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FORECASTING EXPONENTIAL GROWTH OF ROAD ACCIDENTS: A SPECIAL EMPHASIZE ON MORTALITY RATES IN TIRUCHIRAPPALLI DISTRICT

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ABSTRACT

Road traffic deaths are a major one but neglected public health challenge that requires concerted efforts for effective and sustainable prevention. Of all the systems with which people have to deal every day in road traffic systems are the most complex and the most dangerous. In Worldwide estimation 1.2 million people are died in road crashes each year and as many as 50 million are injured. Projections indicate that these figures will be increase by about 65% over the next 20 years, unless there are new commitments to prevent the road accidents. Nevertheless, the tragedy behind these figures attracts less attention of media than other, and considered as frequent types of tragedy. This paper deals with an attempt has been made in Tiruchirappalli District, to forecast Road Accident Mortality Rates (RAMR) such as Accident Severity Rate (ASR), Accident Fatality Rate (AFR) and Accident Risk Rate (ARR) by using statistical time-series modeling technique – Exponential trend.

KEYWORDS: Accident Fatality Rate, Accident Risk Rate, Accident Severity Rate, Exponential Growth Rate, Tiruchirappalli

1. INTRODUCTION

Fatalities have become a big problem in our day to day life. However, the number of death in road accidents is stabilized even though the motor vehicles in worldwide has increased rapidly, as the global population increases (Nantulya and Reich, 2002). In the year 2009-2012, 79 countries have seen a decrease in the absolute number of fatalities while 68 countries have seen an increase. A World Bank study has shown that the economic development of nations is associated with the increase in the number of injuries and deaths from road traffic accidents (Mojtaba Sehat, Kourosh Holakouie Naieni, Mohsen AsadiLari, Abbas Rahimi Foroushani, and Hossein Malek Afzal, 2012).

The frequency of traffic collisions in India is high amongst in the world nations. A National Crime Records Bureau (NCRB) report reveals that every year, more than 135,000 traffic collision related deaths occur in India. It stands out miserably in the latest World Health Organisation's (WHO) "Global Road Safety Report-2015" with an estimated 207,551 deaths on roads. In India, there happens the road accident every minute and a demise for every four minutes, it happens at present also. It is surprising to note that, out of 29 States and 7 Union Territories, 13 States put together accounted for about 88.40% of all road accidents.

Death due to road accident in India especially in the State of Tamilnadu has become more alarming because of growing population size and the traffic density. In 2013, the state recorded 15,563 fatalities out of the 14,504 recorded accidents, the highest of any other states in India. The state also topped in the list of most accidents in a state for previous ten years from 2002 to 2012 (Handbook on Tamil Nadu Police Department 2013). The data from National Crime Record Bureau indicated that the state capital, Chennai, had 9,663 accidental events, the most of any other cities in India in 2012 (Hemalatha, Karthikeyan, 24 June 2013).

The main objective of this study is to describe trend and forecast progresses in the rates of accident fatalities in Tiruchirappalli. The main implications of results obtained from this work are envisioned to Tiruchirappalli as a district to explore different contrivances to setting safety targets aiming at the reduction of traffic fatality numbers.

1.1 Study Area

Tiruchirappalli is situated at the Centre of Tamilnadu and all the transportation passes through all direction, the study area was chosen. The district has an area of 4,404 square kilometers. According to 2011 census, Tiruchirappalli had population of 2,722,290 of which male and female were 1,352,284 and 1,370,006 respectively. There was change of 12.57 percent in the population compared to population as per 2001. In the previous census of India 2001, Tiruchirappalli District recorded increase of 10.10 percent to its population compared to 1991.

1.2 Reviews on Road Accident Causalities

Statistical models using time series approaches to fitting and forecasting number and rates of road accidents are widely discussed in the literature at different prediction levels (G. Yannis and C. Antoniou, 2011). Models have also been used to study injuries and deaths due to Road Traffic Accidents. The common reasons for the accidents are very well known. But the general population is reluctant to follow certain safety measures that have to be followed during driving (Petridou et al., 1998; Derrick, 2009; O'Keeffe et al., 2007).

In 1986, Jacobs G D & Cutting CA carried out an analysis of road traffic accident fatalities in 20 developing countries for different years using linear regression and established significant relationships between fatality rates and level of vehicle ownership (Valli 2006).

