Highway Safety in India (A Case Study)

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Abstract: **The national highways are the lifeline of a nation and facilitate smooth conveyance of both people and goods door to door within the country. Highways not only need proper planning and designing during the preparation but also require safe and smooth movement of traffic. This paper attempts to conduct study of road accident data in India, to minimize the accidents, and to analyse the perception data to understand safety aspect. The Secondary data regression analysis is also conducted with the consideration of accident-data as a depended variable, and the cost of vehicle maintenance in rainfall, as an independent variables to recommend suggestions to improve highway safety measures. If highway maintenance is not proper and regular then it causes more accident by increasing numbers of pot holes and cracks, because water retention on road is for longer time damages pavement. Hence maintenance an safety also correlated on highways.**

1. INTRODUCTION

The safety of roads incorporates the development and management of road infrastructure, provision of safer vehicles, legislation and law enforcement, and proper planning for the use of urban land etc [1]. The success of road safety depends on the support and common action by all stakeholders including government, civil society organisations and road users in adverse weather condition. In the last, more than sixty years after India's Independence, the transport system in the country is expanded and improved with continuous efforts to make it safe and convenient. The management of transport or traffic system has become a serious issue with the incessant growth in population and vehicles, simultaneous growth of highways and different category roads. The roads and highways are managed by the government agencies namely transport department/ PWDs and national highway authority of India. These agencies are engaged in a constant struggle to provide road safety, congestion and proper maintenance of the roads. However, Indian road safety record is quite alarming as reported by Global Safety Report that "More people die in road accidents in India than any other country in the World, including the more populous country like China" [2].

Therefore, the concept of sustainable road quality maintenance management and safety have gained momentum in recent years. It led to policymakers and project managers to give more emphasis on safety aspect in transport system. The roads need proper design and regular evaluation at the stage of planning, construction, operation and maintenance to achieve accident free roads for overall better safety performance. [2].

2. LITERATURE REVIEW

The few studies relating highway safety during the previous decade are as follows:

Thomas [3] showed that linear and nonlinear multivariate statistical analysis are applied to determine how the types of accidents that occur on heavily user freeways in Southern California are related both to the flow of traffic and to weather and ambient lighting conditions.

M.N. Nagabhushana [4] presented that roads are infrastructural assets and need timely proper maintenance for their upkeep, for better intended service.

Sujeeth Reedy [5] presented that the dynamic amplification of vehicle response passing over a series of potholes was obtained analytically. Tamer [6] showed that the implementation of the new mechanistic-empirical design guide has led to the need for more accurate inputs.

Marina [7] highlighted thathighway runoff contains pollutants in concentrations that can harm ecosystems of receiving freshwater. Christopher [8] through a paperhighlighted that in recent years, the techniques for screening transportation network to identify high crash locations have become more sophisticated with significant data requirements.

Coray Davis [9] studies showed that the increasing commuting population often fuels the need for new highways. Further, Otte's [10] accident causation data research is becoming more and more important for identifying the cause of accidents.

As pointed out above, some more studies are also conducted on various components of highway roads in foreign countries but less work done in India. The above cases have a lot of flaws in research work and need further modular study on traffic operations with the variables of safety and maintenance. Hence, this paper is planned to understand the problem and to provide appropriate suggestions for road safety during traffic operations on highways in present conditions drainage with maintenance.

The engineers can foresight some of the challenges they might face in coming days or future.

The growing use of telecommunication and other technology (e.g. route guidance, infotainment, cell phones in vehicles is distracting drivers. However, a few of them know enough about working of equipment and about how it affects attention of driver. There are hardly any laws prohibiting the use of this

technology while driving. Is there any other solutions required? (e.g. blocking of cell phone transmissions while vehicle is in motion)? There is problem in the use of technology and how prepared we are and what steps needs to be taken would be an interesting areas of future research?

