# Road accident models for Khulna metropolitan city, Bangladesh

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## ABSTRACT

Increasing road traffic accidents are a major threat to life in many parts of the world. To ensure safe, effective and sustainable transportation system at Khulna Metropolitan city which is the third largest metropolitan city of Bangladesh, it is indispensable to understand the current situation of road traffic accident of this area. A very few research works with detailed analysis of road traffic accident have been carried out in Khulna Metropolitan city for a full understanding of accident problem. Because of the alarming increase of the road traffic accident at Khulna metropolitan city, it is important to develop road accident models considering the basic factors of those causing accident in this area. In this study, all the reported accidents by Khulna Metropolitan Police during the period of 2000 to 2010 are analyzed. The aim of the present study is to develop models by analyzing these road accident data for five police stations of Khulna metropolitan city. The data for the period of 11 years are analyzed to understand the nature and extent of the causes of accidents using the concept of Smeed's formula and Andreassen's equations. As the variation between actual number of accidents and the accidents obtained from these formulas are quite high, a new inverse model is proposed. These accident prediction models can be used as effective tools in road safety analysis for Khulna Metropolitan City.

**Key words:** Khulna Metropolitan city, accident prediction models, Andreassen's equations, Smeed's formula, Inverse model.

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## INTRODUCTION

Road accidents are one of the major causes of death, injury and disability all over the world both in developed and developing countries. With a broad estimation, in every one minute, two people are killed and 95 people are severely injured or permanently disabled in traffic accidents worldwide. Traffic accident related deaths and injuries result is not only substantial economic losses but also serious physical and mental sufferings. Developing countries are much more affected from traffic accidents than developed countries. According to the world health organization (WHO) statistics, 75% of deaths resulted from traffic accidents occur in developing countries, although they own only 32% of the motor vehicles in the world. While the annual fatality per 10,000 vehicles ranges from 20 to 200 in low or middle income countries, it varies between 1.5 and 5.0 in industrialized countries.

The estimated global economic cost of traffic accidents is$518 billion per year. The share of the developing countries is $100 billion which account for 1 to 3% of their gross national product (Peden et al., 2004).

Each year more than 500000 people die in road accidents around the world (Mannan and Karim, 1999). The majority of these deaths (about 70%) occur in developing countries, 65% of deaths involve pedestrians and 35% of pedestrian deaths are children. About 15 to 20 million people suffer severe injuries. The "Study Global Burden of Disease" undertaken by the World Health Organization (WHO), Harvard University, and World Bank, showed that traffic accidents were the world's ninth biggest cause of deaths during 1990. The study forecasts that by the year 2020, road accidents would move up to third place in the table of major causes of death and disability (Murray and Lopez, 1994). The development and the planning of transport service is a means of assisting the community to satisfy the goals of socio-economic and development.  In this respect the role of road transport is increasing than other mode of transport (viz. rail, water and air) in Bangladesh which is one of the densely populated developing countries in the world. But road traffic crashes, injuries, property damages are great concern to communities in Bangladesh. Each year as reported to police, more than 3300 individuals lose their lives in road traffic accidents in Bangladesh and many more sustain disabling injuries. Almost 2% of Gross Domestic Product (GDP) is lost in road traffic accidents in our country which itself demonstrates the severity both in terms of deaths and injuries as well as in monetary terms. Although Bangladesh is one of the lowest motorized countries (motorization level 2.3) in the world, it has, however, the worst road fatality rates in the Asia-Pacific region (Anjuman and Hoque, 2007). This problem draws significant attention in Bangladesh, where road accidents are extremely high and still increasing.

Khulna metropolitan city is one of the most important industrial and divisional cities of Bangladesh. It is located at the south-western part of Bangladesh. In Khulna city, to date, very few research works has been carried out with a detailed spectrum of analysis of road accidents models for a full understanding of accident problems and thereby developing effective countermeasures (Mahmud et al., 2010). Because of this road accident, model incorporating the basic factors in Khulna Metropolitan City is developed.

## METHODOLOGY

The aim of the present study is to develop models by analyzing the road accident data of five police stations (locally known as thanas) of Khulna Metropolitan City, Bangladesh.These are Khulna, Sonadanga, Daulatpur, Khalishpur, and Khan Jahan Ali.All the accident d ata  for

the period of 11 years (2000 to 2010) were collected from the above mentioned police stations of Khulna Metropolitan City.The rapid growth of population along with numerous economic activities have acted as the major catalyst for the steady growth of the motor vehicle population and has subsequently resulted in the increase of road accidents.

