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Analysis Of Road Traffic Accident And Identification Of Blackspot Locations

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Abstract:
This project endeavors to tackle the pressing public health and safety concerns stemming from road traffic accidents. A primary objective of this research is to pinpoint and scrutinize high-risk locations, colloquially referred to as blackspots. These blackspots are designated as 500-meter stretches of road that have witnessed an alarming number of accidents involving serious injuries or fatalities over the past three calendar years.
To identify blackspot locations, this project employs the Weighted Severity Index (WSI) method. This systematic approach enables us to objectively identify areas of heightened risk, taking into account the severity and frequency of accidents. The WSI method provides a robust framework for analyzing accident data and pinpointing blackspot locations
Upon identifying blackspot locations, the investigation delves into the underlying factors contributing to accidents at these locations. Statistical Package for the Social Sciences (SPSS) software is utilized to facilitate the analysis, which encompasses a range of variables pertinent to road design and configuration. The analysis considers variables such as the width of the road, the radius of curvature, the gradient, the superelevation and the degree of curvature.
By examining the interplay between these variables and accident outcomes, this research aims to provide invaluable insights into the complex dynamics underlying road traffic accidents. The findings of this project will inform evidence-based strategies for mitigating the risk of accidents at blackspot locations, thereby enhancing road safety and reducing the devastating impact of road traffic accidents on individuals, families, and communities.
Keywords: *Road traffic accidents, Blackspots, Public health, Safety concerns, Weighted Severity Index (WSI), Statistical Package for the Social Sciences (SPSS), Road design, Accident analysis, Road safety*

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I. Introduction

Road traffic accidents pose a significant threat to public health and safety, resulting in catastrophic consequences including loss of life, severe injuries, and substantial economic burdens on society. The repercussions of these incidents extend beyond personal tragedies, imposing considerable costs on medical care, productivity, and property damage. Certain stretches of roadways, known as blackspots, are particularly perilous and warrant focused attention due to their propensity for frequent and severe accidents. These blackspots are typically characterized by a short stretch of road, approximately 500 meters in length, where a minimum of five accidents involving serious injuries or fatalities, or ten fatalities, have occurred within a three-year period. This project seeks to investigate road traffic accidents on the Perumbavoor to Muvattupuzha stretch of the MC Road, which has become a pressing concern due to recurring incidents. By leveraging the Weighted Severity Index (WSI) method, the project aims to systematically identify high-risk blackspot locations, examine the underlying factors contributing to accidents, and develop data-driven recommendations to enhance road safety.

The ultimate objective of this project is to implement effective safety measures that can help reduce the frequency and severity of accidents on this road, thereby safeguarding the lives of road users and mitigating the economic impact of road traffic accidents. This project underscores the importance of evidence-based decision-making in creating safer road environments and improving the overall quality of life for the community. By adopting a data-driven approach, this research endeavors to inform policy decisions and contribute to the development of more effective road safety strategies.

II. Methodology

Site Selection

Stakeholder Consultations

Research on road safety commenced with stakeholder consultations, involving police officers and ambulance drivers experienced in road safety and accident response. These stakeholders provided valuable insights into accident hotspots, recurring emergency situations, driver behavior, and road conditions contributing to accidents. The consultations consistently identified the Perumbavoor-Muvattupuzha Road as a high-risk route due to frequent emergencies, heavy traffic volume, congestion, poor road infrastructure, and hazardous driver behavior. This collaborative approach established a strong foundation for the research, informing evidence-based solutions and targeted interventions to enhance road safety. The stakeholder consultations also fostered collaboration, ensured practical data- driven approaches, and bridged the gap between data and real- world experience. Ultimately, the research demonstrated the importance of stakeholder engagement and collaboration in addressing road safety challenges and developing effective solutions.

Site Visit

A thorough site visit to the Perumbavoor-Muvattupuzha Road revealed a multitude of alarming conditions that significantly compromised road safety. The assessment uncovered inadequate road markings, insufficient signage, and inadequate lighting, which collectively contributed to poor visibility and increased the risk of accidents. Furthermore, the presence of hazardous obstructions on the road posed an additional threat to drivers and pedestrians alike. The gravity of the situation was starkly underscored by a serious accident that occurred during the site visit, emphatically highlighting the urgent need for corrective measures. Conversations with local residents and businesses corroborated these findings, with many citing high accident rates and reckless driving as persistent concerns. The comprehensive assessment unequivocally demonstrated the imperative for immediate intervention, including targeted safety improvements, enhanced signage, road markings, lighting, and infrastructure upgrades to effectively mitigate accidents and enhance road safety.

