Modeling Traffic Accident Severity Analysis on NH-202 in Rangareddy District

V. Ranjith Kumar[1]
Assistant Professor,
Malla Reddy Engineering College, Autonomous
Andhra Pradesh, India

***Abstract* — In this paper, a brief practical review is presented on the statistical evidence showing how different characteristics such as seasonal variation, vehicle type, road user's attributes and collision type can lead to variations in the probabilities of sustaining different levels of injury severity in motor vehicle accidents. Different injury severity levels which are classified as minor injury, major injury and death are analyzed using the ordered probit modeling methodology. A total of 535 accidents occurring on NH-202 in RangaReddy district collected from different police stations of year 2008, 2009 & 2010 had been considered for this study. After initial investigation it was found that there was overrepresentation of crashes. Hence distinct models— individual crash model, all crash model, and a model with all crashes have been developed. This model investigate how various factors such as the seasonal variation, weekly variation, time of day variation, crash location, collision type, victim gender, and vehicle type influence severities of sustained injuries.**

***Keywords*—Accident Analysis, severity, ranga reddy, NH-202, Accident Modeling,**

1. INTRODUCTION

Throughout the world, the growth of the transport system has been and continues to be a key element in economic development. Increase in gross national product is associated with greater movement of people and goods and greater investment in both vehicles and transport infrastructure. In the developing world, current trends in population growth, industrialization and urbanization are causing heavy pressure on the transport network in general and on road network in particular. Most unwanted side-effect of this growth in traffic is growing numbers of deaths and injuries from road traffic accidents resulting in enormous cost in terms of lost productivity of the society. This also includes personal losses due to injuries (or fatalities) in traffic accidents as the victims must deal with pain and suffering, medical costs, wage loss, and vehicle repair costs. As a result traffic safety issues had attracted much attention of traffic engineers and planners to do effective research and get better understanding of the problem that provides the framework against which effective policies and counter-measures could be developed.

Traffic safety is a major concern because of the economic and social costs of traffic crashes. The impact that traffic accidents have on society is significant. Individuals injured (or killed) in traffic accidents must deal with pain and suffering, medical costs, wage loss, and vehicle repair costs. For society as a whole, traffic accidents result in enormous costs in terms of lost productivity and property damage. It is assumed that there is total 2% loss of GDP only due to road accident in India. Clearly, efforts to improve our understanding of the factors that influence accident severity are warranted. So the common practice in transportation engineering is a thorough study of traffic accidents and gets an understanding of the factor affecting them. Severity of injury sustained by victim involved in crashes is of considerable interest to policy makers & safety engineers. The relationship between the injury severity of traffic crashes and factors such as driver and passenger characteristics, vehicle type, and traffic and geometric conditions has attracted much attention. Better understanding of this relationship is necessary and very important for improving vehicle and roadway designs such that severe injuries can be reduced. Numerous studies have applied statistical models for crash injury severity study.

2. NEED OF HIGH STRENGTH CONCRETE

Initial investigation of collected sample data on National Highway-202 (NH-202) of Rangareddy District as shown in the figure-2.1 and last three years i.e. 2008-2010 accident data of Rangareddy district that in 2010, 53 % of total crashes on NH-202 were fatal and 39 % were major injury crashes. While in 2009 major injury and fatal crashes were 51% and 44% and in 2008 it was 49% and 40% respectively as shown in figure-2.2. This clearly shows that crashes occurring on NH-202 rarely result in minor or no injury crashes, probably due to higher average speed of these facilities. A further investigation on share of crashes on various roadways in RangaReddy district shows that, 54% of the total people died in the district due to road traffic crashes occurred on NH-202 only, compared to other state and district roadways. These statistics clearly shows that the accident situation on NH-202 is worsening.