The growth rates of motor vehicles, population and accidents for selected police stations in Khulna Metropolitan City were estimated. Road accident index was also determined. It is the specified number of victim of accident in analyzed year per each 1000 person (Valli, 2004).Rate of change in road accident indices from 2000 to 2010 were determined. A useful result in terms of rate of changes in road accident indices over a period of eleven years (2000 to 2010) for five police stations was presented.

Based on Smeed's formula(Smeed,1949) an attempt has been made to develop relationships among the parameters, namely, road accidents, the number of registered motor vehicles and population. The data on road accidents in terms of total number of accidents (C), fatalities (F), injuries (I) and the number of registered motor vehicles (N) were used from road accidents in Khulna Metropolitan City. It was proposed to investigate the data and develop appropriate models based on the concept of Smeed's and Andreassen'sprescribed models. The standard statistical testwas used to assess the validity of each model. In this analysis the t-test was used to determine whether an estimated regression coefficient is statistically significant. Here, level of significant 5% is used, i.e. 95% confidence level.

## Smeed's Formula

In the present study to develop Smeed's model for the years 2000 to 2010for Khulna Metropolitan City the following equations were used:

$$C / N = \beta_1 (N / P)^\beta \qquad (1)$$

$$F / N = \beta_1 (N / P)^\beta \qquad (2)$$

$$I / N = \beta_1 (N / P)^\beta \qquad (3)$$

Where, C is total number of accidents, F is fatalities, I is injuries, N is the number of registered motor vehicles, P is population and $\beta$, $\beta 1$are model parameters.

## Andreassen's Formula

Smeed's analysis was heavily criticized by Andreassen (Andreassen,1991)for model accuracy. It was mentioned that the Smeed's formula cannot be applied universally to all countries. The generalized relationship  developed  by

**Table1.**Number of Accidents in Khulna Metropolitan Area in the period 2000-2010.

| Thana | Khulna | Daulatpur | Khalishpur | Khan Jahan Ali | Sonadanga | Total |
|-------|--------|-----------|------------|----------------|-----------|-------|
| 2000 | 10 | 8 | 7 | 10 | 7 | 42 |
| 2001 | 13 | 9 | 6 | 8 | 4 | 40 |
| 2002 | 5 | 11 | 6 | 10 | 6 | 38 |
| 2003 | 7 | 9 | 1 | 5 | 9 | 31 |
| 2004 | 3 | 1 | 1 | 6 | 4 | 15 |
| 2005 | 8 | 6 | 1 | 1 | 2 | 18 |
| 2006 | 8 | 8 | 7 | 16 | 3 | 42 |
| 2007 | 7 | 9 | 3 | 16 | 5 | 40 |
| 2008 | 9 | 2 | 4 | 7 | 6 | 28 |
| 2009 | 6 | 7 | 6 | 9 | 11 | 39 |
| 2010 | 9 | 4 | 4 | 5 | 7 | 29 |

**Table 2.** Growth rates of motor vehicles, population and accidents for Khulna Metropolitan Area from 2000 to 2010.

| | Khulna | Daulatpur | Khalishpur | Khan JahanAli | Sonadanga |
|---|--------|-----------|------------|---------------|-----------|
| AAGR of Motor Vehicles, $N_R$ | 0.075 | 0.078 | 0.072 | 0.082 | 0.065 |
| AAGR of Population, $P_R$ | 0.017 | 0.016 | 0.016 | 0.017 | 0.016 |
| AAGR of Total Accidents, $C_R$ | -0.130 | -0.244 | -0.181 | -0.291 | -0.027 |
| AAGR of Fatalities, $F_R$ | -0.510 | -0.698 | -1.097 | -0.244 | -0.763 |
| AAGR of Injuries, $I_R$ | -0.904 | -0.122 | -0.056 | -2.280 | -0.183 |
| $C_R/N_R$ | -1.733 | -3.128 | -2.514 | -3.549 | -0.415 |
| $N_R/P_R$ | 4.410 | 4.880 | 4.500 | 4.820 | 4.060 |

Andreassenis given below:

$$D = Constant \times N^{M1} \times P^{(M2)} \qquad (4)$$

Where, D is the numbers of deaths and M1, M2 are model parameters.Regression analysis was conducted to determine the model parameters of both Smeed's and Andreassen's Formulae. The regression analysis was performed for inverse equation by using the SPSSv16software. A comparison of observed and model values using the above two approaches were presented. As the variation between model and observed values is quite high, a new developed model was proposed.The mathematical form of the model is as follows:

$$A/N = \beta_0 + \beta_1/(N/P) \qquad (5)$$

Where,A / N = Accidents per 1000 motor vehicles;N / P = Motor vehicles per 1000 population;$\beta_0$ and$\beta_1$ are model parameters.

