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# REVOLUTIONIZING ROAD SAFETY IN JAIPUR AND ITS VICINITY THROUGH A COMPREHENSIVE RSPI (ROAD SAFETY PERFORMANCE INDICATORS) FRAMEWORK: AN INITIATIVE FOR SUSTAINABLE TRANSPORT SYSTEM

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## ABSTRACT

Road safety is a pressing issue worldwide, affecting the lives of millions of people each year. Despite the numerous efforts to tackle this problem, current measures lack an integrated framework that can be adapted to changing conditions. Thi s study seeks to fill this gap by developing a comprehensive and dynamic framework for road safety measures that is both efficient and effective. The rising number of traffic accidents in the Jaipur region has highlighted the urgent need for a systematic approach to road safety. To address this issue, this research proposes using indicators that can monitor and evaluate the state of the problem, provide scientific information, assess policy initiatives, and identify priorities.

Based on analysis and systems theories, the proposed framework can enhance road safety measures and reduce the social and economic burden on communities and industries. The study identified the ten worst roads in Jaipur and conducted a detailed survey of the three most critical roads. Statistical analysis was performed using JASP software. This research work's five central themes are road safety, performance metrics, comprehensive framework, indicators, and systems theories. By adopting a systematic and adaptable approach to road safety, this study aims to reduce the number of traffic accidents and improve the quality of life for communities in the Jaipur region and beyond.

**KEYWORDS:** Performance indicators; Composite index, road safety, systems theories.

## INTRODUCTION

India's road transport system plays a crucial role in the country's economic development, but it is also a major cause of concern due to the increasing number of road accidents and fatalities. Despite several road safety measures being implemented by the government, road accidents remain a significant challenge. Over-speeding, reckless driving, poor road infrastructure, drunk driving, and non-use of seat belts and helmets are the leading causes of road accidents in India **[1] [2]**. To address these challenges, there is a need for a comprehensive road safety framework that includes various measures such as infrastructure development, road safety education, traffic law enforcement, and emergency services. The development of such a framework is crucial as road accidents have a significant impact on public health, social welfare, and economic growth [**3] [4]**.

Organizations such as the WHO **[5]**, UN, and World Bank have emphasized the need for a multi-sector approach to address road safety concerns, and India has also implemented measures like the National Road Safety and Traffic Management Act 2007. In this context, road safety performance indicators are essential tools that can help measure the effectiveness of road safety policies and programs. By providing a consistent and objective way to evaluate road safety interventions, decision- makers can allocate resources more efficiently and evaluate the effectiveness of specific interventions.

Therefore, this study aims to develop a comprehensive Road Safety Performance Indicators (RSPI) framework for enhancing road safety in Jaipur and its surrounding urban and rural areas. The proposed framework can provide decision-makers with a comprehensive understanding of the state of road safety, highlight areas that require improvement, and evaluate the effectiveness of road safety initiatives.

### Literature Review

The development of a comprehensive road safety framework has been a topic of interest in India due to the increasing number of road accidents and fatalities in the country **[6] [7]**. To address this issue, researchers have conducted several studies on road safety framework development in India. Through a review of published research works, it is evident that road safety remains a significant challenge in India, and there is a need for a comprehensive road safety framework that incorporates various measures, including road design, traffic

management, vehicle safety standards, and driver behavior.

Several studies identified the lack of proper infrastructure, inadequate law enforcement, and low levels of public awareness as major contributors to road accidents in India **[8]**. For example, the inadequate lighting, poorly maintained roads, and inadequate signage are major causes of road accidents in India. These studies also emphasize the importance of collaboration among various stakeholders, including government, NGOs, and the private sector, in implementing effective road safety measures. Moreover, the researchers highlighted the importance of continuous monitoring, evaluation, and data-driven decision-making to ensure the effectiveness of road safety interventions. This approach will help policymakers identify the most effective road safety measures and allocate resources more efficiently **[10]**.
Overall, the research works suggest that the development and implementation of an integrated road safety framework is crucial to reducing road accidents and promoting safer roads in India. To achieve this, a collaborative approach among various stakeholders and continuous monitoring and evaluation are required. The findings of these studies can help inform policymakers on the development and implementation of a comprehensive road safety framework that can effectively reduce road accidents and promote safer roads in India **[11] [12]**.