3. ACCIDENT DATA ANALYSIS

3.1 Road Accidents

It is an undesirable event occurring on road involving vehicles causing damage to human being or property. The road accidents, deaths and injuries are global phenomena but the situation is more serious due to poor traffic condition as prevailing on Indian highways. Worldwide, the number of people killed in road traffic each year is estimated at almost 1.2 million, while the number of injured could be as high as 50 million-the combined population of five of the World's large cities and account for 2.1 per cent of the global mortality. The developing countries bear a large share of and account for about 85 per cent of the deaths. It has been estimated that at least 6 million more will die and 60 million will be injured during the next 10 years in developing countries unless urgent action is taken. It means that if the rate of traffic death will remain same, the proportion for developing countries expected to rise as much as 80 per cent by 2020 [11].

3.2 Indian Scenario

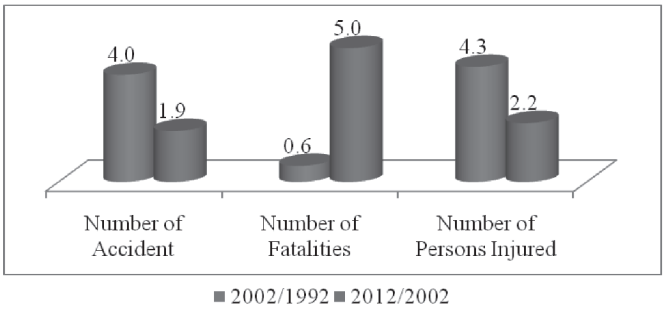
The road fatality rates in India are probably among the highest worldwide. Every year almost 10 people out of one lakh killed due to road accidents. The number of fatal road accidents has gone up from 71 thousand in 2001 to 123 thousand in 2012, and the total number of killed person also increased from 81 thousand to 138 thousand during the same period. There was some improvement in the most recent years as a result of concerted and coordinated road safety efforts were taken reduced in 2012 compared to 2011. Since 2000, for the first time, the total number of road accidents registered a decline for two consecutive years 2011 and 2012. On the other hand proportion of fatal accidents in total has consistently increased since 2003 from 18.1 per cent to 25.1 per cent in 2012. Further, the severity of road accidents, measured in terms of persons killed per 100 accidents increased from 20 in 2001 to 27 in 2012. Although declined for the first time to 27.1 during 2012 from to 27.9 in 2011 [11].

Table 2: Physical Specification of Chain [4]

Year	No of Accidents		No of Persons		Accident Severity
	Total	Fatal	Killed	Injured	
2001	405.6	71.2	80.9	405.2	20.0
2002	407.5	73.6	84.7	408.7	20.7
2003	406.7	73.6	85.9	435.1	19.7
2004	429.9	79.4	92.6	465.5	19.9
2005	439.3	83.5	95.1	465.3	20.4
2006	460.9	93.9	105.7	496.5	21.3
2007	479.2	101.2	114.4	513.3	22.3
2008	484.7	106.6	119.9	523.2	22.9
2009	486.4	110.9	125.7	515.5	24.4
2010	499.6	119.6	134.5	527.5	25.5
2011	497.7	121.6	142.5	511.4	27.9
2012	490.4	123.1	138.3	509.7	27.1

**Killed out of those injured*

The growth of traffic fatalities and serious injuries occurring in India from 1992 to 2012 are shown in . It shows that the compound annual growth rate of accidents and injuries during the last two decades has reduced but the growth of death has gone up more than eight times.



This indicates that severity of fatalities has gone up due to more traffic congestions, poor traffic management, and lack of safety consideration.

Figure 1:Compound Growth Rate of Accidents, Death and Injuries during the decades

Further, to generate an appropriate measure of such accidents and death. The normalized/standardized rates are worked out in terms of number of accidents per lakh persons; accident per ten thousand motor vehicles and road deaths per lakh population.

This shows that the rate of accident per lakh population has continuously reduced over the years, but the rate of accident per ten thousand vehicles is found up during the same period.