**RESULTS AND DISCUSSION**

Road accident is a global trauma and like many other countries in the world Bangladesh also suffers a great deal due to road accidents every year. With the growth of motorization, urbanization and hence number of road users, the number of accidents and fatalities on road are increasing with the passage of time. Table 1 shows the accident statistics of Khulna Metropolitan Area during the period 2000 to 2010. For the development of accident models for Khulna Metropolitan City it is very important to calculate the Average Annual Growth Rate (AAGR). Table 2 presents the growth rates of motor vehicles, population and accidents for five police stations (Khulna, Khalishpur, Daulatpur, Khan Jahan Ali, and Sonadanga) of Khulna Metropolitan City.It can be seen from Table 2 that the ratio of average annual growth rate of motor vehicles to population varies from 4.06 to 4.88. From this table it is found that the total accident rate is decreasing gradually. Although, there is a certain increase in the growth rate of motor vehicles. It may be due to improvement of road geometrics and cautiousness of the road users. Table 3 presents a useful result in terms of rate of changes in road accident indices. Where, (C/N)r is the rate of change of total number of accidents, (F/N)r is the rate of change total fatalities w, (I/N)r is the rate of change total injuries with respect to number of motorized vehicles from the year 2000 to 2010 respectively.And, (C/P)r is the rate of change total number of accidents, (F/P)r is the rate of change total fatalities, (I/P)r is the rate of change total injuries with respect to number of total population from the year 2000 to 2010 respectively.It can be seen from Table 3 that over a period of eleven years (2000 to 2010), all the five police stations have experienced a decline in rate of change in road accident

**Table 3.**Rate of changes in road accident indices from 2000 to 2010.

| Thana | $(C/N)_r$ | $(F/N)_r$ | $(I/N)_r$ | $(C/P)_r$ | $(F/P)_r$ | $(I/P)_r$ |
|---|---|---|---|---|---|---|
| Khulna | -1.879 | -3.211 | -3.319 | -0.330 | -0.946 | -0.996 |
| Daulatpur | -4.644 | -2.980 | -3.939 | -1.395 | -1.395 | -1.095 |
| Khalishpur | -3.644 | -3.210 | -6.961 | -1.095 | -0.796 | -2.592 |
| Khan Jahan Ali | -5.014 | -3.210 | -17.042 | -1.395 | -0.677 | 0.095 |
| Sonadanga | -1.665 | -2.198 | -9.661 | -0.197 | -0.437 | -3.790 |

**Table 4.**Smeed and Andreassen's model for Khulna Metropolitan Area.

| | Case | Developed Models | $R^2$ | p-value $X_1$ | p-value $X_2$ | Comment |
|---|---|---|---|---|---|---|
| Smeed's Model | Total Accidents | $C/N = 8.956 * 10^{-6} (N/P)^{-1.230}$ | .424 | .030 | 0 | * |
| | Fatalities | $F/N = 6.460 * 10^{-6} * (N/P)^{-1.257}$ | .534 | .011 | 0 | * |
| | Injuries | $I/N = 2.126 * 10^{-7} * (N/P)^{-1.775}$ | .459 | .022 | 0 | * |
| Andressen's Model | Total Accidents | $C = e^{35.974} * N^{0.459} * P^{-2.633}$ | .137 | .852 | .543 | # |
| | Fatalities | $F = e^{18.963} * N^{0.191} * P^{-1.252}$ | .015 | .817 | .755 | # |
| | Injuries | $I = e^{55.161} * N^{0.246} * P^{-3.949}$ | .039 | .645 | .588 | # |

Where, *=Accepted at 5% level of significance, #= Rejected at 5% level of significance.

