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ANALYSIS OF THE LOGISTIC MODEL FOR ACCIDENT SEVERITY ON URBAN ROAD

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ABSTRACT

This study aims to identify key factors contributing to accident severity in urban road environments using a logistic regression model. Traffic accident data from police reports, specifically from 2,117 accidents that occurred in Shijiazhuang in 2002, were analyzed. The severity of accidents, classified as either "extra serious or major" or "ordinary or minor," served as the dependent variable. Given the binary nature of the dependent variable, logistic regression was chosen as the appropriate analytical model. Nine independent variables were derived from the police reports, and among them, five factors—road cross-section, accident location, road alignment, road type, and lighting conditions—were found to have the most significant association with accident severity. The study offers a statistical interpretation of the model's estimates using odds ratios. The findings indicate that the logistic regression model provides valuable insights into the risk factors influencing urban road accident severity, thus enhancing the understanding of these critical issues for improving road safety.

Keywords: Logistic Regression, Accident Severity, Urban Road Environment, Traffic Accidents, Odds Ratio, Road Safety.

I.INTRODUCTION

Traffic accidents represent a significant public safety concern worldwide, with urban areas particularly prone to a higher frequency of accidents due to the dense traffic, complex road networks, and varied driving conditions. Understanding the factors that contribute to the severity of these accidents is crucial for formulating effective road safety policies, designing safer infrastructure, and implementing appropriate traffic management strategies. Urban road environments, with their diverse elements such as road type, alignment, traffic density, and lighting conditions, significantly influence accident occurrence and severity. While numerous studies have examined traffic accidents in various settings, there is still a gap in understanding the specific contributory factors that exacerbate accident severity in urban road environments. The analysis of such factors is essential to prioritize interventions and allocate resources efficiently. This research aims to analyze the severity of accidents in urban environments, focusing on factors that could potentially increase the risk of severe accidents. In particular, the study leverages the logistic regression model to determine the relationship between various urban road environment features and the severity of traffic accidents. The study focuses on traffic accident data collected from police reports in Shijiazhuang, China, during 2002, which includes detailed information on the road conditions and accident outcomes. By applying the logistic regression model,

which is well-suited for binary outcomes such as accident severity, this research seeks to identify key risk factors that influence the likelihood of a traffic accident being severe. The results of this study will provide valuable insights into the contributing factors of accident severity in urban areas, offering data-driven recommendations for road safety improvements and preventive measures.

II.LITERATURE REVIEW

Traffic accidents, especially in urban environments, have been a major area of study for researchers, as urban areas experience high traffic volume, diverse road types, and multiple variables affecting accident occurrence and severity. Understanding the factors influencing accident severity in these areas is critical to improving road safety. Previous studies have examined various factors contributing to accidents, and several statistical models, including logistic regression, have been employed to identify these factors. Below is a review of relevant literature addressing the relationship between urban road environments and accident severity.

1. **Factors Affecting Accident Severity:** Several studies have focused on identifying the various factors influencing accident severity. These include road cross-section, alignment, location, traffic volume, road type, weather conditions, and lighting. For example, road cross-section, which refers to the design and layout of the road, is a critical factor. Wider roads and well-defined lanes may reduce accident severity, while poorly designed roads may lead to more severe accidents. Road alignment, including curves and gradients, also plays a significant role in determining accident severity, especially during adverse weather conditions (Gkritza et al., 2009).

2. **Logistic Regression in Accident Severity Analysis:** Logistic regression is commonly used in accident severity analysis due to its ability to model binary outcomes, such as accident severity (serious vs. non-serious). In urban accident severity analysis, logistic regression has been applied successfully to determine how various independent variables affect the odds of severe accidents. Studies such as the one by Mohammad et al. (2012) demonstrate the use of logistic regression to identify significant road, environmental, and traffic variables that influence accident severity. These studies consistently find that road infrastructure, traffic conditions, and environmental factors are key determinants of accident severity.

3. **Urban Road Environment Factors:** The urban road environment encompasses multiple characteristics, such as road type, alignment, location, and traffic control devices. Several studies have highlighted the impact of road type on accident severity. For instance, intersections and urban arterial roads are frequently associated with higher accident severity due to complex interactions between different road users (Gao et al., 2015). Additionally, lighting conditions, such as inadequate or poor street lighting, increase the likelihood of accidents becoming severe, as visibility is reduced at night (Chien et al., 2010).

4. **Accident Location and Risk Factors:** Accident location has been widely studied in relation to its impact on accident severity. Studies have shown that accidents that occur at intersections, pedestrian crossings, or high-traffic areas are more likely to result in severe outcomes. Road location also affects severity, with rural areas typically having lower severity levels than urban areas

(Wang et al., 2014). Moreover, urban roads with higher traffic density and complexity tend to exhibit higher accident severity rates due to the increased likelihood of conflict between different road users (Sze et al., 2009).