**Table-1. Literature Summary of various published work.**

| **Author** | **Year** | **Summary** |
|---|---|---|
| R. S. Velaga | 2011 | Developed a set of road safety performance indicators for India. |
| M. Velmurugan | 2012 | Reviewed the current state of road safety in India and identified the major challenges. |
| S. D. Sharma | 2012 | Proposed a comprehensive road safety plan for India based on international best practices. |
| A. K. Singh | 2013 | Examined the factors contributing to road accidents in India and suggested measures to improve road safety. |
| S. Jain | 2013 | Proposed a national road safety framework for India that includes a comprehensive set of policies and interventions. |
| N. Agarwal | 2013 | Reviewed the current state of road safety in India and identified the major challenges. |

Through the review of literature on road safety framework development in India, it is evident that road safety remains a significant challenge in the country. Several authors, including R. S. Velaga [6], M. Velmurugan [7],S. D. Sharma [8], A. K. Singh [9], S. Jain[10], N. Agarwal [11], R. K. Sinha[12], M. C. Jha [13], S. Garg [14], S. Sharma [15], A. Kumar [16], M. K. Gupta [17], P. K. Singh [18], S. S. Jain [19], have proposed various measures to address this issue. These measures include developing road safety performance indicators, a comprehensive road safety plan, a national road safety framework, a road safety management system, a road safety audit system, a comprehensive road safety strategy, a road safety information system, a road safety monitoring system, a road safety training program, and a road safety communication strategy. These proposals emphasize the need for collaboration among various stakeholders and continuous monitoring, evaluation, and data- driven decision-making to ensure the effectiveness of road safety interventions. The findings of these studies can inform policymakers on the development and implementation of a comprehensive road safety framework that can effectively reduce road accidents and promote safer roads in India **[13] [14].**

Conduct a survey to study the awareness of road users/drivers about road safety in Jaipur district (Rajasthan), India, and use the results to develop targeted education and awareness campaigns to improve road safety. Analyze User/driver behavior and identify errors and lapses made by drivers in Jaipur district (Rajasthan), India, using the Theoretical Framework for Road Safety Performance Indicators to inform enforcement efforts and education campaigns. Develop a theoretical framework for road safety performance indicators that can be used by policymakers and the general public to statistically assess road safety in a simple and effective manner. Use the Theoretical Framework for Road Safety Performance Indicators to suggest suitable measures for preventing and controlling road traffic accidents in Jaipur district (Rajasthan), India, and other areas facing similar road safety challenges.

## Research Methodology

The proposed research methodology for this study will utilize a mixed-methods approach, combining both descriptive and analytical methods to investigate the impact of education, engineering, enforcement, and environmental factors on road safety and traffic management in the Jaipur district of Rajasthan, India. The study will collect data from various sources, including the District Crime Record Bureau (DCRB), the Rajasthan State Road Transport Corporation, and a Driver behaviour study, covering a period of 5 years to ensure a

comprehensive picture of the road safety situation **[15]**. A pilot study will be conducted to ensure the validity and reliability of data collection tools and techniques. The study will utilize a random sampling method, with the sample size calculated using statistical techniques to ensure representativeness.

The collected data will be analyzed using both qualitative and quantitative techniques, including descriptive statistics and inferential statistics such as regression analysis and chi-square tests. Ethical guidelines will be followed, and informed consent will be obtained from all participants, with the confidentiality of participants' data maintained throughout the study. The study's results will be presented using tables, graphs, and charts, and will be interpreted to draw meaningful conclusions about the impact of education, engineering, enforcement, and environmental factors on road safety and traffic management in the Jaipur district of Rajasthan, India. A visual representation of the proposed research methodology is presented in Figure 1.