The present study was conducted to understand the contributing factors affecting severity of road crashes in RangaReddy with a broad consideration of driver characteristics, roadway features, vehicle types and environmental factors. For this purpose, the type of accident

severity analyses have been incorporated, i.e. all vehicle crash severity to get an overview of the factors affecting the severity throughout the RangaReddy district. The reason behind choosing this type of accident in severity analysis is that they constitute about the accidents that occurred in RangaReddy district from 2008 to 2010.

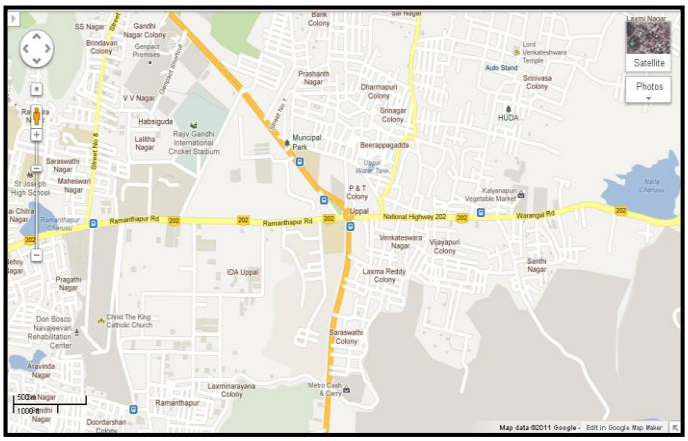

Figure-2.1 Map of NH-202 in Ranga Reddy district.

Further, another reason to examine the factors affecting injury severity is that NH-202 has been proposed to be widened from 4 lanes to 6 lanes. Therefore situation is going to be worse if precautionary measures are not implemented. For this purpose, it is important that thorough studies on accident occurrence and severities are done to recognize the different geometric, environmental, driver, & vehicle characteristics contributing higher number of accidents and higher severities.

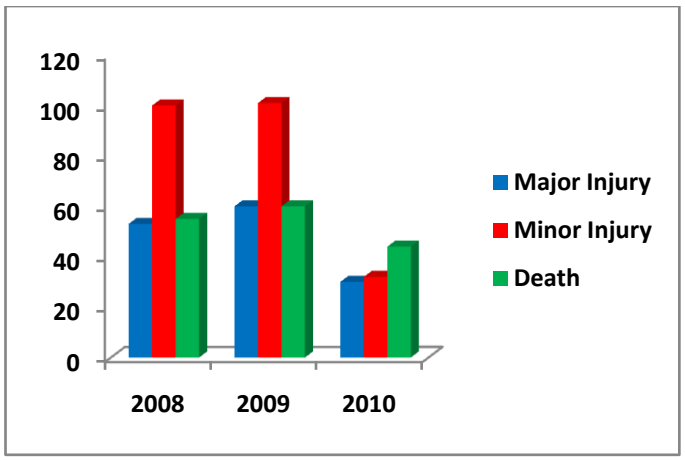

Figure-2.2 Crash Severity Distribution during year 2008-2010 on NH-202 in Ranga Reddy district.

Years	Major Injury	Minor Injury	Death
2008	53	100	55
2009	60	101	60
2010	30	32	44

Table2.3 Crash Severity Distribution during year 2008-2010 on NH-202 in Ranga Reddy district.

However, scientific investigation of crashes and remedies are not common in India. In this regards, it is noteworthy that efforts to understand causes of road traffic crash severities are even fewer if not completely absent. Very few works have been done on national highways confined to general accident trends (Rao et al. 2005, Rajaraman 2009).

Due to dis-similarity in roadway type, roadway user, geometric layout of roads, type of vehicles, traffic control and regulatory conditions research findings on factors affecting injury severity in other countries may not be directly applicable to national highways of India. Therefore it becomes quite important to identify the factors that affect injury severity by investigating historical accident data so that safety countermeasure could be implemented

3.0 OBJECTIVE AND SCOPE OF STUDY

The principal objective of this study is to investigate how various factors such as the seasonal variation, weekly variation, time of day variation, collision type, victim gender, crash location, and vehicle type can lead to variations in the probabilities of sustaining different levels of injury severity in motor vehicle accidents on NH-202.