**Table 5.**Comparison of actual and predicted values for Smeed's model for Khulna Metropolitan Area.

| Year | Total Accident Actual | Total Accident Predicted | Total Accident % PD | Fatalities Actual | Fatalities Predicted | Fatalities % PD | Injuries Actual | Injuries Predicted | Injuries % PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 42 | 33 | -21.43 | 38 | 28 | -26.32 | 31 | 23 | -25.81 |
| 2001 | 40 | 30 | -25.00 | 35 | 25 | -28.57 | 20 | 16 | -20.00 |
| 2002 | 38 | 30 | -21.05 | 24 | 26 | 8.33 | 26 | 16 | -38.46 |
| 2003 | 31 | 32 | 3.23 | 24 | 27 | 12.50 | 14 | 18 | 28.57 |
| 2004 | 15 | 33 | 120.00 | 13 | 28 | 115.38 | 7 | 19 | 171.43 |
| 2005 | 18 | 32 | 77.78 | 26 | 27 | 3.85 | 9 | 17 | 88.89 |
| 2006 | 42 | 33 | -21.43 | 26 | 28 | 7.69 | 32 | 17 | -46.88 |
| 2007 | 40 | 32 | -20.00 | 30 | 27 | -10.00 | 20 | 15 | -25.00 |
| 2008 | 28 | 31 | 10.71 | 24 | 26 | 8.33 | 14 | 14 | 0.00 |
| 2009 | 39 | 33 | -15.38 | 35 | 27 | -22.86 | 14 | 15 | 7.14 |
| 2010 | 29 | 33 | 13.79 | 25 | 27 | 8.00 | 11 | 15 | 36.36 |

Where, %PD: Percentage deviation of the predicted value.

indices. All the indices with respect to motor vehicle ownership (N) are much higher than with respect to total population(P). So, this indicates that Table 4 represents the models for total accident, fatalities and injuries for the Khulna Metropolitan City.Table 4 shows the Smeed and Andressen's models for Khulna Metropolitan City. It is seen that Smeed's model satisfies the condition of 95% confidence level, but Andreassen's model does not satisfy the 95% confidence level. Again, the value of coefficient of determination ($R^2$) for Andreassen's model is very small. So, Andreassen's model is not acceptable for Khulna Metropolitan City (KMC). Again, for Smeed's model the value of coefficient of determination (R2) is near 0.5 for all three cases which is acceptable (Abojaradeh, 2013). Table 5 shows the variation between observed and predicted values for Smeed's model.It is seen from Table 5, although Smeed's model satisfies the condition of 95% confidence level, but the percent prediction between model values and observed values are quite high. A comparison of values from Smeed's model with observed values in terms of total accidents, fatalities and injuries are shown in Figure 1 to Figure 3.

It is seen from Figure 1 to Figure 3 that the observed values and model values are not perfectly well fitted. For all three cases there is an abrupt change in the year 2004. It may be due to lack of data collection as these data were collected from police stations. Many of the incidents were not reported to the police stations.But the significance value is within the 95% confidence level. Again, for individual police stations Smeed's model doesn't satisfy the 95% confidence level. So, a new model is developed to satisfy the accident pattern at

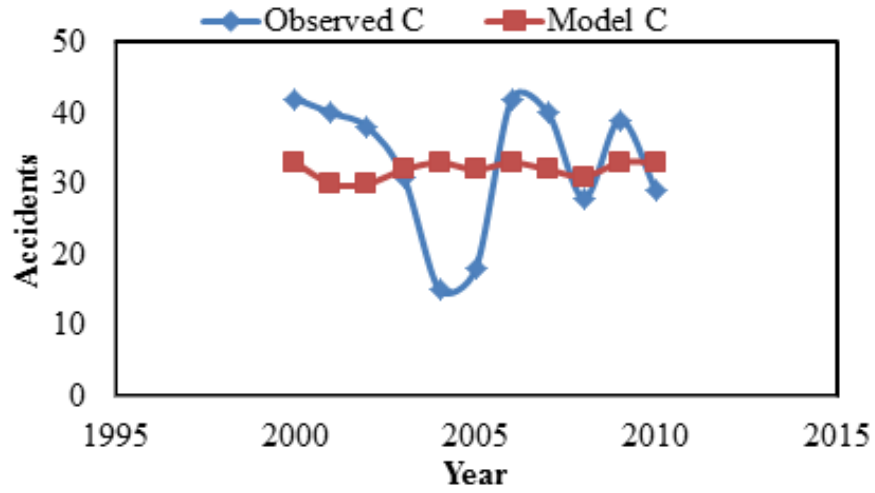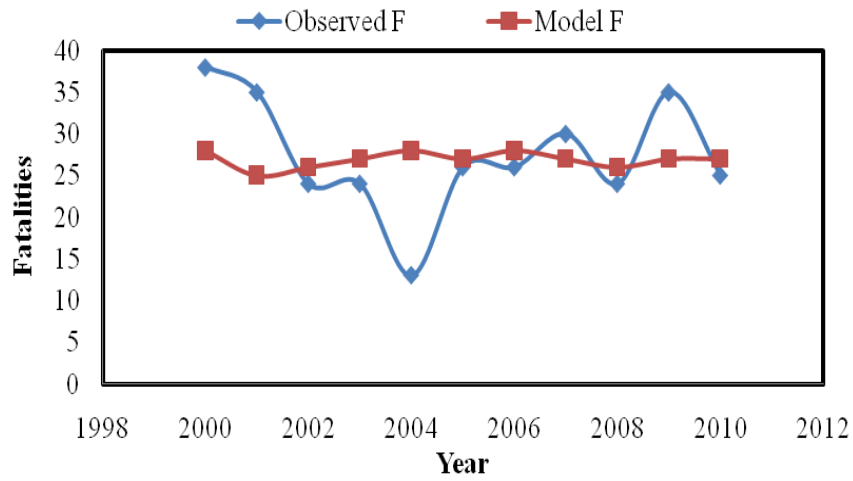**Figure 1.** A comparison of observed C and model C values using Smeed's model.



