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Development of Road Accident Prediction Model: A Case Study at Bhuj City

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***Abstract*: The problem of accident is vary acute in highway transportation due to complex flow patterns of vehicular traffic presence of mixed traffic and pedestrians. Traffic accidents may involve property damages, personal injuries or even causalities. One of the main objectives of traffic engineering is to provide safe traffic movements. Road accident cannot be totally prevented, but by suitable traffic engineering and management measure, the accident rate can be decreased considerably. Therefore, to carry out systematic accident studies to investigate the causes of accidents and to take preventive measures in terms of design and control. To develop road accident prediction model each and every parameter related with the accident is considered and a micro level analysis of road accident is performed. For micro level analysis road accident data of last eleven years (2010 to 2019) from different five police station is collected and a detailed analysis is performed on basis like Hour, year, location, type of collision, type of road, physical feature of road, age group, sex etc. On basis of these analyses effect of accident is identified. After analysis road accident prediction models is developed based on different parameter like Number of Vehicle and population ratio and vehicular composition. All the models are validate through F test and Chi Square test.**

***Keywords*: Road Safety in Bhuj city, Accident risk, Prediction of accident.**

1. Introduction

India is a second largest populated country in the world. Transportation sector plays the important role in developing our country. Transportation sector of any country, acting as an indicator for the economic development of that nation. The hike in Industry, trade and commerce depends on the growth of transportation facility of a country. More the lengths of roads, more the safe, easy and comfort transportation facility and more the prosperity of the country. Roads are the foundations of any country, brightness of transportation but the dark side of transportation are pollution and accidents.

Over 1.2 million people die each year on the world's roads accident, with millions more sustaining serious injuries and living with long-term adverse health consequences. Universally, road traffic injuries are a leading cause of death among young people, and the main cause of death among those aged 15–29 years (see Figure 1). Road traffic injuries are currently expected to be the ninth leading cause of death across all age groups globally, and current trends suggest that by 2030 road traffic deaths will become the seventh leading cause of death unless urgent action is taken. The fig 1-2 below shows the accident scenario in future years with and without taking action to prevent it.

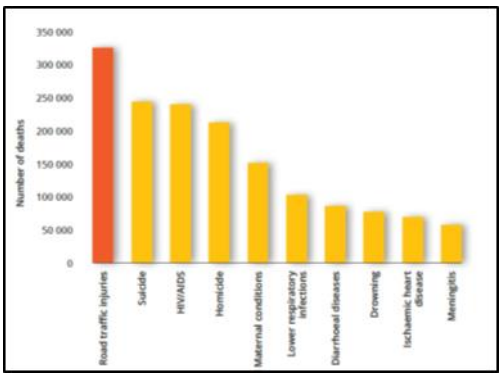

Fig. 1. Top ten causes of death among people aged 15–29 years, 2019 (Source: Global Safety Report on Road Safety, 2019 – WHO)

2. Study Area Profile

Bhuj is located at a height of about 110m. It is located in center of the Kutch District. The location of Bhuj is strategic as it is having hills on its eastern side and a huge lake Hamirsar on the other side. The city has derived its name from this hill named "Bhujiyo Dungar" which also houses a fort on its top. This fort, Bhujia Fort, separates Madhapar Town and Bhuj City. Bhuj is located on 23.27 N Latitude and 60.67 E Longitude. Bhuj also houses many small and big lakes. Originally Bhuj City was surrounded by Bhujia Fort that had 5 major gates and a single small gate called Chathi Bari. Due to development and lots of constructions being done in the city, most part of the wall got destroyed. The wall was also destroyed due to 2001 earthquake.

Fig. 2. Study Area

3. Methodology

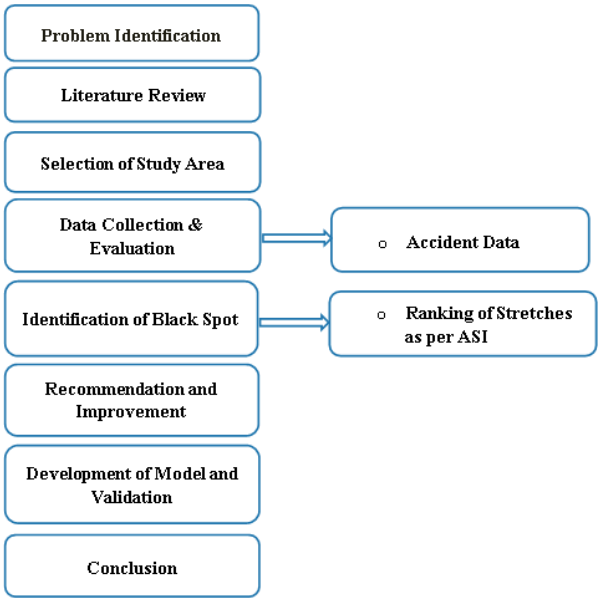

Fig. 3. Flow chart of proposed methodology

4. Accident Data Analysis

Primary Analysis:

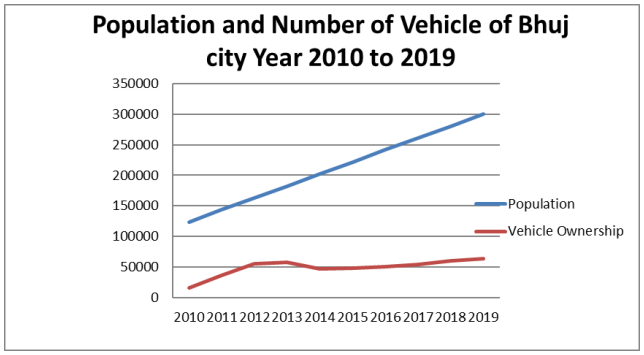

Fig. 4. Population and Number of Vehicle of Bhuj City from Year 2010 to 2019

A. Accident rate and fatality rate based on population

Table 1
Accident rate and fatality rate based on population

Year	Population	Total Accident	Fatal Accident	Accident Rate	Fatality Rate
2010	123699	683	127	552.16	102.66
2011	143286	739	140	515.75	97.71
2012	162873	635	129	389.87	79.20
2013	182460	579	148	317.33	81.11
2014	202047	572	160	283.10	79.20
2015	221634	557	168	251.31	75.80
2016	241221	390	109	161.17	45.19
2017	260808	436	140	167.17	53.68
2018	280395	531	170	189.37	60.63
2019	299983	652	124	217.34	41.33

B. Accident rate and fatality rate based on number of vehicle

Table 2
Accident rate and fatality rate based on number of vehicle

Year	vehicle register	Total Accident	Fatal Accident	Accident Rate	Fatality Rate
2010	140236	683	127	48.70361	9.056162
2011	165989	739	140	44.52102	8.434294
2012	168597	635	129	37.66378	7.651382
2013	169586	579	148	34.14197	8.727135
2014	171514	572	160	33.35005	9.328685
2015	176895	557	168	31.48761	9.497159
2016	147896	390	109	26.36988	7.370044
2017	179856	436	140	24.24162	7.784005
2018	225986	531	170	23.49703	7.52259
2019	279898	652	124	102.44	19.48

C. Detailed (Micro Level) Analysis

Accident data can be analysis considering monthly distribution and hourly distribution of accidents. Accidents classified according to weather conditions, type of vehicle involved, age of vehicle, nature of accident, details of driver (age/sex of driver) may be taken into account for detailed analysis of accident data. Further it may also be analyzed according to classification of road, condition of road and geometric features of road. This Micro level analysis of accident data are described in the following sections.