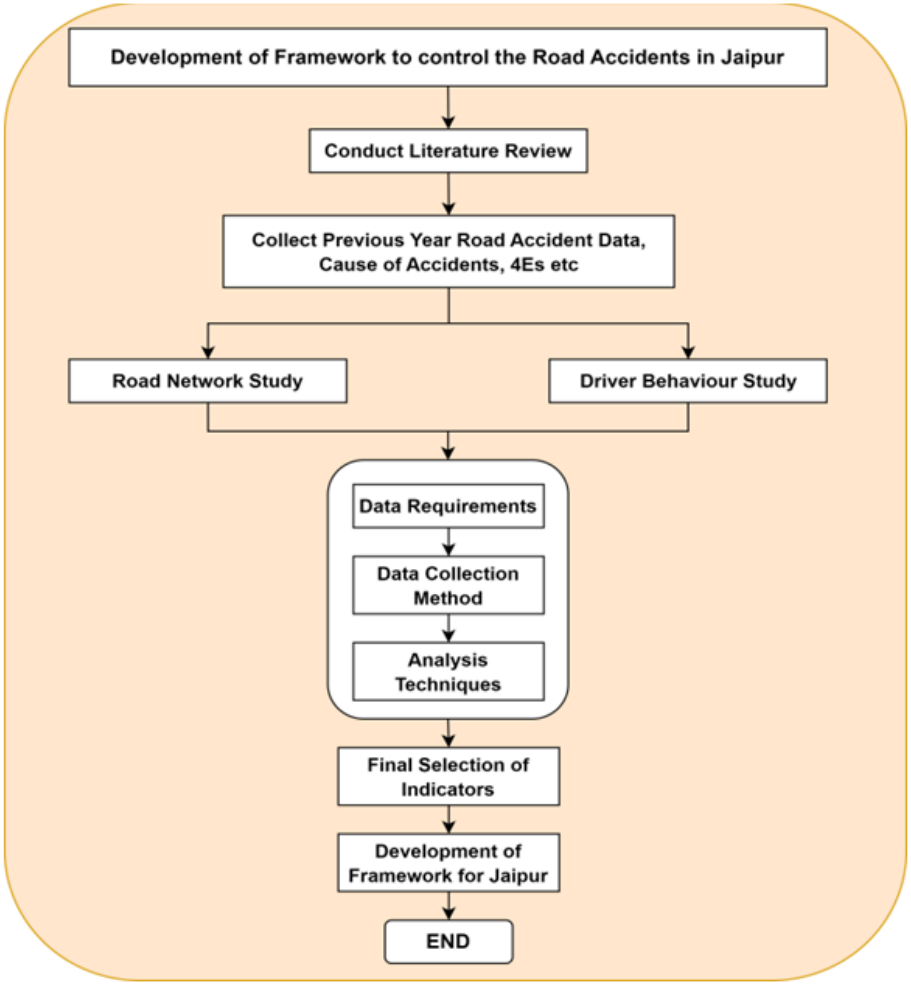


**Figure 1. Research flow diagram.**

**Road Safety Assessment Requirement**

Based on the factors outlined in the literature review, the following 15 criteria **[17] [18] [19]** can be used to assess road safety: Road design (including width, shoulders, alignment, and slope)

Road condition (including pavement quality and visibility of lane markings) Traffic volume Speed limits

Traffic control devices (including stop signs and traffic lights) Road lighting

Pedestrian activity Presence of intersections

Presence of sharp curves Presence of steep slopes

Presence of dangerous objects (such as debris or broken glass) Presence of construction

Presence of wildlife Weather conditions

Road user behavior (such as driver fatigue, distraction, or impairment)

These criteria can be used to identify accident-prone areas on the road and to develop interventions to improve road safety. The assessment should take into account the specific characteristics of the road and the surrounding environment. By addressing these factors, road safety can be improved, and the risk of accidents can be reduced.