In 1984, Zlatoper investigated the causes of motor vehicle deaths in the United States from 1947 to 1980. He also used linear regression models to explain total motor vehicle deaths, vehicle occupants' death and pedestrians' death. He found that disposable income and driving speed had statistically significant effects on increasing the accident death rates. Many countries have established safety plans and traffic safety targets. Targets provide a clear focus for the work of those who involved in transport planning and traffic safety management. There is an overriding consensus that traffic safety targets should be specific, measurable, relevant and time-bound (Ibrahim, M. Abdalla Alfaki, 2014).

In 2010, Nasr studied death resulting from road accidents in Pakistan for both rural and urban areas, using regression model that attributed accidents to weather condition, driving skills, condition of the vehicles, length of roads and number of population in the different regions and adherence to car insurance. He found that while total accidents had grown by 10% during the period of 1998 – 2008, the rate of growth in fatal accidents went worse as it grew by 16%.

However, Raeside in 2014 had suggested the use of models based on Broughton's approach to produce predictive distribution based on numbers rather than rates per some million vehicles - kilometer driven. The models do not integrate traffic volumes. This approach used in annual data series of the number of total, serious and slight casualties for Great

Britain and modelled the series as using autoregressive and linear trend terms.

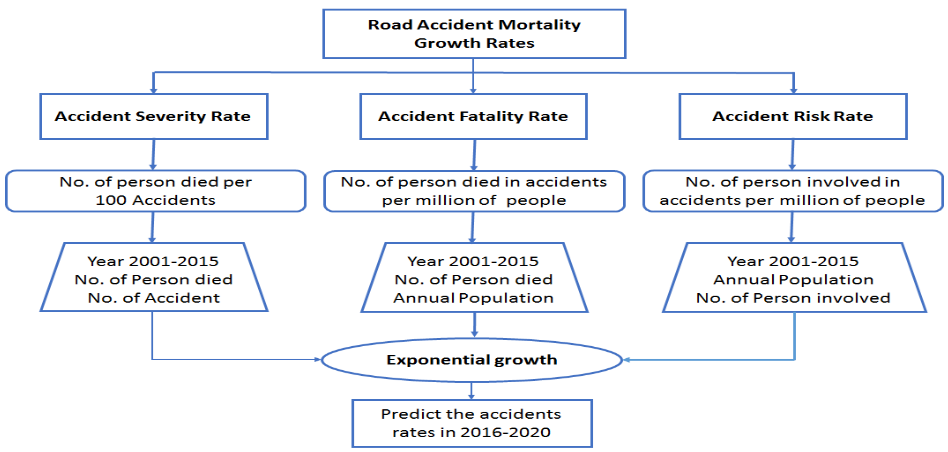
Till best of our knowledge, this is the first report to forecast Road Accident Mortality Rates by using the exponential terms.

2. MATERIALS AND METHODS

The relevant data were collected from District Crime Record Bureau (DCRB), Tiruchirappalli District Police Office during the year 2001 to 2015.

2.1 Road Accidents Mortality Growth Rate

To forecast the road accident mortality growth rate can be categorized under the Accident Severity Rate (ASR), Accident Fatality Rate (AFR) and Accident Risk Rate (ARR).



System Chart

2.1.1. Accident Severity Rate

ASR is a way of measuring the seriousness of accidents. It is defined as the number of persons died (N_d) over the number of accidents happened (N_i) per 100 accidents.

$$Accident\ Severity\ Rate\,(ASR) = \frac{N_d}{N_i} \times 100$$

2.1.2. Accident Fatality Rate

The AFR is defined as the number of accidental death (N_d) reportable accidents over the annual population (N_p) by per a million of people.

$$Accident\ Fatality\ Rate\,(AFR) = \frac{N_d}{N_p} \times 1{,}00{,}000$$

2.1.3. Accident Risk Rate

The ARR can be expressed as a hazard rate, it is the number of those involving accidents (N_i) over the annual population (N_p) by per a million of people in the same year.

$$Accident\ Risk\ Rate\,(ARR) = \frac{N_i}{N_p} \times 1{,}00{,}000$$

2.2 Exponential Trend

Forecasting techniques can be categorized in two broad categories: Quantitative and Qualitative. The techniques in the quantitative category include mathematical models such as moving average, straight line projection, exponential smoothing, regression, trend-line analysis, simulation, life-cycle analysis, decomposition, expert systems and neural network. Exponential growth is a rule of thumb technique for smoothing time series data. Exponential growth rate as recent observations are given relatively more weight in forecasting than the older observations *(Gardner 1985)*. It is an easily learned and easily applied procedure for approximately calculating or recalling some value or for making some determination based on prior assumptions by the researcher.