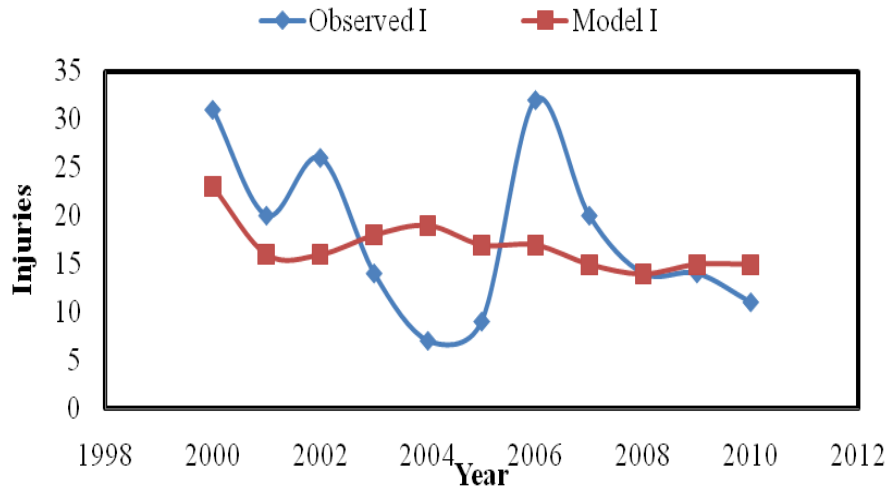**Figure 2.** A comparison of observed F and model F values using Smeed's model.



**Figure 3.** A comparison of observed I and model I values using Smeed's model.

**Table 6:** Developed Road Accident Model for Khulna Metropolitan City.

| Thana | Total Accident | Fatality | Injury |
|---|---|---|---|
| Khulna | C/N=-4.644+46.478/(N/P) | F/N =-9.375+63.393/(N/P) | I/N=-2.893+25.333/(N/P) |
| Daulatpur | C/N= -7.06+58.627/(N/P) | F/N=-5.955+42.084/(N/P) | I/N=-9.299+52.508/(N/P) |
| Khalishpur | C/N=-7.125+32.410/(N/P) | F/N=-5.101+28.250/(N/P) | I/N=-3.910+18.109/(N/P) |
| Khan Jahan Ali | C/N=-11.382+91.029/(N/P) | F/N=-3.111+55.928/(N/P) | I/N=-41.844+128.27/(N/P) |
| Sonadanga | C/N=-3.220+77.318/(N/P) | F/N=-3.489+70.504/(N/P) | I/N=-2.831+43.476/(N/P) |
| All | C/N=-.005+5.24*10^5/(N/P) | F/N=-.005+4.80*10^-5/(N/P) | I/N=-.007+4.47*10^-5/(N/P) |

**Table 7.** Comparison of actual and predicted road accidents of Khulna in Metropolitan Khulna for the year 2000 to 2010.

| Year | Actual (C) | Predicted (C) | % PD | Actual (F) | Predicted (F) | % PD | Actual (I) | Predicted (I) | % PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 10 | 9 | -10.00 | 13 | 11 | -15.38 | 5 | 5 | 0.00 |
| 2001 | 13 | 8 | -38.46 | 13 | 9 | -30.76 | 4 | 5 | 25.00 |
| 2002 | 5 | 8 | 60.00 | 4 | 9 | 125.00 | 2 | 3 | 50.00 |
| 2003 | 7 | 8 | 14.28 | 6 | 9 | 50.00 | 5 | 5 | 0.00 |
| 2004 | 3 | 9 | 200.00 | 2 | 9 | 350.00 | 2 | 5 | 150.00 |
| 2005 | 8 | 9 | 12.50 | 12 | 9 | -25.00 | 2 | 5 | 150.00 |
| 2006 | 8 | 9 | 12.50 | 3 | 9 | 200.00 | 9 | 5 | -44.44 |
| 2007 | 7 | 8 | 14.28 | 5 | 6 | 20.00 | 4 | 4 | 0.00 |
| 2008 | 9 | 6 | -33.33 | 6 | 4 | -33.33 | 5 | 2 | -60.00 |
| 2009 | 6 | 7 | 16.66 | 9 | 5 | -44.44 | 1 | 4 | 300.00 |
| 2010 | 9 | 7 | -22.22 | 8 | 5 | -37.50 | 3 | 4 | 33.33 |