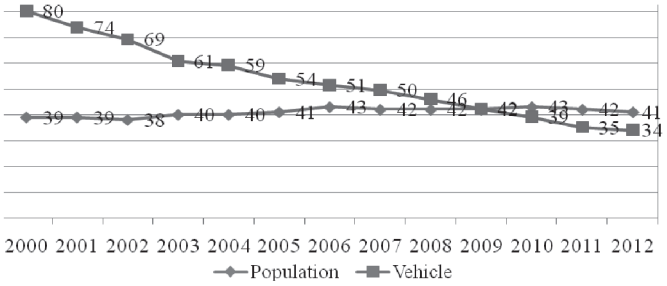


Fig 2: Accidents on per lakh Population and Ten Thousand Vehicles[11]

The above depicted figure 2 presents normalized road accidents, injuries and deaths per lakh population and ten thousand vehicles. Number of accidents per lakh population has continuously decline over the years and reduced more than half during the last decade from 80 accidents per lakh population in 2000 to 34 accidents per lakh population in 2012. Contrary to accident per lakh population, accidents per ten thousand vehicles have marginally increased from 39 accidents per ten thousand in 2000 to 41 accidents per ten thousand in 2012. This shows although the intensity of growth has come down drastically but management of vehicles may emerged as a major problems of accidents.

3.3 Road Injuries & Deaths

There has been fluctuation in the number of persons injured per lakh of population from 39 in 2000 to 46 in 2008 but declined to 42 in 2012 (Figure 3). This indicates that road injuries had increased most of the years in the last decade but after 2008 showing a declining trend after enhancing road safety programme.

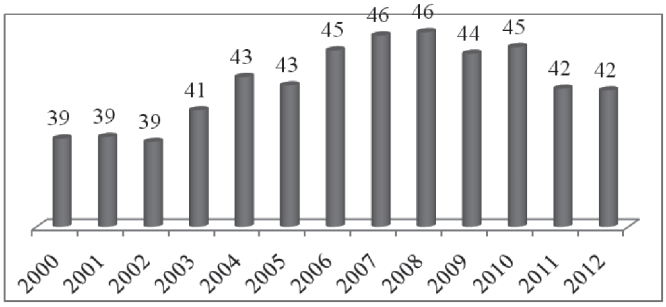


Fig 3: Road Injuries per Lakh Population

The people killed per lakh of population increased from 8 in 2000 to 12 in 2011 and marginally declined first time during the study period from 12 to 11 in 2012 (Figure 4).

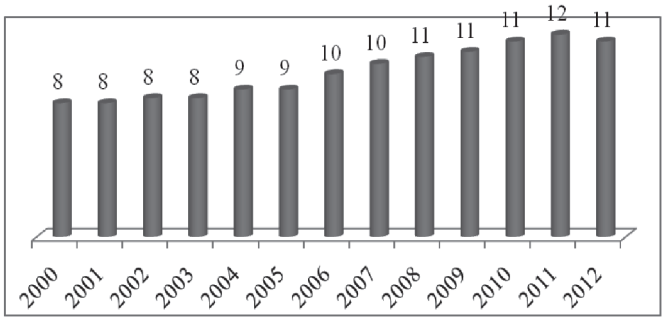


Fig 4: Road Deaths per Lakh Population [11]

The analysis data presented by the above figures show to have more emphasis on road safety issue in transportation system and it needs further systematic recommendations to minimize accidents.

3.4 Analysis With Road Category

In India, roads are classified as national highways, state roads and other roads as per traffic importance and connectivity. National highways accounted for little less than one-third of (29 per cent) total road accidents and injured (30 per cent) more than one third (35 per cent) in total number of persons killed in road accidents during 2012. Whereas, the state highways accounted for quarter of (24 per cent) of total accidents and injured (26 per cent) with similar share (27 per cent) in the total number of persons killed in road accidents during same period of time (Figure 4). On the other hand other roads showed the opposite picture with more accidents and injured with lower number of persons killed. This indicates the problem of highways which permit greater speed resulting in relatively greater number of road accidents and fatalities. So, it is needed to deal with safety issues more rather then the issue of less important roads. Hence safety is important features in highway design.

