Kim, K., L. Nitz, R. James, and L. Li.(1995) Personal and Behavioral Predictors of Automobile Crash and Injury Severity, Accident Analysis and Prevention, Vol.34, No. 5, pp 469-481,

Kockelman, K.M. and Kweon Y.J. (2002) Driver Injury Severity: An Application of Ordered Probit models. *Accident Analysis and Prevention, 34(3)*, pp.313- 321.

Krull, K., Khattak, A. and Council, (2000) Injury Effects of Rollovers and Events Sequence in Single-Vehicle Crashes. *Transportation Research Record*, 1635, pp. 93-103.

Lee, J., & Mannering, F. L. (2002). Impact of Roadside Features on the Frequency and Severity of Run-Off-Roadway Accidents: An Empirical Analysis. *Accident Analysis and Prevention*, 34(2), 149– 161.

O' Donnel, C.J. and Connor, D.H. (1996) Predicting the Severity of Motor Vehicle Accident Injuries Using Models of Ordered Multiple Choice. Accident Analysis and Prevention, *28(6)*, 739-753.

Quddus et al., (2002) M.A. Quddus, R.B. Noland, H.C. Chin An analysis of motorcycle injury and vehicle damage severity using ordered probit models *Journal of Safety Research*, 33 (4), pp. 445–462

S. Nassar, F. Saccomanno, J. Shortreed, (1994), Road Accident Severity Analysis: A Micro Level Approach Canadian *Journal of Civil Engineering*, 21, pp. 847–855

T. Hutchinson, (1986) Statistical Modeling of Injury Severity, with Special Reference to Driver and Front Seat Passenger in Single-Vehicle Crashes. *Accident Analysis and Prevention*, 18 (2), pp. 157–167

Treat, J. R.; Tumbas, N. S.; McDonald, S. T.; Shinar, D.; Hume, R. D.; Mayer, R. E.; Stansifer, R. L., and Castellan, N. J. (1979) Tri- Level Study of the Causes of Traffic Accidents: Final Report. Volume I: Causal Factor Tabulations and Assessments. *Institute for Research in Public Safety, Indiana University, Bloomington, Indiana.*

Yamamoto T and Shankar VN (2002). Bivariate Ordered- Response Probit Model of driver's and passenger's injury severities in collision with fixed objects. *Transportation Research Board*, Annual Meeting

Zhang, J., Lindsay, J., Clarke, K., Robbins, G., Mao, Y., (2000). A factor affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario *Accident Analysis and Prevention* 32 (1), 117–125.