1) Monthly spectrum of accidents for the Year 2010 to 2019

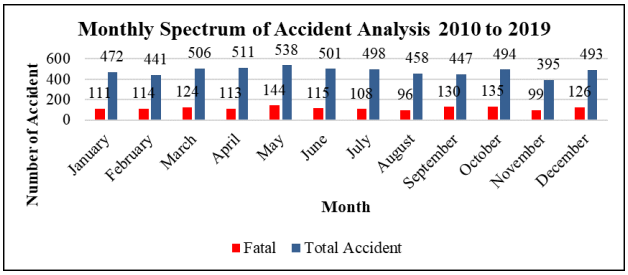

Fig. 5. Monthly spectrum of accident analysis

2) Hourly spectrum of accidents for the year 2010 to 2019

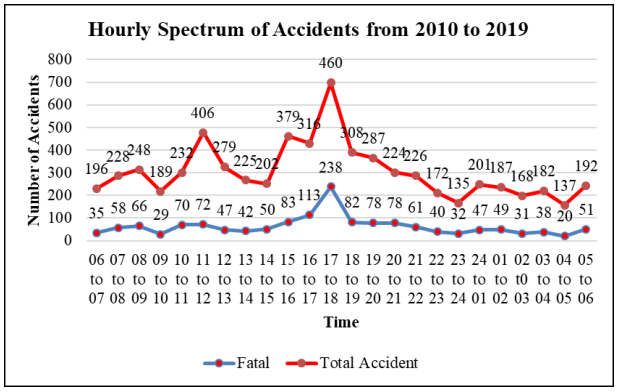

Fig. 6. Hourly spectrum of accident from year 2010 to 2019

3) Location-wise analysis of accidents for the year 2010 to 2019

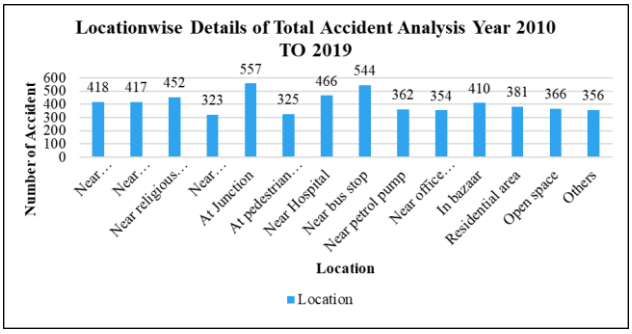

Fig. 7. Location wise total accident analysis from year 2010 to 2019

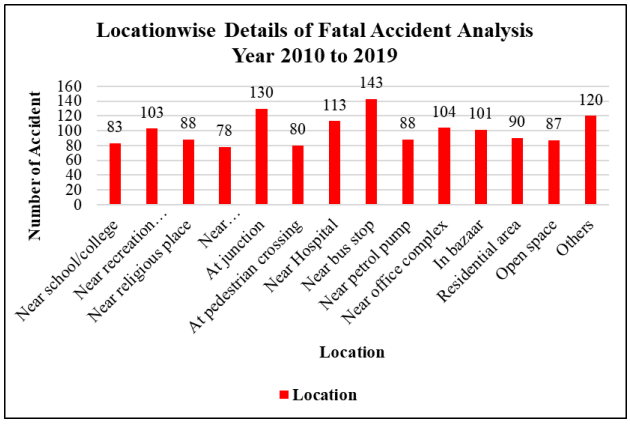

Fig. 8. Location wise fatal accident analysis from year 2010 to 2019

4) Vehicle-wise distribution of accidents for the year 2010 to 2019

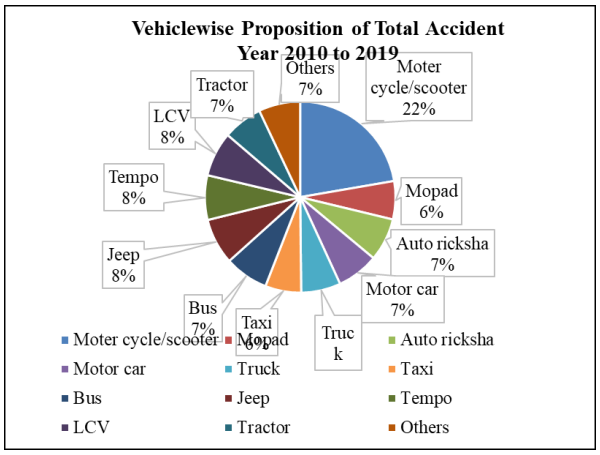

Fig. 9. Vehicle-wise proportion of total accidents from the year 2010 to 2019

5. Accident Prediction Model

A. Development of Prediction Model Based on Vehicle Ownership to Population (v/p) Ratio

The linear regression models are developed for prediction of total accidents and fatal accidents, considering number of total accidents or fatal accidents as dependent variable (Y) and vehicle ownership to population (V/P) ratio as independent variable(X). The models developed will take the following form:

$$y=mx+b$$

Where y = number of total accidents or fatal accidents per year, x = vehicle ownership to population ratio (for year 2010 to 2019)
m = Coefficient for Independent variable
b= Constant (Estimated parameter)

Model: 1 (For Total Accidents)

$$Y = 576.51*X+61.72$$

Model: 2 (For Fatal Accidents)

$$Y = 149.52*X+(-8.91)$$

The fitness of models is proved on the basis of statistical test values i.e. R^2, F-statistics. The models developed on base f parameter estimation and different statistics are shown in Table 6-1 of model summary. It is explained from the table that for model 1 for total accidents, R^2value is near to 0.85 and F > Fcr. For model 1 of total, parameter are found significant and therefore it is statistically good it is proved. For model 2 of fatal accidents, R^2 value is observed to be less which is less than 0.85 standard value for significant. The observed values of accident data 2010 to 2019 and the estimated values of accident data from the accident prediction model are tested for comparability by Chi-square test. The result summary is too given in Table 3. It is found that the goodness observed from values are significant at 5 % level of significance. Table 3 represent the validation summary of the model.