An exponential function is given by $Y = \alpha\, e^{\beta t}$ where α and β are constants calculated so the function is the best fit of the point series. To add an exponential function, no point in the series may have a y-coordinate that is negative or zero. Many real world phenomena can be modeled by functions that describe how things grow or decay as time passes. Any rate that grows or decays by a fixed percent at regular intervals is said to possess Exponential Growth Rate (EGR) or Exponential Decay Rate (EDR). This can be exemplified by,

$$EGR\ \ y_n = a(1+r)^n \ ; \quad EDR\ \ y_n = a(1-r)^n$$

Where a = initial amount before measuring growth/decay, r = growth/decay rate (often a percent), n = number of time intervals that have passed.

Exponential trend assigns *exponentially decreasing/increasing ASR, AFR and ARR* as the observation get past years 2001-2015. The data were analysed using the Exponential growth while the statistical package uses the SPSS (Statistical Package for the Social Sciences). Graphs were also drawn to show the pictorial pattern of Road accidents fatality rates in the District using MS-Excel.

3.0 ANALYSIS AND RESULTS

The following table (1) shows mortality growth rate resulting as of road accidents from 2001 to 2015. The parameter of t-value tests is statistically significant.

Table 1: Exponential Trend

Accident Mortality Growth Rate		Unstandardised Coefficients		R	R^2	T-Value	Residual (EGR)
		B	Std. Error				
ASR	Year	0.0635	0.006	0.953	0.908	11.344	0.114
	Constant	1.038E-54	0.000				
AFR	Year	0.0844	0.006	0.965	0.932	13.314	0.146
	Constant	3.499E-73	0.000				
ARR	Year	0.0503	0.006	0.928	0.862	9.004	0.114
	Constant	9.178E-73	0.000				

In ASR, the R^2 value of 90.8% provides us with a measure of fit of the model. It is the proportion of the variance of Y that can be accounted for by the exponential model. The Accident severity rate plot seems to curving upwards. We may assume that the relationship between the accident severity rate and year is one of exponential growth rate (ASGR). Therefore, *Y* to be assumed as the accident severity rate (the dependent variable) and *t* to be the year (the independent variable)

$$i.e., Y = 1.038E - 54\, e^{0.0635t}$$

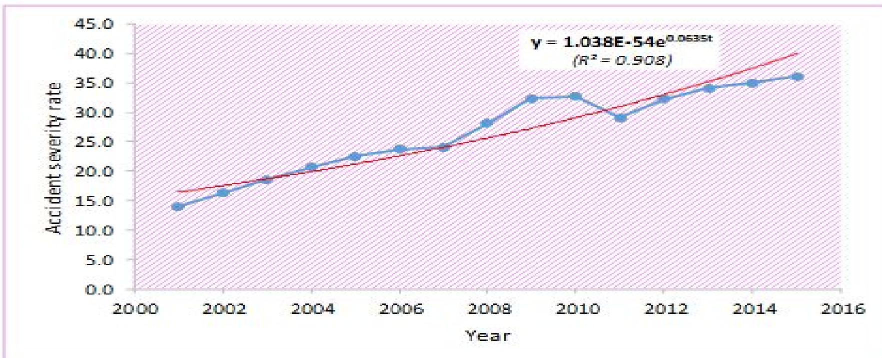


Figure 1: Exponential Growth -ASR

Time plot (figure 1) of the number of person died in per 100 accidents reveal that the ASGR will be increased in the upcoming year 2016-2020. The Residual shows that the compound annual accident severity growth rate is 11.4%. The ASGR will be significantly increased in the forthcoming years.

In AFR, the R^2 value of 93.2% provides us with a measure of fit to the model. It is the percentage of the variance of Y that can be also accounted by the exponential model. The Accident fatality rate plot seems to curving upwards, we may assume that the relationship between the accident fatality rate and year is one of exponential growth rate (AFGR). The fitted model for forecasting the AFGR is agreed by,