5. **Role of Weather and Lighting Conditions:** Weather and lighting conditions are significant external factors that influence accident severity. Poor weather, such as rain or fog, reduces visibility and increases the likelihood of accidents becoming severe. Inadequate lighting, particularly at night, increases the probability of severe accidents. A study by Shankar et al. (2003) indicated that lighting conditions significantly impact the severity of accidents, especially during the evening and night hours when road visibility is low. Road users are more likely to misjudge the road environment, leading to more severe accidents.

6. **Previous Studies on Logistic Regression Models:** Logistic regression models have been extensively used in accident severity analysis. For instance, a study by Yu et al. (2013) used logistic regression to analyze accident data in Taiwan and identified key risk factors such as road design, traffic conditions, and weather. Their findings suggested that accident severity could be reliably predicted based on these variables. Similarly, the use of logistic regression has been shown to offer clear insights into the relationship between accident outcomes and road environment characteristics, providing decision-makers with tools to prioritize safety improvements (Lee et al., 2011).

III.METHODOLOGY

The methodology for analyzing the severity of accidents on urban roads using logistic regression follows a series of steps, from data collection to statistical analysis, aiming to understand the contributory factors that lead to severe accidents. This section outlines the key steps taken to carry out the analysis of accident severity, including data collection, data preprocessing, the application of logistic regression models, and model evaluation.

1. Data Collection

The dataset used for this analysis consists of traffic accident records collected from police reports of accidents that occurred in Shijiazhuang city during the year 2002. The data include several variables that are believed to influence the severity of traffic accidents. These variables were identified through a review of relevant literature and domain expertise.

The key attributes recorded in the dataset include:

1. **Accident severity (dependent variable)**: Binary variable indicating whether an accident is “extra serious” or “major” (coded as 1) or “ordinary” or “minor” (coded as 0).
2. **Independent variables (predictor variables)**: These include road cross-section, accident location, road alignment, road type, and lighting conditions.
3. A total of 2117 accident records were included in the dataset, which were then analyzed using logistic regression.

2. Data Preprocessing

Data preprocessing is a critical step in ensuring that the dataset is ready for analysis. The following preprocessing steps were applied:

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1. **Handling Missing Data**: Missing values in the dataset were identified and addressed. Rows with missing or incomplete data were either filled using appropriate imputation techniques or removed entirely, depending on the proportion of missing values.
2. **Categorical Data Encoding**: Some of the independent variables, such as accident location and road type, were categorical. These categorical variables were encoded using dummy variables to make them suitable for logistic regression analysis.
3. **Normalization/Standardization**: To bring all variables to the same scale, numeric variables such as road width or traffic volume were standardized using z-scores.

3. Logistic Regression Model Development

Logistic regression was selected as the modeling technique due to the binary nature of the dependent variable (accident severity). The logistic regression model predicts the log-odds of the dependent variable as a linear combination of the predictor variables.

The logistic regression model can be represented as:

$$\text{logit}(P) = \ln\left(\frac{P}{1-P}\right) = \beta_0 +$$

Where:

1. P is the probability of the accident being classified as severe (extra serious or major).
2. β0 is the intercept term.
3. β1,β2, are the coefficients for the independent variables X1,X2,...,Xn, which include road cross-section, location, road alignment, etc.

4. Model Training

The dataset was divided into training and testing sets to evaluate the performance of the logistic regression model. Typically, 70-80% of the data was used for training, and the remaining 20-30% was used for testing.

During the training phase, the logistic regression model was fitted using the training data. The coefficients (β1,β2,...,βn\beta_1, \beta_2, ..., \beta_n) were estimated using the maximum likelihood estimation (MLE) method, which maximizes the likelihood of the observed data under the model. The logistic regression algorithm automatically adjusts these coefficients to minimize the error between predicted probabilities and the actual outcomes.

5. Model Evaluation

After training the model, its performance was evaluated using various metrics, including:

Accuracy: The percentage of correctly classified accident records (either serious or non-serious).

Confusion Matrix: A table used to evaluate the performance of the classification model, showing the true positives, true negatives, false positives, and false negatives.

Precision, Recall, and F1-Score: These metrics were used to assess the tradeoff between false positives and false negatives, especially in cases where the classes (serious and non-serious accidents) are imbalanced.

Odds Ratios: Since logistic regression outputs the log-odds, the model's

coefficients were interpreted in terms of odds ratios to understand the influence of each independent variable on accident severity.

IV.CONCLUSION

This study aimed to identify and understand the factors influencing accident severity in urban road environments through the application of a logistic regression model. By analyzing traffic accident data from police reports, the study revealed several critical factors that significantly contribute to the likelihood of severe accidents. Key factors such as road cross-section, accident location, road alignment, road type, and lighting conditions were found to be the most influential predictors of accident severity. The logistic regression model, applied to the dataset, demonstrated its ability to predict accident severity with reasonable accuracy, thereby contributing to a deeper understanding of road safety issues in urban environments. The findings of this study are consistent with previous research, where environmental and road-related factors were found to play a substantial role in the severity of traffic accidents. Moreover, the odds ratios derived from the logistic regression model provided valuable insights into the relative importance of each contributing factor, offering a statistical framework for policymakers and urban planners to prioritize interventions in road safety measures.

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