B. Development of prediction model based on vehicular composition

The multiple linear regression models are developed for prediction of total accidents and fatal accidents considering number of total accidents or fatal accidents as dependent variable(Y) and vehicular composition as independent variable (X). Data for vehicular composition for last eleven year 2010 to

Table 3
Model 1 & 2 Summary

Model	Parameter	Estimate	R^2	DOF	F-Statistic		Comments
					F	fcr	
Model 1 for Total Accidents	m	576.51	0.93	9	35.893	3.020	Fairly Accepted
	b	61.72					
Model 2 for Fatal Accidents	m	149.52	0.0064	9	1.585021	3.020	Rejected
	b	-8.91					

Table 4
Model 3 & 4 Summary

Model	Parameter	Estimate	R^2	DOF	F-Staticstic		Comments
					F	fcr	
Model 3 for Total Accidents	m_1	-29.79443794	0.83		5.81	3.020	Accepted
	m_2	55.15913777					
	m_3	1.69					
	m_4	55.85452449					
	m_5	-124.4219083					
	B	2150.578318					
Model 4 for Fatal Accidents	m1	-6.2097655	0.38	9	0.79	3.020	Rejected
	m2	-5.57784011					
	m3	1.23					
	m4	-2.62086518					
	m5	2.523374834					
	B	546.6334252					

2019 from RTO is consider. 2W, 3W, Bus, LCV, HCV is consider as an independent variable and the multiple linear regression is carried out.

The Models developed will take the following form:

Y = m1x1+m2x2+m3x3+m4x4+m5x5+m6x6+b

Where y = number of total accidents or fatal accidents per year

X1 = Volume of Two wheeler
X2 = Volume of Three wheeler
X3 = Volume of Four wheeler
X4 = Volume of LCV
X5= Volume of HCV
m1, m2, m3, m4, m5 are coefficient
b = Estimate Parameter = Constant

Model: 3 (For total accidents)

Y=-29.79443*2W+55.15913777*3W+-1.69*4W+ 55.85452449*LCV +-124.4219083*HCV+2150.578318

Model: 4 (For fatal accidents)

Y= -6.2097655*2W+-5.57784011*3W+-1.23*4W+--2.62086518*LCV +2.2523374834*HCV+546.6334252

The goodness of models is analyzed on the basis of statistical values i.e. coefficient of determination R^2, t-statistics. Model summary is given in Table 4. It is observed from the table that for model 3 and model 4, R^2 value is 0.83 and 0.38 respectively, 0.83 is very near to 1. This indicates that there is near to perfect correlation ship between independent and dependent variables for total accidents and fair relationship for fatal accident. For both the models as F <Fcr. For these models parameters are found significant with 95 % confidence level and therefore they are statistically good.

6. Results and Discussion

- During these ten years the population and vehicle ownership have raised but the number of total accidents and fatal accidents has remained approximately constant in the Bhuj city.
- Maximum number of total accidents is reported in the month of April, May and June. Minimum number of total accidents and fatal accidents are observed in November respectively.
- Majority of accidents are being observed during high peak hours in morning (i.e. 11am to 13pm) and in evening it is in between 6pm to 7 pm. This may because of heavy traffic volume in said hours.
- Accident data based to location resulted that Near bus stop and Collages, religious place residential area, open space and bazaar are accident prone locations, having high accident frequency. This is due to the fact that the accident goes up at an uncontrolled intersection/junction.
- It is seen that two wheelers contribute 77% of the traffic composition and its involvement in total accidents is 39%. Maximum number of fatal accidents is also caused by two wheelers i.e. 39% and it is followed by four wheelers i.e. 20 %, though truck contributes only 4 % of traffic composition.
- It is observed that three-fourth of the total and fatal accidents occurred on surfaced roads.

7. Conclusion

It is fact that traffic rules should be enforced to be scientific so that road users use the facility within the boundary of law, rules and regulation. This basic enforcement should be done on base of technical research and past data records. Following points has been concluded

1) Percentage of sharing of two wheelers is near about 75% and the involvement in fatality is nearly 35%. There is require to control the 2W traffic and also Awareness regarding use of public transport should be increased so that the accidents can be reduced.
2) For accident prediction models based on V/P (Number of Vehicle to Population) ratio, Model is Fairly accepted for total accident as R^2 is near to 0.85 for total accidents and it is model rejected for fatal accident, also F > Fcr for total accident and F<Fcr for fatal accident. These models satisfy the Chi-square test of validity. Models are proved to be significant at 5 % level of significance.

3) For Accident prediction model based on vehicular composition R^2 value is near to 1 for total accident and it is failed for fatal accident as it is only 0.28. This indicate that there is good relationship. For these models F <Fcr. And also satisfy the Chi-square test. These parameters are proved significant with 95 % confidence level and statistically good and found to be significant at 5 % level of significance.

8. Scope of Future Work

In this study micro level analysis of accident data is carried out for Bhuj city. Identification and prioritization of accident prone stretches are being done. Road accident models are developed on base of three different parameters. In future following type of work can be carried out to improve road safety.

- Development of models can be done based on speed of vehicle and other road features like sign, signals etc.
- Development of models can be done based on Traffic volume.
- Recommendation and Road Safety Policy can be suggest on base of this micro level analysis.

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