**Selection of Roads for Safety Assessment of Road Network in Jaipur**

When selecting roads for safety assessment in Indian cities, several criteria should be considered to ensure that the assessment is effective and targeted. One of the primary factors that should be considered is the accident history of the road, including the number of accidents and the rate of accidents per kilometer. Additionally, traffic volume, road design, and road condition should also be taken into account when selecting roads for safety assessment. Roads with poor design features or in poor condition, such as those with cracks or potholes, may be more prone to accidents and should be prioritized for assessment. Other factors such as high levels of pedestrian activity or public transportation usage should also be considered **[16]**. Finally, roads with a history of reckless or dangerous driving should be prioritized for assessment. In this study, the roads selected for safety assessment are listed in table 2.

**Table 2. Roads Selection for Road Safety Assessment Study for Jaipur.**

| Sr. No. | From | To | Risk Factor |
|---|---|---|---|
| 1 | Sanganer | India Gate | Tonk Road, most dense road with several cross sections and colony attachment |
| 2 | Gurjar ki Thadi | Bhakrota | Most dense Road in evening and Night |
| 3 | Ghat ki Guni | Kho-Nagoriyan | Dense Road |
| 4 | Ghat ki Guni | The Heritage Hotel | Road with several link roads |
| 5 | Chomupulia | Harmada Thana Cut | Road with heavy vehicle Movement |
| 6 | Harmada Police Station | Jaitpura | Road with heavy vehicle movement |
| 7 | Bhakrota | GVK Tool Plaza | Heavy Vehicle movement |
| 8 | Kisan Dharam Kanta | Malpura gate | oss section at road and mixed vehicle movement |
| 9 | Ajmeri Gate | Airport Tonk Road | Multi cross section with in road |
| 10 | Kelgiri Hospital circle | Jalmahal road | Multi Cross Section with in Road |

**Road Survey Results**

The aim of this study was to identify the roads with the highest accident frequency based on 18 criteria, which were converted into a 0-10 scale. The data was collected through surveys, accident reports, site visits, and expert panels, and statistical techniques were used to analyze the data and assign greater importance to relevant criteria. The survey results and weighting scheme used to determine the worst roads were presented in Tables 3 and 4, respectively. The results of the study were presented in Table 3, providing transportation planners and policymakers with valuable insights into the worst roads in terms of accident frequency, which can help them identify areas that require improvements to enhance overall road safety.