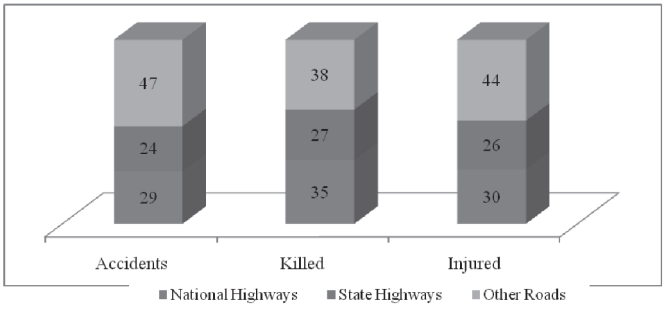


Fig 5: Share of Accidents, Persons Killed & Injured as per Road Classification

4. FACTORS OF SAFTEY BY PERCEPTION OF DRIVERS

The sample survey involving 300 nos. respondents conducted

to analyze the problem of safety through perception of drivers and highway users. The average monthly vehicle-maintenance expenditure of trucks and buses is significantly higher than other vehicles like car/jeep and motor cycle. The heavy vehicles like buses and trucks are mostly used for freight and passenger transfer from one place to another. Therefore, according to their axle load and distance coverage expenditure incurred on the maintenance is higher compared to other vehicle-maintenance cost but it can be improved by smooth and safe movement of traffic.

Table 2: Average Monthly Expenditure by vehicle Type

Vehicle type	Monthly Expenditure (inRs.) Approx.
Car	2600
Jeep	4100
Motor Cycle	1250
Truck/Bus	14875
Three wheelers	4397

Common Factors on Vehicle Maintenance Cost

Most of the respondents revealed that vehicle maintenance cost can be reduced by the condition of road, driver driving habits and life of vehicle (older or new) are the three main factors to reduce the vehicle maintenance cost on highways

Table 3: Factors of Vehicle Maintenance Cost on Highway

Factors	Number	Reasons
Condition of Road	255	87.9
Driver's Habits	240	82.8
Life of Vehicle or Old	170	58.6
Maintenance of Vehicle	125	43.1
Cost of Vehicle	80	27.6
Total	300	100

Factors of Maintenance of highway geometrics on vehicle operation

The further attributed maintenance of highways, drainage system and surface conditions of highways, as the other three factors which affect the operation cost of vehicle on highways. Few other think that highway curve design and accident free zones are the other factors in the vehicle maintenance cost on highways.

Table 4: Vehicle Maintenance with features on Highway

Factors	Number	Reasons
Maintenance of Highway	275	91.7
Drainage System	230	76.7
Surface Condition	160	53.3
Highway Curve	145	48.3
Accident Free	75	25.0
Total	300	100

Reasons of Accidents on Highways

The reasons of accidents on highways, according to the respondents, are lack of traffic management, untimely maintenance of highways and absence of drainage systems with presence of patches on surfaces. Recklessness on the part of drivers and poor maintenance of vehicle result in severeaccidents.

Table 5: Reasons of Accidents on Highways

Reasons	Number	Reasons
Lack of Traffic management	200	66.7
Untimely maintenance of highway	155	51.7
Absence of drainage with surface patches	100	33.3
Carelessness of driver	105	35.0
Insufficient maintenance of vehicle	90	30.0
Total	300	100

Measures to tackle these accidents also result from vehicles and highway maintenance. The timely maintenance of highways, proper drainage system, sign board, lights on highways and proper traffic management are the necessary measures to stop accidents on highways.

Table 6: Accident Tackle Measures on Highway

Measures	No	%
Timely maintenance of highway	255	85.0
Proper water drainage system	260	86.7
Lane marking / Sign Board	250	83.3
Management of Lights on the highway	235	78.3
Proper Traffic management	235	78.3
Total	300	100.0

Finally, there are both direct impact and indirect impact of accidents on highway roads. According to respondents, the main direct impact is loss of human life, which is very precious on earth. The other direct impacts are vehicle damage and huge expenditure incurred on medical care. Further, indirect impacts are future damages due to injury and death of people, Jam on highways and future medical expenditure to heal the injuries.