Police Station Visit

The visit to the Perumbavoor Police Station helped in understanding the road accident scenario in the area, providing a quantitative understanding of accident trends, including frequency, nature, and severity, which revealed alarming patterns confirming the road's notorious reputation for accidents, aligning with stakeholder feedback and site visit observations. Discussions with police officials further emphasized the high incidence of severe and fatal accidents, solidifying the road's designation as an accident-prone area, with their insights providing firsthand context to the statistics, highlighting safety concerns and underscoring the urgent need for targeted interventions to enhance road safety. The police records offered a detailed view of accident trends, including types of accidents, frequency of occurrence, and severity of injuries, which will inform evidence-based solutions to address root causes, such as inadequate road infrastructure, reckless driving, and poor visibility. By leveraging these insights, stakeholders can collaborate to implement effective safety measures, reducing accidents and saving lives, and by combining these findings with research on traffic patterns and infrastructure improvements, comprehensive solutions can be developed to enhance road safety.

Data Collection

To gather accurate and reliable accident data for the Perumbavoor-Muvattupuzha Road, involving coordination with local authorities, which began with a visit to the Perumbavoor Police Station to request access to accident records specific to the Perumbavoor region, but it was discovered that detailed records for the entire district are maintained at the District Crime Records Bureau (DCRB) in Aluva. The DCRB office provided access to comprehensive records, including information on accident frequency, types, locations, times, contributing factors, and details on individuals involved, spanning several years, which enabled the analysis of accident trends and frequency on this road section. The successful data collection from DCRB was vital, providing the factual basis for analysis and enabling the team to identify accident-prone locations, assess contributing factors, and formulate evidence-based safety recommendations. By leveraging the collected data, targeted interventions can be developed to enhance road safety and reduce accidents along the Perumbavoor-Muvattupuzha Road, ensuring a comprehensive and credible study, with findings rooted in official records and verified data sources.

Data Preprocessing

To analyze accident patterns on the Perumbavoor-Muvattupuzha Road, leveraging a combination of geographic tools and data filtering techniques to ensure accuracy and reliability. Utilizing Google Maps, specific locations along the route were pinpointed, and police station jurisdictions were identified, facilitating the association of accidents with specific geographic areas. The initial dataset from the District Crime Records Bureau (DCRB) for Ernakulam District was extensive, comprising 11,888 accident cases in 2021 alone, which was then systematically filtered using a rigorous methodology involving data cleaning, filtering, segmentation, and validation techniques. This process ensured the extraction of relevant data specific to the Perumbavoor-Muvattupuzha Road, enabling in-depth analysis of accident frequency and distribution, types of accidents, contributing factors, time and day of accidents, and location-specific accident patterns. The refined dataset provided invaluable insights into road safety dynamics, highlighting trends and patterns that informed evidence-based recommendations to enhance road safety along the Perumbavoor-Muvattupuzha Road, ultimately reducing the risk of injury or fatality for road users. The integration of Google Maps location verification, DCRB filtering, and police jurisdiction sorting ensured the accuracy and reliability of the findings, forming a cornerstone for targeted interventions to mitigate accidents and improve road safety.

Blackspot Identification

To pinpoint accident-prone areas along the Perumbavoor- Muvattupuzha Road, enhancing road safety and reducing the impact of road traffic accidents on individuals, families, and communities, by importing location data into Google Maps and scrutinizing each point to create a comprehensive list of verified latitude and longitude coordinates linked to corresponding accident data, spanning three years from 2021 to 2023. A thorough analysis of major, minor, and fatal accidents was conducted, initially separately for each year and then consolidated into a single Excel sheet, revealing clusters of accidents and enabling the identification of blackspots, which were defined, guided by IRC 131:2022, as 300-500m road sections with at least 5 major accidents, exhibiting patterns of road crash types due to local risk factors. The Weighted Severity Index (WSI) equation was employed to quantify the severity of each blackspot, taking into account the number of deaths, grievous injuries, and minor injuries, resulting in a prioritized list of blackspots, empowering policymakers and transportation authorities to target resources effectively and enhance road safety by addressing these high-risk areas, demonstrating the importance of rigorous data verification and analysis in identifying accident-prone areas and contributing meaningfully to the development of evidence-based road safety strategies, ultimately informing targeted interventions to mitigate accidents and improve road safety.

Table no 1: Blackspot ranking with respect to WSI value

Rank	Place Ofoccurrence	Accident Spot	WSI Value
1	Pezhakkappilly	Near Hdfc Bank	438
2	Pezhakkappilli	Near Sabine Hospital	422
3	Pallichirangara	Near Ith Paint Hub	418
4	Pezhackapilly	Near Panchayath Road	358
5	Pezhakkappilly	Near Communication Sub Division Kseb	328
6	Thrikalathoor	Near Pallichira Road	284
7	Vattakattupady	Near Clear Waste Burners	284
8	Pulinchuvadu	Near Ishara Pre Owned Cars	224
9	Pezhakkappilly	Near Appus Nagar Road	190
10	Pezhackappilly	Near High Line Autos	152

Figure:1 Major blackspot location (Pezhakapilly) in google map

Figure:2 Pezhakapilly Junction (Major blackspot *Determination Of Contributing Factors*

Accident Modelling In SPSS Software

A comprehensive analysis of geometric data was conducted to identify the primary accident contributing factors at blackspots along a specific route. The process commenced with the meticulous collection of geometric data, encompassing road width, radius of curvature, gradient, degree of curvature, and superelevation. This data was then inputted into the Statistical Package for the Social Sciences (SPSS) software, a robust tool renowned for its advanced data analysis capabilities.