To do so injury severity levels had been categorized into three levels. Three levels are minor injury, major injury and death. Data have been collected from different police stations of RangaReddy district along NH-202. Then after initial investigations of primary data has been done. From those analyses it was found that there were over-representation of pedestrian and truck involved crashes. So three distinct model, all crash model, truck involved crash model, and model for all pedestrian involved crashes have been developed to get clear understanding of the factors influencing higher level of severities. Finally the probability of occurring different levels of injury severity associated with different factors such as collision type, vehicle type, time of day variation have been estimated.

In all the above studies environmental factors such as climatic condition, roadway geometry like horizontal curve, vertical curve are not taken into account due to lack of accident data. Victim's age have not been considered into model due to insufficient data and has been separately investigated.

To achieve the above mentioned objective ordered probit model have been applied to real accident data. Ordered probit

model is a widely used statistical tool which is generally used for analysis of ordinal data. Here injury severities are ordinal data type. The models are analyzed to find the factors causing higher level of severities in traffic crash.

4.0 METHOLODGY

The methodology implemented to analyze police-reported crash data on national highway-202 to identify possible factors that cause these crashes and to understand their effect on injury severity using statistical modeling techniques. The method and procedures adopted for this study can be divided into three steps-

a. Collection of accident data,
b. Variable selection and development of statistical model and
c. Analysis and interpretation of model findings. A detailed description of the above mentioned steps is presented in the following sections.

4.1 DATA COLLECTION

As mentioned in Section 1.4 of Chapter one above, since the objective of the study was to understand the effects of various factors such as the seasonal variation, weekly variation, time of day variation, collision type, victim gender, crash location, and vehicle type on injury severity of crashes on NH-202, several data sources have to be used to obtain all the data necessary to carry out the study. In order to meet this objective of the research, which specifically is attempting to create a better understanding the effects of these factors believed to possibly influence injury severity, collection of accurate and representative data was the most critical and of course lengthiest part of the research.

4.2 COLLECTION AND PROCESSING OF ACCIDENT DATA

Due to lack of any standard traffic crash data reporting system a field survey have been done to collect all police-reported crash data on NH-202. Since the study area was NH-202 in RangaReddy district all the police station that were reporting any crash occurred on national highway have been taken into consideration. Unfortunately, police reports at accident sites do not describe injuries in much detail because of the lack of police qualifications and training as well as facilities needed to perform complex examinations. All these police station having theses crash data in form of FIR sheets and complaint lodged by victim or else one. All the reported crashes occurring in last three years i.e. from 2008 to 2010 were collected. From these FIR sheets and complain letter a data set have been prepared. Preparation of data set was the most time consuming part of the study.

Also, medical reports were hard to obtain because police accident data and medical data are not kept together. Consequently, it was impossible to obtain details on the degree of accident severity. All that can be learned from the police records is that the accident is a fatal accident, minor injury, severe injury on accident. Each observation in this data set is a record of the level of injury severity sustained by crash victim, Vehicle type involved in crash, location of the accident, type of collision, year, month, day, date, and time of the collision, victim gender, victim age, and lane direction.

A total of 535 crashes occurring on NH-202 in RangaReddy district of the year 2008 to 2010 have been summarized from the developed traffic crash data set. Out of these 535 observations 29.71% crashes classified as fatal injury, 26.72% as major injury, 43.55% as minor injury and only as shown in figure-4.1.

