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 “Bhuiyo 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

- Problem Identification
- Literature Review
- Selection of Study Area
- Data Collection & Evaluation
- Identification of Black Spot
- Recommendation and Improvement
- Development of Model and Validation
- Conclusion

Fig. 3. Flow chart of proposed methodology

4. Accident Data Analysis

Primary Analysis:

A. Accident rate and fatality rate based on population

Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Total Accident</th>
<th>Fatal Accident</th>
<th>Accident Rate</th>
<th>Fatality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>123699</td>
<td>683</td>
<td>127</td>
<td>552.16</td>
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<tr>
<td>2011</td>
<td>143286</td>
<td>739</td>
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<tr>
<td>2012</td>
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<td>635</td>
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<td>389.87</td>
<td>79.20</td>
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<tr>
<td>2013</td>
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<td>579</td>
<td>148</td>
<td>317.33</td>
<td>81.11</td>
</tr>
<tr>
<td>2014</td>
<td>202047</td>
<td>572</td>
<td>109</td>
<td>283.10</td>
<td>79.20</td>
</tr>
<tr>
<td>2015</td>
<td>221634</td>
<td>557</td>
<td>168</td>
<td>251.31</td>
<td>75.80</td>
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<tr>
<td>2016</td>
<td>241221</td>
<td>590</td>
<td>109</td>
<td>161.77</td>
<td>45.19</td>
</tr>
<tr>
<td>2017</td>
<td>260808</td>
<td>436</td>
<td>140</td>
<td>167.17</td>
<td>53.68</td>
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<tr>
<td>2018</td>
<td>280395</td>
<td>531</td>
<td>170</td>
<td>189.37</td>
<td>60.63</td>
</tr>
<tr>
<td>2019</td>
<td>299983</td>
<td>652</td>
<td>124</td>
<td>217.34</td>
<td>41.33</td>
</tr>
</tbody>
</table>

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

Table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Vehicle Register</th>
<th>Total Accident</th>
<th>Fatal Accident</th>
<th>Accident Rate</th>
<th>Fatality Rate</th>
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</thead>
<tbody>
<tr>
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<tr>
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<td>739</td>
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<td>515.75</td>
<td>97.71</td>
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<tr>
<td>2012</td>
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</tr>
</tbody>
</table>

C. Detailed (Micro Level) Analysis

Accident data can be analyzed 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 accidents from year 2010 to 2019
3) Location-wise analysis of accidents for the year 2010 to 2019

4) Vehicle-wise distribution of accidents for 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)**

\[ Y = 576.51X + 61.72 \]

**Model: 2 (For Fatal Accidents)**

\[ Y = 149.52X + (-8.91) \]

The fitness of models is proved on the basis of statistical test values i.e. \( R^2 \), F-statistics. The models developed on the basis of 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, \( R^2 \) value is near to 0.85 and \( F > F_{cr} \). 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>
<thead>
<tr>
<th>Table 3</th>
<th>Model 1 &amp; 2 Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Parameter</td>
</tr>
<tr>
<td>Model 1 for Total Accidents</td>
<td>m</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td>Model 2 for Fatal Accidents</td>
<td>m</td>
</tr>
<tr>
<td></td>
<td>b</td>
</tr>
</tbody>
</table>
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:

\[ Y = m_1x_1 + m_2x_2 + m_3x_3 + m_4x_4 + m_5x_5 + m_6x_6 + b \]

Where \( y \) = number of total accidents or fatal accidents per year

- \( X_1 = \) Volume of Two wheeler
- \( X_2 = \) Volume of Three wheeler
- \( X_3 = \) Volume of Four wheeler
- \( X_4 = \) Volume of LCV
- \( X_5 = \) Volume of HCV

\( m_1, m_2, m_3, m_4, m_5 \) are coefficient

\( b = \) Estimate Parameter = Constant

**Model: 3 (For total accidents)**

\[ Y = -29.79443794 + 55.15913777x_1 + 1.69x_2 + 55.85452449x_3 - 124.4219083x_4 + 2150.578318 \]

**Model: 4 (For fatal accidents)**

\[ Y = -6.2097655 + 5.57784011x_1 + 1.23x_2 - 2.62086518x_3 + 2.523374834x_4 + 546.6334252 \]

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 \( F < F_{cr} \). 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. 11 am to 13 pm) and in evening it is in between 6 pm 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 \( F > F_{cr} \) for total accident and \( F < F_{cr} \) 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 $F < F_{cr}$. 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.

References

[8] www.morth.nic.in/