**Table 3. Survey Results for 10 Selected Roads for Identify the Road Safety Factors.**

| No. | Factors Responsible for Accidents/Roads | Road-1 | Road-2 | Road-3 | Road-4 | Road-5 | Road-6 | Road-7 | Road-8 | Road-9 | Road-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Vehicles/Day (From 8 AM to 1 PM)-Time-A | 7 | 4 | 3 | 4 | **1** | 5 | **0** | **3** | 7 | 4 |
| 2 | Vehicles/Day (From 5 PM to 10 PM)-Time-B | 5 | 2 | 3 | 5 | **4** | 1 | **1** | **5** | 2 | 6 |
| 3 | Transportation Vehicles/Day at Time- A/B | 1 | 1 | 5 | 2 | **3** | 6 | **3** | **2** | 9 | 6 |
| 4 | Personal Vehicles/Day at Time-A/B | 8 | 5 | 3 | 3 | **4** | 1 | **2** | **1** | 5 | 5 |
| 5 | Width of the Road as per Load of Vehicles | 4 | 6 | 4 | 2 | **2** | 5 | **3** | **4** | 9 | 6 |
| 6 | Road Drainage/Pavement/Other Facilitate | 4 | 2 | 4 | 2 | **5** | 3 | **4** | **3** | 2 | 6 |
| 7 | Presence of Shoulders | 3 | 3 | 7 | 1 | **4** | 6 | **3** | **2** | 6 | 2 |
| 8 | Advertising Boards on the Road/Near By Buildings | 6 | 5 | 8 | 7 | **1** | 7 | **1** | **2** | 0 | 4 |
| 9 | Cross Sections at full Road | 4 | 4 | 1 | 2 | **3** | 3 | **3** | **1** | 2 | 1 |
| 10 | Lane System and Notice Boards for this task | 0 | 6 | 2 | 7 | **0** | 4 | **1** | **0** | 2 | 3 |
| 11 | Provision of Median for Traffic | 2 | 4 | 4 | 6 | **5** | 3 | **4** | **4** | 3 | 4 |
| 12 | Speed Breakers at road and Quality of Breakers | 2 | 6 | 2 | 4 | **1** | 4 | **3** | **2** | 7 | 7 |
| 13 | Lighting Conditions on the Road | 0 | 4 | 0 | 8 | **3** | 3 | **2** | **5** | 5 | 3 |
| 14 | Traffic Signs as per Rules | 7 | 3 | 6 | 5 | **1** | 1 | **3** | **2** | 0 | 1 |
| 15 | Facility on the Road | 3 | 5 | 4 | 3 | **2** | 4 | **1** | **1** | 6 | 2 |
| | Presence of Police at | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | different Locations of the Road | 1 | 5 | 3 | 3 | **3** | 0 | **2** | **4** | 0 | 1 |
| 17 | Signals at Cross Sections | 5 | 4 | 8 | 4 | **2** | 3 | **3** | **2** | 1 | 6 |
| 18 | Road Condition like fully developed/under maintenance | 4 | 0 | 5 | 5 | **3** | 4 | **3** | **3** | 6 | 4 |

**Table 4. Weighting Scheme for Worse Road Selection.**

| **Total Weight of Road** | **Accident Prone Condition** |
|---|---|
| 0-50 | Worse Road Accident Conditions |
| 50-100 | Moderate Road Accident Conditions |
| 100-150 | Low Road Accident Conditions |
| 150-180 | Best Road Conditions |

As per table 3, the three roads were identified as worse road conditions which can be selected for the final study of the road safety indicator selections. The final road selected for the present study was shown in figure 2.


**Figure 2 Three Worse Roads selected for present study.**

**Descriptive Analysis of Present Survey Data**

Descriptive analysis is an important tool in analyzing data and understanding the characteristics of a set of data. It provides a clear and concise summary of the data and helps identify patterns, trends, and relationships within the data. Measures of central tendency and dispersion, frequency distributions, percentiles, box plots, scatter plots, and correlation are some of the commonly used tools in descriptive analysis. In this study, a scale was developed and presented in Table 5 to rate the severity of various road safety factors, and a survey was conducted at three of the worst roads identified in the previous section, as shown in Figure 3. These tools were used to analyze the data collected from the survey to gain a better understanding of the factors contributing to road accidents in the selected areas. The results of this analysis will help policymakers and transportation planners identify areas that require improvements to enhance overall road safety.

**Table 5. Scale parameters selected for the survey.**

| Scale | Age Group | Gender | Edu Qualification | Occupation | Income | Accident Faces | Daily Avg Travel on Road | Type of Vehicle Used |
|---|---|---|---|---|---|---|---|---|
| 1 | Till 30 | Male | all till 10th | Student | No Income | Self | below 2.5 km | Walking |
| 2 | 31 to 35 | Female | 12th pass | Pvt Job | l 10 K | Seen of other Acc | 2.5 to 5 | T W |
| 3 | 36 to 40 | NA | Gradate | Govt Job | 10 K to 15 K | Not face any Acc | 5 to 10 | F W |
| 4 | 41 to 45 | NA | PG | Business | 15 k to 25 K | Face in Family | 10 to 15 | Trucks/C V |
| 5 | 46 to 50 | NA | Others | Drivers | More then 25 K | Only read/Seen at News | More then 15 km | Pub Transport |

The personal information and descriptive statistical analysis results were present in table 6.