Table 7: Direct and Indirect Impact of Accidents

Reasons	%
Direct Impact	
Vehicle Damage	75.9
Loss of life	92.3
Expenditure on medical	35.8
Indirect Impact	
Highway jam or delay	51.0
Medical expenditure	53.8
In Injury/Death future damage	92.7

5. SECONDARY DATA ANALYSIS

The detailed analysis of factors on the basis of secondary is been done to understand some of the major factors of road safety apart its from engineer design. Informal discussion approach has been used to elicit the design problem on the highways with engineer and other highway workers because they did not reveal much in the formal interview presented. Highway connecting Jaipur city is selected for study purpose, as mentioned in above stretches. The monthly data of 2008 to 2012 is presented in figure 9 showing number of vehicles, accidents, rainfalls and maintenance cost of the highways. It can be observed from the data that number of vehicles rising gradually, accident rate and maintenance cost also fluctuate. But the rainfall showed high fluctuation with some month

almost nil and other months as high as 204 cms. [12].

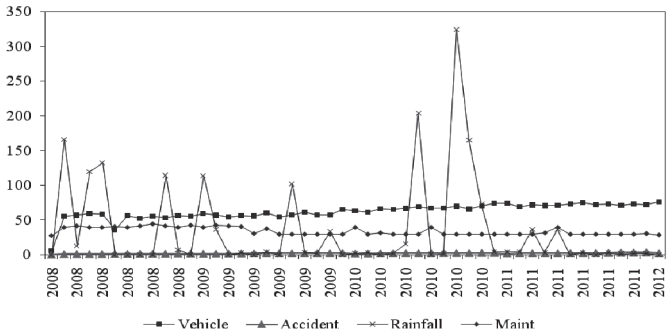


Fig 9: Monthly Data of Vehicle, Accident, Rainfall (Cms) and Maintenance Cost (Value in Lakh)

6. ANALYSIS

Multiple regression analysis factor of road safety with maintenance

In the study multiple-regression analysis is used to examine the factors of road safety. For the regression analysis, accident data is used as dependent variable and rainfall (proxy for environment and road damage, which is main cause of accidents), maintenance cost (if maintenance is not proper, it will lead to pot holes on the road and no sign boards etc) and number of vehicles (congestion and more vehicle on the road also leads to more accidents due to rash driving and other reasons) [12-14].

A number of other factors may contribute to the risk of an accident including- vehicle design, speed of operation, road design, environmental factors and human errors. These data on these indicators is not readily available, so, excluded in the analysis. The regression model can be represented as following:

$Ai=\alpha+\beta_1 V_i+\beta_2 R_i+\beta_3 M_i+e_i$

Where

Dependent variable is A= Number of monthly accidents (in lakh)

Impendent variables are:-

V=Number of vehicle monthly data (in lakh)

R=Rainfall monthly data (in cms)

M=Maintenance cost monthly data (in lakh)

i= time period, 1-48 months data (January 2008 to January 2012);

e_i=error terms

7. OBSERVATIONS AND STATISTICAL ANALYSIS

7.1 Testing of Model

In table below R squared and adjusted R squared of the regression model. R is the multiple correlation coefficients between the observed and predicted values of the dependent variable. The larger values of R indicate the stronger relationships and the value in the table 7 indicate the same with high value of R (0.835). R squared is the proportion of variation in the dependent variable explained by the regression model. It helps to determine whether the model fit the data well or not. Again larger value of R square (0.697) in the output shows it. The R squared tends to optimistically estimate how well the models fit the traffic data. On the other hand, adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model predicting traffic problem. However, sometimes the models with too many variables are often a misfitt and hard to interpret, which is not true in our case due to only three independent variables in the mode. Therefore, the model is suitable the data and generate meaningful results.

Table 8: Model Summary

Statistics	R	R Square	Adjusted R Square
Results	0.835	0.697	0.677

Predictors: (Constant), Maintenance Cost, Rainfall, Vehicle
Dependent Variable: Number of Accident.