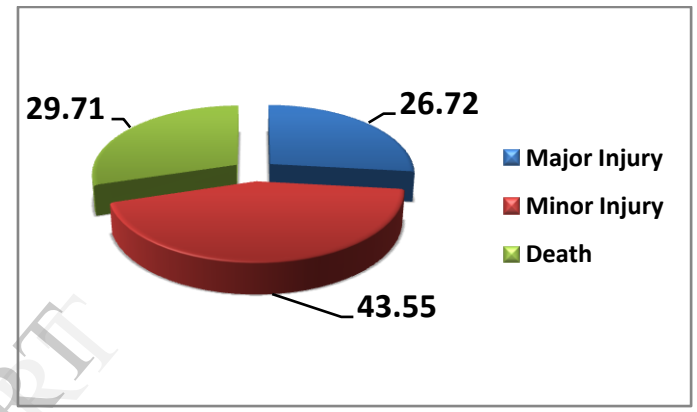

Fig-4.1 Percent share of crash severity on NH-202 in RangaReddy district

4.2.2 PRIMARY INVESTIGATION OF ACCIDENT DATA.

A total of 10 major factors contributing to higher crash severity were summarized from those 535 crash counts. A preliminary investigation of these factors was done so that their impacts on injury severity could be estimated. Detailed discussion of these major variables is given in following paragraphs.

MONTHLY DISTRIBUTION OF CRASH INJURY SEVERITY:

As illustrated in figure-4.2 highest accidents are occurring in month of August. It is 11.76% of all accident occurring during 2008-2010.

About 12.93 % of all fatal crashes are occurring in August and October each. In August highest major injury has been observed which is about 11 % of all major injury occurred during 2008-2010.

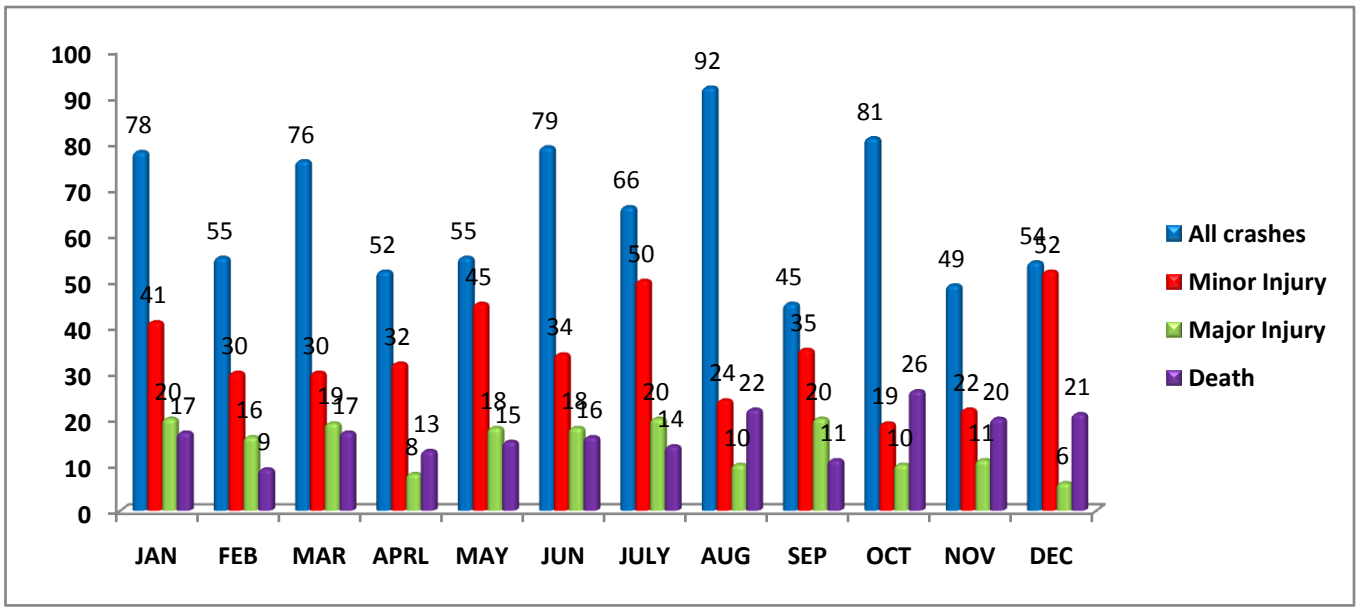

Fig-4.2 Monthly variation of crash Severity on NH-202 during 2008-2010

WEEKLY DISTRIBUTION OF CRASH SEVERITY:

Percent distribution of crash severity by week of the day is shown in figure-4.3.