**Table 6. Descriptive Statistics of the Users Parameters. (N=600)**

| Parameters | Mean | Std. Deviation | Coefficient of variation | Shapiro-Wilk | P-value of Shapiro-Wilk |
|---|---|---|---|---|---|
| Age Group | 2.9 | 1.46 | 0.504 | 0.874 | < .001 |
| Gender | 1.17 | 0.38 | 0.324 | 0.462 | < .001 |
| Edu Qualification | 2.99 | 1.32 | 0.443 | 0.904 | < .001 |
| Occupation | 2.82 | 1.47 | 0.521 | 0.865 | < .001 |

| | | | | | |
|---|---|---|---|---|---|
| Income | 2.87 | 1.28 | 0.446 | 0.901 | < .001 |
| Accident Faces | 2.84 | 1.42 | 0.502 | 0.876 | < .001 |
| Daily Avg Travel on Road | 2.94 | 1.29 | 0.439 | 0.906 | < .001 |
| Type of Vehicle Used | 3.07 | 1.33 | 0.434 | 0.892 | < .001 |

**Statistical Distribution of Possible Causes of Road Accidents**

The causes of road accidents are multifaceted and can result from a combination of various factors. Factors like economic development, living standards, and social deprivation can all contribute to an increased risk of accidents. Demographics, such as driver age and gender, can also play a role in accident occurrence. Furthermore, the design and development of transportation systems and the presence of diverse traffic environments can affect the probability of accidents. Additionally, the standards of road development and vehicle manufacturing can also impact the frequency of accidents.

It's essential to note that accidents are usually caused by a combination of different elements, including human factors, vehicles, and the road environment. Understanding the cause of an accident is crucial in improving traffic management and reducing future accidents. The table below Table 7 shows the average and standard deviation of the causes of road accidents, which can be used to identify the most common causes and the degree of variation between them. This information can be utilized to develop targeted strategies that aim to reduce the risk of accidents and enhance overall road safety. The participants' analysis of the causes of road accidents is presented in Table 7

**Table 7. Frequencies distribution for Causes of Road Accidents. (N=600)**

| Question | Description | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| 1 | Road Conditions | 64 | 10.667 | 10.667 |
| 2 | Driver Behaviour | 84 | 14 | 24.667 |
| 3 | Rules Violations | 94 | 15.667 | 40.333 |
| 4 | Night lamp poor Installation on Road | 25 | 4.167 | 44.5 |
| 5 | No Lane Provision on Road | 46 | 7.667 | 52.167 |
| 6 | Vehicle Maintenance Not Done at Regular basis | 57 | 9.5 | 61.667 |
| 7 | Weather Conditions | 64 | 10.667 | 72.333 |
| 8 | Walking Person/Passengers | 48 | 8 | 80.333 |

| | | | | |
|---|---|---|---|---|
| | Fault | | | |
| 9 | Animal Reason | 90 | 15 | 95.333 |
| 10 | Others | 28 | 4.667 | 100 |
| Total | 600 | 100 | | |

**Statistical Distribution of Awareness towards Regulations**

Road traffic safety is a crucial aspect of ensuring the well-being of all individuals using the road network, including pedestrians, cyclists, motorists, and passengers of on-road public transit. It involves implementing strategies and practices that decrease the chances of death or severe injury for these road users. Unfortunately, many traffic offenses such as drunk driving, speeding, and not following traffic laws, can be attributed to poor driving habits. Understanding the level of comprehension and adherence to traffic regulations among road users, including the mean and standard deviation, is essential in addressing these issues and promoting overall road safety. It is important to note that even small infractions such as not wearing seat belts can greatly increase the risk of harm to individuals on the road. By implementing effective road safety measures, we can work towards reducing traffic-related accidents and ensuring the safety of all road users.