**Table 8.** Comparison of actual and predicted road accidents of Daulatpur in Metropolitan Khulna for the year 2000 to 2010.

| Year | Actual(C) | Predicted (C) | % PD | Actual(F) | Predicted (F) | %PD | Actual (I) | Predicted (I) | %PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 8 | 9 | 12.50 | 6 | 6 | 0.00 | 7 | 7 | 0.00 |
| 2001 | 9 | 8 | -11.11 | 9 | 5 | -44.44 | 10 | 6 | -40.00 |
| 2002 | 11 | 7 | -36.36 | 6 | 5 | -16.66 | 7 | 5 | -28.57 |
| 2003 | 9 | 8 | -11.11 | 3 | 6 | 100.00 | 3 | 6 | 100.00 |
| 2004 | 1 | 8 | 700.00 | 2 | 6 | 200.00 | 2 | 6 | 200.00 |
| 2005 | 6 | 8 | 33.33 | 2 | 5 | 150.00 | 3 | 6 | 100.00 |
| 2006 | 8 | 8 | 0.00 | 6 | 5 | -16.66 | 6 | 6 | 0.00 |
| 2007 | 9 | 7 | -22.22 | 8 | 5 | -37.50 | 3 | 5 | 66.66 |
| 2008 | 2 | 7 | 250.00 | 1 | 4 | 300.00 | 2 | 4 | 100.00 |
| 2009 | 7 | 8 | 14.28 | 5 | 5 | 0.00 | 6 | 5 | -16.66 |
| 2010 | 4 | 7 | 75.00 | 3 | 4 | 33.33 | 4 | 4 | 0.00 |

Khulna Metropolitan City.The mathematical form of the model is as follows:

$$A/N = \beta_0 + \beta_1/(N/P)$$ (5)

Where, A / N = Accidents per 1000 motor vehicles; N / P = Motor vehicles per 1000 population;
$\beta_0$ and $\beta_1$ are model parameters; Table 6 shows the developed form of this model for each police station in terms of total accident, fatality and injury. From Table 6, it is seen that the developed models for five police stations and KMC is the inverse model. The significance values of these models are less than 0.05. It means the significance value is within 95% confidence level. That is

why these models are applicable for Khulna Metropolitan city as well as for five police stations (Khulna, Daulatpur, Khalishpur, KhanJahan Ali and Sonadanga).Tables 7 to 12 show the variation in model values and observed values. It is seen from Table 7 to Table 12, although this model satisfies the condition of 95% confidence level, the percent deviation between model values and observed values are quite high. One of the main reasons for this deviation is that as the number of accident is very low, so single number of variation causes large percent prediction deviation.From the tables it is found that there is still large percent deviation between actual values and predicted value in the year 2004. It may be due to lack of data collection. As, these data were collected from police stations. Many of the incidents were not reported to the police stations.

**Table 9.** Comparison of actual and predicted road accidents of Khalispur in Metropolitan Khulna for the year 2000 to 2010.

| Year | Actual (C) | Predicted (C) | %PD | Actual(F) | Predicted (F) | %PD | Actual(I) | Predicted (I) | %PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7 | 6 | -14.28 | 6 | 5 | -16.66 | 3 | 3 | 0.00 |
| 2001 | 6 | 5 | -16.66 | 6 | 5 | -16.66 | 3 | 3 | 0.00 |
| 2002 | 6 | 4 | -33.33 | 7 | 5 | -28.57 | 2 | 3 | 50.00 |
| 2003 | 1 | 5 | 400.00 | 3 | 5 | 66.66 | 3 | 3 | 0.00 |
| 2004 | 1 | 5 | 400.00 | 1 | 5 | 400.00 | 1 | 3 | 200.00 |
| 2005 | 1 | 5 | 400.00 | 1 | 5 | 400.00 | 1 | 3 | 200.00 |
| 2006 | 7 | 5 | -28.57 | 6 | 5 | -16.66 | 6 | 3 | -50.00 |
| 2007 | 3 | 4 | 33.33 | 2 | 4 | 100.00 | 1 | 2 | 100.00 |
| 2008 | 4 | 3 | -25.00 | 4 | 4 | 0.00 | 2 | 2 | 0.00 |
| 2009 | 6 | 4 | -33.33 | 6 | 4 | -33.33 | 2 | 2 | 0.00 |
| 2010 | 4 | 4 | 0.00 | 4 | 4 | 0.00 | 1 | 2 | 100.00 |