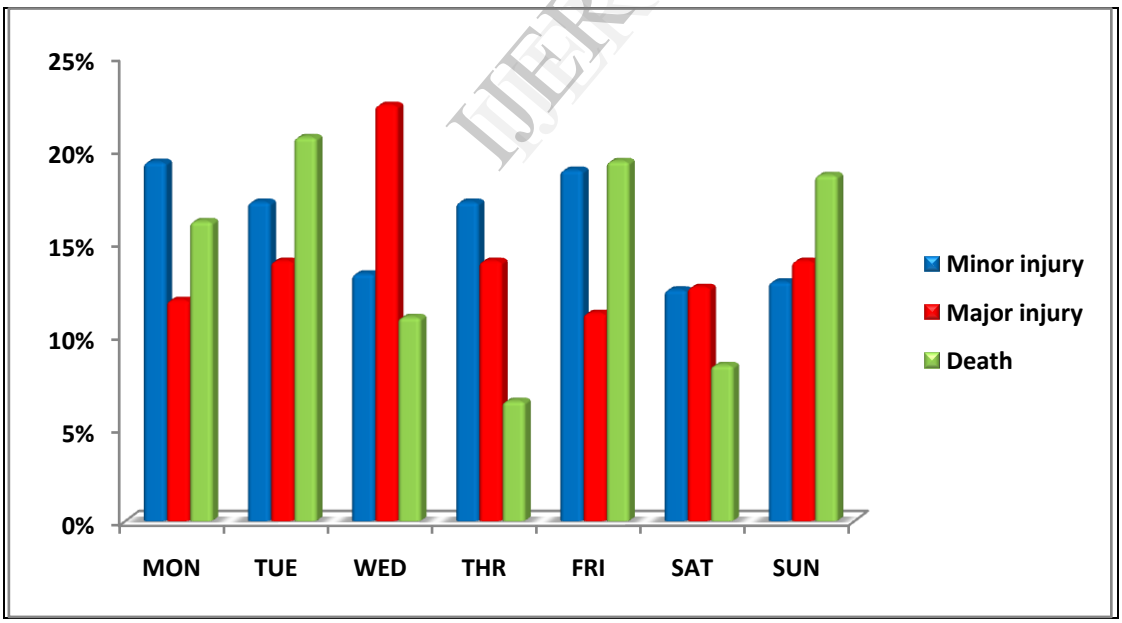

Fig-4.3 Weekly distribution of crash severities

WEEKLY DISTRIBUTION OF CRASH SEVERITY:

Through-out the week no major variation have found. All crashes are between1% to 4 %, minor injury crashes are between 4% to 8 % where as major injury and fatal crashes are always greater than 20%.

HOURLY VARIATION OF CRASH INJURY SEVERITY

Hourly variation of crash severity is estimated with four hours of interval throughout the day by plotting percent distribution of crash severity on Y-axis. Table 4.1 show that between night 00:00 hrs to morning 03:59 hrs percentage of occurring fatal crashes are higher which is 31.20% of total crash occurring between that hours.