$$Y = 3.499E - 73\, e^{0.0844t}$$

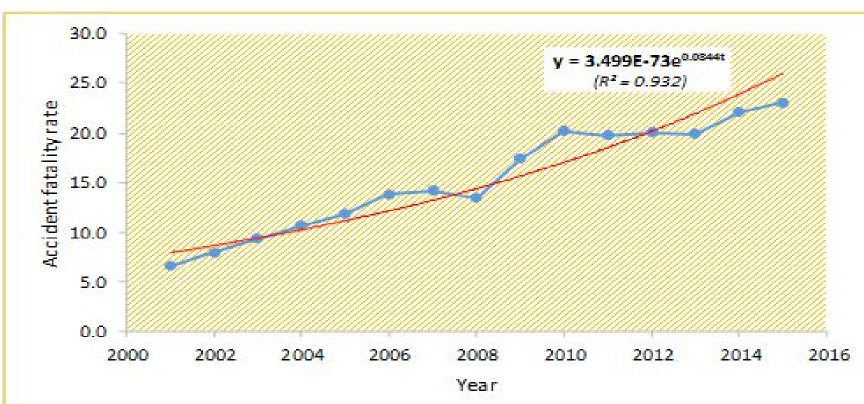


Figure 2: Exponential Growth -AFR

Time plot (figure 2) of the number of person died in accidents per million people to reveal that there is an increasing *AFGR* in the upcoming years 2016-2020. The value of residual shows that the compound annual accident fatality growth rate is 14.6% it reveals that the AFGR will be significantly increased in the forthcoming years.

In ARR, the R^2 value of 86.2% be responsible for us with a measure of fit to the model. It is the proportion of the variance of Y that can be accounted for by the exponential model. The Accident risk rate plot seems to curving upwards, we may assume that the relationship between the accident risk rate and year is one of exponential growth (ARGR). The fitted model for forecasting the ARGR is specified by,

$$i.e., Y = 9.178E - 43e^{0.0503t}$$

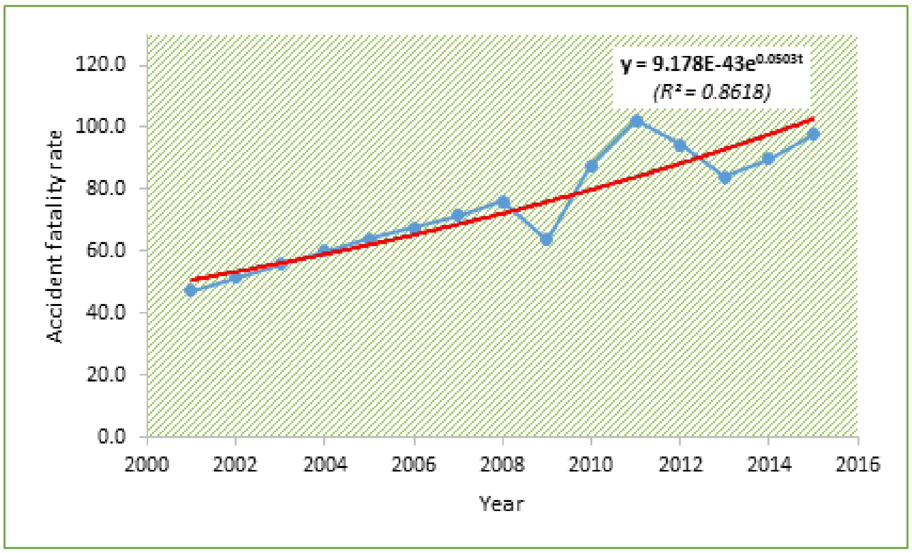


Figure 3: Exponential Growth -ARR

Time plot (figure 3) of the number of persons involved in accidents per 1 lakh people reveals that the *increasing of ARGR* in the upcoming years in 2016-2020. The Residual value shows that the compound annual accident risk growth rate is 11.4%. It shows the significant increasing of ARGR in the upcoming years.

Table 2: Forecasted Mortality Road Accidents Growth Rates

Year	2016	2017	2018	2019	2020
ASR	41	43.7	46.6	49.6	52.9
AFR	27.5	29.9	32.6	35.4	38.5
AHR	100.5	105.7	111.2	116.9	122.9

From the prediction values and the figures, it can be observed that the road accidents in Tiruchirappalli will continue to increase the next five years.

CONCLUSIONS

Time series analysis of the data from the years 2001 – 2015 shows that the patterns of Road Accident cases are increasing in Tiruchirappalli District. Exponential growth has concluded from Road Accident Mortality Growth Rate that road traffic accident cases in Tiruchirappalli will increase over the upcoming years of 2016-2020. In order to put a stop or reduce death rate due to road accident in Tiruchirappalli and its environment the State Government has cited the importance of road safety to the agencies which involved. The Government also works in the areas of non – motorized vehicle accidents, motor cycle helmet usage, design standards and operational practices, road safety in and around schools, establishment of state own drivers' school in the district and other research into driver evaluation methods. Therefore, improved and better policies of National road safety commission should be introduced with much emphasis on publication and education to ensure the maximum reduction of Road accident rates.

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