**Table 10.** Comparison of actual and predicted road accidents of Khan Jahan Ali in Metropolitan Khulna for the year 2000 to 2010.

| Year | Actual (C) | Predicted (C) | %PD | Actual (F) | Predicted (F) | %PD | Actual (I) | Predicted (I) | %PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 10 | 9 | -10.00 | 7 | 7 | 0.00 | 12 | 9 | -25.00 |
| 2001 | 8 | 9 | 12.50 | 6 | 6 | 0.00 | 1 | 6 | 500.00 |
| 2002 | 10 | 9 | -10.00 | 6 | 6 | 0.00 | 10 | 6 | -40.00 |
| 2003 | 5 | 9 | 80.00 | 5 | 7 | 40.00 | 2 | 6 | 200.00 |
| 2004 | 6 | 10 | 66.66 | 2 | 7 | 250.00 | 1 | 8 | 700.00 |
| 2005 | 1 | 9 | 800.00 | 10 | 7 | -30.00 | 1 | 6 | 500.00 |
| 2006 | 16 | 9 | -43.75 | 7 | 7 | 0.00 | 8 | 6 | -25.00 |
| 2007 | 16 | 9 | -43.75 | 10 | 7 | -30.00 | 10 | 4 | -60.00 |
| 2008 | 7 | 8 | 14.28 | 5 | 7 | 40.00 | 2 | 1 | -50.00 |
| 2009 | 9 | 9 | 0.00 | 6 | 7 | 16.66 | 3 | 4 | 33.33 |
| 2010 | 5 | 8 | 60.00 | 5 | 7 | 40.00 | 2 | 1 | -50.00 |

**Table 11.** Comparison of actual and predicted road accidents of Sonadanga in Metropolitan Khulna for the year 2000 to 2010.

| Year | Actual (C) | Predicted (C) | %PD | Actual(F) | Predicted (F) | %PD | Actual(I) | Predicted (I) | %PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7 | 7 | 0.00 | 6 | 6 | 0.00 | 4 | 4 | 0.00 |
| 2001 | 4 | 6 | 50.00 | 1 | 5 | 400.00 | 2 | 3 | 50.00 |
| 2002 | 6 | 6 | 0.00 | 1 | 5 | 400.00 | 5 | 3 | -40.00 |
| 2003 | 9 | 7 | -22.22 | 7 | 6 | -14.28 | 1 | 3 | 200.00 |
| 2004 | 4 | 7 | 75.00 | 6 | 6 | 0.00 | 1 | 3 | 200.00 |
| 2005 | 2 | 6 | 200.00 | 1 | 5 | 400.00 | 2 | 3 | 50.00 |
| 2006 | 3 | 6 | 100.00 | 4 | 5 | 25.00 | 3 | 3 | 0.00 |
| 2007 | 5 | 6 | 20.00 | 5 | 5 | 0.00 | 1 | 2 | 100.00 |
| 2008 | 6 | 6 | 0.00 | 8 | 4 | -50.00 | 2 | 2 | 0.00 |
| 2009 | 11 | 6 | -45.45 | 9 | 5 | -44.44 | 2 | 2 | 0.00 |
| 2010 | 7 | 6 | -14.28 | 5 | 5 | 0.00 | 1 | 2 | 100.00 |