7.2 Analysis of Variance

The table 9 summarizes the results of analysis of various results of the regression model. The sum of squares, degrees of freedom, and mean square are displayed for two sources of variation, regression and residual. The output for regression displays information about the variation accounted for by the regression model. Total is the sum of the information for regression and residual. A model with a large regression sum of squares in comparison to the residual sum of squares indicates that the model accounts for most of variation in the dependent variable. The very high residual sum of squares indicate that the model fails to explain a lot of variations in the dependent variables. The result clearly indicates that regression sum of squares value are higher than residual some of square means and the model accounts for most of variation in the dependent variable.

The mean square is the sum of squares divided by the degrees of freedom. The F statistic is the regression mean square (MSR) divided by the residual mean square (MSE).The regression degrees of freedom is the numerator df and the residual degrees of freedom is the denominator df for the F statistic. The total number of degrees of freedom is the number of cases minus 1. If the significance value of the F statistic is small (smaller than 0.05) then the independent variables do a good job explaining the variation in the dependent variable. If the significance value of F is larger than say 0.05 then the independent variables do not explain the variation in the dependent variable. In the results the F value is smaller than 0.01 means independent variables do a good job explaining the variation in the dependent variable also termed as highly significant or significant at 1 per cent level.

Table 9: Analysis of Variance (ANOVA)

	Sum of Squares	df	Mean Square	F	Significance
Regression	17.632	3	5.877	34.557	0.000
Residual	7.653	45	0.170		
Total	25.285	48			

Predictors: (Constant), Maintenance Cost, Rainfall, Vehicle
Dependent Variable: Number of Accident
The above results clearly indicate that model is fit well to the

data and independent variables also done good job in explaining variation in dependent variables.

7.3 Establishment of Safety Model

The coefficients of the estimated regression model presented in table 10 shows that number of vehicle has positive and statistically significant relationship with number of accidents. This means increasing vehicles are creating chaos, jam and difficulty in traffic management. It may be due to limited road length and lack of number of traffic personnel and traffic sense among the vehicle drivers. Another variable, the cost of maintenance shows negative and statistically significant relationship with number of accidents that means if the cost of maintenance declines the number of accidents goes up. It indicates that if highway maintenance is not proper that will leads to more accidents due to poor road conditions with increasing number of pot holes and cracks.

The rainfall variable shows positive relationship with statistically moderately significant relationship with number of accidents. This is because the study area Rajasthan is left dry throughout the years although if it rains. The water stays on the road for a longer period and damages roads.

Table 10: Regression Result (coefficient)

Number of accident dependent variable	Coefficients		t	Significance
	B	Std. Error		
(Constant)	1.795	0.602	2.979	0.005
Vehicle	0.038	0.005	7.087	0.000
Rainfall	0.001	0.001	1.164	0.050
Maintenance cost	-0.052	0.012	-4.475	0.000

(Dependent Variable: Number of Accidents)

8. CONCLUSION

- The results of study area analysis show that number of vehicles rising gradually and accident and maintenance cost fluctuates. Rainfall shows high fluctuation in some months almost nil and other months very high as 204 cms. The increase in the number of vehicles creates chaos, jam and difficulty in traffic management due to limited road length and lack in the of traffic personnel and traffic sense among the vehicle drivers. Another variable cost of maintenance shows negative and statistically significant relationship with number of accidents that means if the cost of maintenance reduces the number of accidents goes up. The rainfall variable has positive relationship with accidents means more rains resulting in more accidents. This reflects the need of proper drainage system on the roads. However, maintenance and traffic management shows statistically stronger results compared to rainfall in the study area.

* Further, as the result of informal discussion with highway engineers and other workers revealed about poor design and lack of maintenance for safety of highway roads. Horizontal and Vertical Curve should be designed, as per IRC requirement, adequate super elevation, transition lengths should beprovided at curveto have enough sight distance, crash barriers on embankments whose height is more than 3.0 meter, road studs installed at all junctions, Lane marking, 'STOP' line marking, directional arrows, pedestrian markings etc, should be presented at all the junctions, adequate vertical clearances have to be provided under all the flyovers and vehicular underpasses etc. to enhance safety.

* The engineer also elicited some of the challenges they might face in coming days or future like thegrowing use of telecommunication and other technology (e.g. route guidance, infotainment, cell phones in vehicles are distracting drivers.

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