Time	Minor Injury	Major injury	Death
00.00-03.59	24.4	23.39	31.2
04.00-07.59	7.29	8.39	6.28
08.00-11.59	15.45	15.38	13.2
12.00-15.59	16.18	15	13.27
16.00-17.59	14.16	13.98	13.2
18.00-19.59	16.3	17.48	18.23
20.00-24.00	16.3	18.18	22.64

Table-4.1 Hourly distribution of crash severity

Model Selection

The crash injury severity is a typical ordered variable which could be categorized at different levels from the least severe level to the most severe. In this study crash injury severity is ordinal variable categorized as "no injury = 0," "minor injury = 1," "major injury = 2," and "fatal = 3". As ordered response models are capable of recognizing the indexed nature of various response variables so it is commonly used for analyzing the data sets that include categorical and ordered dependent variable. Among ordered response model ordered probit/logit are the most often used models

Model Specification

The general specification of each single equation model is:

$$Y_n^* = \beta' x_n + \varepsilon_n,$$

Where, Y_n^* is the latent and continuous measure of injury severity faced by the accident victim 'n' in a crash, x_n is a vector of explanatory variables measuring the attributes of accident victim.β' is vector of parameters to be estimated, and ε_n is a random error term which assumed to follow a standard normal distribution with mean zero and variance one.

The observed and coded discrete injury severity variable, Y_n, is determined from the model as follows:

$$Y_n = \begin{cases} 0 & \text{if } -\infty \le Y_n^* \le \mu_1 \quad \text{(no injury)}, \\ 1 & \text{if } \mu_1 < Y_n^* < \mu_2 \quad \text{(not severe injury)}, \\ 2 & \text{if } \mu_2 < Y_n^* < \mu_3 \quad \text{(severe injury)}, \\ 3 & \text{if } \mu_3 < Y_n^* < \infty \quad \text{(fatal)}, \end{cases}$$

Where, the μ_i represents thresholds to be estimated along with the parameter vector β.

The probabilities associated with the coded responses of an ordered probit model are as follows:

$$P_n(0) = \Pr(Y_n = 0) = \Pr(Y_n^* \le \mu_1) = \Pr(\beta' x_n + \varepsilon_n \le \mu_1)$$
$$= \Pr(\varepsilon_n \le \mu_1 - \beta' x_n) = \varphi(\mu_1 - \beta' z_n)$$
$$P_n(1) = \Pr(Y_n = 1) = \Pr(\mu_1 < Y_n^* \le \mu_2)$$
$$= \Pr(\varepsilon_n \le \mu_2 - \beta' x_n) - \Pr(\varepsilon_n \le \mu_1 - \beta' x_n)$$
$$= \varphi(\mu_2 - \beta' x_n) - \varphi(\mu_1 - \beta' x_n)$$
$$P_n(k) = \Pr(Y_n = k) = \Pr(\mu_k < Yn^* \le \mu_{k+1})$$
$$= \varphi(\mu_{k+1} - \beta' x_n) - \varphi(\mu_k - \beta' x_n)$$
$$P_n(K) = \Pr(Y_n = K) = \Pr(\mu_k < Yn^*)$$
$$= 1 - \varphi(\mu_k - \beta' x_n)$$

Where, n is an individual, k is a response alternative ($Y_n=k$) is the probability that individual n responds in manner k, and $\varphi(.)$ is the standard normal cumulative distribution function. The model is usually identified by setting $\mu_0=0$. So the unknown parameters needing to estimate then become β and $(\mu_1, \mu_2, \mu_3, \ldots\ldots \mu_k)$.

The parameters of ordered multiple choice models are estimated by the method of maximum likelihood (ML). In very simple terms, the method of ML is a method for choosing parameter estimates in order to maximize the probability, or likelihood, of observing given data. A likelihood function is an equation expressing this probability/likelihood as a function of the data and the unknown parameters, and ML estimation involves the systematic evaluation of this function at different points (i.e. sets of parameter values) in order to find the point at which the function is maximized. This set of parameter values then becomes set of ML estimates.

For a sample of N accident victims, the log-likelihood function (i.e. the logarithm of the likelihood function) for ordered probit models can be written as

$$\log(L) = \sum_{n=1}^{N} \sum_{k=1}^{K} d_{nk} \log[P_n(k)]$$

Where d_{nk} is a dummy variable which takes the value one if individual n chose alternative k and $d_{nk} = 0$ otherwise.