**Table 12.** Comparison of actual and predicted road accidents of Khulna Metropolitan City for the year 2000 to 2010.

| Year | Actual (I) | Predicted (I) | %PD | Actual (F) | Predicted (F) | %PD | Actual (I) | Predicted (I) | %PD |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 42 | 37 | -11.90 | 38 | 33 | -13.15 | 31 | 27 | -12.90 |
| 2001 | 40 | 32 | -20.00 | 35 | 29 | -17.14 | 20 | 20 | 0.00 |
| 2002 | 38 | 32 | -15.78 | 24 | 28 | 16.66 | 26 | 19 | -26.92 |
| 2003 | 31 | 35 | 12.90 | 24 | 31 | 29.16 | 14 | 22 | 57.14 |
| 2004 | 15 | 36 | 140.00 | 13 | 32 | 146.15 | 7 | 23 | 228.57 |
| 2005 | 18 | 34 | 88.88 | 26 | 30 | 15.38 | 9 | 20 | 122.22 |
| 2006 | 42 | 35 | -16.66 | 26 | 31 | 19.23 | 32 | 21 | -34.37 |
| 2007 | 40 | 31 | -22.50 | 30 | 27 | -10.00 | 20 | 15 | -25.00 |
| 2008 | 28 | 28 | 0.00 | 24 | 24 | 0.00 | 14 | 10 | -28.57 |
| 2009 | 39 | 32 | -17.94 | 35 | 28 | -20.00 | 14 | 15 | 7.14 |
| 2010 | 29 | 31 | 6.89 | 25 | 26 | 4.00 | 11 | 13 | 18.18 |

## Conclusion

The growth of road accidents in five police stations of Khulna Metropolitan City is becoming a great concern to which takes away as many lives adding to human miseries. An attempt had been made in this study to develop a road accident model for Khulna Metropolitan City, Bangladesh. Different models were developed for different police stations depending upon the data trends of each police station.There were 349 road accidents in Khulna Metropolitan City during the year 2000 to 2010 with fatalities of 280 and injuries of 187.The analysis based on Andreassen's equations showed that the significance values were greater than 0.05. Therefore, the estimated coefficient of dependent variable was not significant at 95 % confidence interval. So, this model was not acceptable for Metropolitan Khulna. The analysis based on Smeed's equations for all Metropolitan police stations of Khulna showed that the significance values were less than 0.05. Therefore, the estimated coefficient of dependent variable was significant at 95% confidence interval. So, this model can be accepted for the Metropolitan Khulna. In case of individual police stations viz. Khulna, Daulatpur, Khalishpur, Khan Jahan Ali, Sonadanga, the analysis based on Smeed's equations showed that the significance values were greater than 0.05. Therefore, the estimated coefficient of dependent variable was not significant at 95% confidence interval. So, this model was not acceptable for individual police stations. Lastly by analyzing these data an inverse model was developed which showed that the significance values were less than 0.05 for Khulna Metropolitan city and individual police stations of Khulna Metropolitan city. Therefore, the estimated coefficient of dependent variable was significant at 95% confidence interval. So, this model was acceptable for Metropolitan Khulna and the five police stations viz. Khulna, Daulatpur, Khalishpur, Khan Jahan Ali and Sonadanga.Accident prediction model's are usually used to monitor the effectiveness of various road safety policies that have been introduced to minimize accident occurrences. The fatalities and injuries during this period exhibit a declining trend significantly from 10.52% to 6.00% and from 23.28% to 8.96%, respectively. This declination in most of the selected cities reflects not only the relative expansion of the road-network, but also the extent of safety measures taken by concerned city authorities.

## REFERENCES

Abojaradeh M, (2013). Traffic Accidents Prediction Models to Improve Traffic Safety in Greater Amman Area.Civil Environ. Res.3(2) pp:87-101.

Andreassen D, (1991). Population and registered vehicles data Vs. Road deaths. Accident Analysis and Prevention 23(5):342-351.

Anjuman T,Hoque MM(2007).Road Traffic Accident: a Leading Cause of the Global Burden of Public Health Injuries and Fatalities. Proceedings of the International Conference on Mechanical Engineering, Dhaka, Bangladesh.

Mahmud HMI, Hossain QS, Paulmd KK and Islam T, (2010).Current situation of road-traffic accidents in Khulna metropolitan city, Bangladesh.Adv.Transp. Stud.Inter. J. pp. 81-86

MannanMS and Karim M, (1999).Road Accidents in Metropolitan Dhaka, Bangladesh.IATSS Research,23(2):90-98.

Murray CJL, Lopez AD (1994).The Global Burden of Disease. Volume 1: A comprehensive assessment of mortality and disability from disease, inquires and risk factors in 1990 and projected to 2020, Harvard University Press.

Peden M, Scurfield R, Sleet D, Mohan D, Hyder AA, Jarawan E, and Mathers C (eds), (2004). The world report on road traffic injury prevention, World Health Organization, Geneva, Switzerland.

Smeed RJ(1949).Some statistical aspects of road safety. J.Royal Stat. Society 112 CX11 (Part 1,Series 4), pp.1-24.

Valli PP (2005). Road Accident Models for Large Metropolitan Cities of India. IATSS Research.29(1): 57-65.