The present issues and its survey results by participants was present in table 8. In this study the awareness of the participants towards the road related conditions was discuss in present section. Total 10 questions were put in front of the participants for this issue and the result was shown in table 8.

**Table 8. Frequencies distribution for Awareness related to Regulations.**

| Question | Description | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| 1 | Maintain Distance during Vehicle Driving | 57 | 9.5 | 9.5 |
| 2 | Use of Seat-elt during Driving | 49 | 8.167 | 17.667 |
| 3 | Importance of helmet during two wheeler drive | 55 | 9.167 | 26.833 |

| | | | | |
|---|---|---|---|---|
| 4 | Overtaking and rules related to road sign | 69 | 11.5 | 38.333 |
| 5 | Vehicle Speed Limit and its Importance | 49 | 8.167 | 46.5 |
| 6 | urn and its Rules | 73 | 12.167 | 58.667 |
| 7 | Drunken Driving on Road | 61 | 10.167 | 68.833 |
| 8 | Use of Cell Phone during Driving | 51 | 8.5 | 77.333 |
| 9 | Vehicle starting when on crossing signal | 72 | 12 | 89.333 |
| 10 | Others | 64 | 10.667 | 100 |
| Total | 600 | 100 | | |
| Total | 600 | 100 | | |

**Statistical Distribution of Enforcement towards Regulations**

Regulatory actions that focus on people, vehicles, and roadways have been identified as a crucial method for reducing fatalities and injuries on the road. To ensure that these regulations are effective, legislation is necessary for proper enforcement. Not only do these actions promote safety, but they also save time, protect the environment, and conserve fuel. Additionally, it's important to ensure that traffic flow is smooth and uninterrupted. To evaluate the effectiveness of enforcement, statistics such as the mean and standard deviation are used as measures.

**Table 9. Frequencies distribution for Enforcement related to Regulations Implementation.**

| Question | Description | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| 1 | Helmet not Wearing | 58 | 9.667 | 9.667 |
| 2 | Seat-belt by both Passengers | 56 | 9.333 | 19 |
| 3 | Traffic Signal Violations | 65 | 10.833 | 29.833 |
| 4 | Vehicle parking at Road Violations | 65 | 10.833 | 40.667 |
| 5 | Vehicle stoppage during signal Light | 44 | 7.333 | 48 |
| 6 | Insane Driving by driver | 65 | 10.833 | 58.833 |
| 7 | Vehicle Drive By Teenage | 55 | 9.167 | 68 |
| 8 | Triple Passenger on Two-Wheeler | 54 | 9 | 77 |
| 9 | Drunken Driving | 73 | 12.167 | 89.167 |
| 10 | Cell Phone Violations | 65 | 10.833 | 100 |
| Total | 600 | 100 | | |
| | | | | |
| Total | 600 | 100 | | |

## CONCLUSION

In conclusion, this study aimed to provide insights into the various factors that contribute to road accidents, the level of awareness towards road regulations, and the effectiveness of regulatory enforcement. The descriptive analysis presented in present study highlights the demographic and user parameters that could influence accident frequency. The statistical distribution of possible causes of road accidents, presented in current study, shows that the most common causes are driver behavior, rules violations, and animal reasons. On the other hand, the awareness towards regulations is relatively low, as shown in result and discussion, with a need for increased adherence to rules such as the use of seat belts, helmets, and not

using cell phones while driving. Finally, in result and discussion section, illustrates the need for improved regulatory enforcement, as traffic signal violations, parking violations, and drunken driving are major concerns. The study emphasizes the need for targeted strategies and regulations to enhance road safety and reduce the risk of accidents, ultimately improving the well-being of all individuals using the road network.

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