DISCUSSION AND RECOMMENDATION

In this model the developed study on crashes occurring in night, are resulting higher level of crash severity. Particularly accidents occurring between midnight to early morning hours are more sensitive to higher level of crash severity. This may be due to poor illumination and absence of warning measures such as retro-reflective signs which helps in roadway hazard identification. Hence to avoid such crashes proper illumination in night hours on highways along with retro-

reflective materials is strongly recommended. For this purpose installation of solar lights may be very effective.

Pedestrians, bicycles, motorcycle and auto-rickshaws are facing higher crash severity. This is mainly because of the discontinuous service roads leading to wrong side movement of traffic in order to avoid long detours. Hence it is logical to provide separate service lane for local traffics. On NH-202 there is lack of proper facilities for vulnerable road users to cross highway forcing them midblock crossing. Therefore, infrastructure and planning such as additional side walk and cross walks that would act to separate vulnerable road users are needed. Educational programs to encourage riders to use helmet will be very effective and is highly recommended.

In accused vehicle categories trucks are resulting higher crash severity. Most of trucks on highways are overloaded and old and also there is absence of safety features in trucks. Also, a high percentage of these vehicle fleets are old, thus improperly maintained and lack safety features such as antilock braking. The crashworthiness of these vehicles is also low. In addition, they are hard to locate at night since they have neither tail lights nor reflective tapes. As a result, they are highly involved in crashes and the chance of survival of the truck users is also very low. Therefore developing stronger enforcement strategies and education programs in order to remove overloading and to improve the safety features in truck is strongly recommended and could only be done through government policies.

Hit and run type of crashes is also resulting in higher level of crash severity. There is no remedy for hit and run type of crashes except enforcement and stringent punishment.

Overturning crashes are also resulting higher crash severity. To take care of overturning crashes pavement distress such as potholes and rutting should be removed. Also median openings and turning radius are to be re-designed for better safety.

CONCLUSIONS

This study highlights factors that are responsible for higher level of crash severity on national highway-202. Ordered probit regression methodology has been used to develop statistical models that were able to recognize those factors. To get clear understanding of those factors affecting higher crash severity three distinct models- all crash model, truck involved crash model and pedestrian involved crash model, have been developed. Finding of all this study may be concluded as follows:

- Accidents occurring during night time are more severe than accidents occurring in day light. In case of trucks, the early morning time crashes between 4 and 8 am resulted in higher severity than other time of the day.

- Accidents occurring at intersections are less severe than other roadway sections.

- Pedestrians, bicycle, motorcycle, and auto-rickshaws are always facing higher level of crash severity.

- Unknown vehicles and trucks are responsible for high crash severity on national highway.

- Both all crash model and lorry involved crash model show that hit and run and overturning crashes are more severe than head-on collision.

In this study some important variable that may be associated with higher severity level such as roadway geometrics, environmental factors are not included due to data unavailability. However findings of this study may help for future research when data become available. Finally, for future studies combination of crash frequency analysis with injury severity analysis including all risk factors by more extensive data collection would be helpful in getting an all rounded understanding of risk factors which can be instrumental for planning safety improvement programs.

REFERENCES

1. Kockelman, K. M., and Kweon, Y. J. (2002). “Driver injury severity: an application of ordered probit models.” Accident Analysis and Prevention, 34, 313–321.
2. Abdel, M. A. (2003). “Analysis of driver injury severity levels at multiple locations using ordered probit models.” Journal of Safety Research, 34, 597–603.
3. Qudus, M. A., Noland, R. B., and Chin H. C. (2002). “An analysis of motorcycle injury and vehicle damage severity using ordered probit models.” Journal of Safety Research, 33, 445–462.
4. Gray R. C., Qudus, M. A. and Evans, A. (2008). “Injury severity analysis of accidents involving young male drivers in Great Britain.” Journal of Safety Research, 39, 483–495