Utilizing the SPSS software, a series of modelling processes were employed to determine the most suitable model that contributes to accidents. This involved a rigorous evaluation of various models, each incorporating different combinations of geometric parameters. Through a systematic comparison of the models' performance, the most suitable model was selected based on its ability to accurately predict accident severity and identify the most critical contributing factors. The selected model was then validated to ensure its reliability and accuracy in predicting accident outcomes.

Table no 2: Selected model in SPSS

MODEL	t VALUE	R^2 VALUE
$WSI = 87.462 - 0.079D^2 + 0.001R^2 + 2.076W - 60.169\sqrt{G}$	0.980,3.555,1.730,1.490,1.895	0.223

The selected model revealed that specific geometric variables such as road width, degree of curvature, gradient and radius of curvature, were significant contributors to accidents.

$$WSI = 87.462 - 0.079D^2 + 0.001R^2 + 2.076W - 60.169\sqrt{G}$$

Where,

- D=Degree of curvature
- R=Radius of curvature
- W=Width
- G=Gradient

Prioritizing Safety Measures

To improve road safety at the Pezhakapilly junction, we have identified three crucial safety measures to implement. Firstly, shifting bus stops will play a significant role in reducing congestion and improving visibility at the junction. By relocating bus stops, we can minimize the number of vehicles stopping and starting at the junction, thereby reducing the likelihood of accidents. Moreover, shifting bus stops will also improve visibility for drivers and pedestrians, making it easier for them to navigate the junction safely. This, in turn, will enhance pedestrian safety, as they will have a safer and more accessible route to cross the road.

Another critical safety measure is the installation of median dividers. These dividers will prevent vehicles from crossing over into oncoming traffic, thereby reducing the risk of head-on collisions. Moreover, median dividers will also prevent vehicles from sideswiping each other, further minimizing the risk of accidents. In addition to improving safety, median dividers will also improve traffic flow and reduce congestion at the junction. By separating opposing traffic flows, median dividers will enable vehicles to move more smoothly and efficiently through the junction, reducing the likelihood of congestion and accidents.

The third safety measure is the placement of an accident-prone area board. This board will serve as a critical warning system, alerting drivers to the high-risk nature of the junction. By raising driver awareness, the board will encourage drivers to exercise extra caution when navigating the junction, thereby reducing the risk of accidents. Furthermore, the board will also remind drivers to reduce their speed, which is critical for preventing accidents at the junction. The board will also serve as a data collection point, enabling authorities to monitor and analyze accident trends at the junction. This data will be critical for identifying areas for further improvement and for evaluating the effectiveness of the safety measures implemented.

Checking The Effectiveness of The Safety Measures

In this study, we utilized VISSIM to construct a road model replicating the geometry of a major blackspot to analyze traffic safety conditions, identify conflict points, and evaluate potential safety improvements. To achieve this, a traffic volume survey was conducted to assess traffic flow, development trends, and movement patterns in the study area. The data was collected for one hour during peak traffic conditions, recorded at 15-minute intervals. Vehicles were classified into different categories, including cars, two-wheelers, autos, trucks/lorries, pickups, and buses. This classification enabled a detailed understanding of traffic composition and movement patterns, ensuring that the simulation accurately reflected real-world conditions.

Once the data collection was complete, road parameters such as width, number of lanes, connectors, and links were input into the VISSIM model, along with the precise location of the bus stop. After configuring the model, we conducted the initial simulation to observe traffic flow and identify conflict points—locations where vehicle interactions posed a high risk of collisions. These conflict points were then visually examined within the simulation to understand their distribution and severity.

To further analyze the contributing factors to traffic conflicts, we used SPSS software to process and interpret the collected data. The analysis revealed two key factors that significantly impacted traffic safety: increasing road width and relocating the bus stop. Widening the road provided additional space for vehicle movement, reducing congestion and minimizing conflicts, while relocating the bus stop helped minimize its interference with general traffic flow, reducing sudden vehicle stoppages and abrupt lane changes.

Based on these findings, we modified the VISSIM model by implementing the two proposed safety measures. The same traffic data was re-entered, and the simulation was conducted again to evaluate the impact of these modifications. We then compared the results from both simulations to assess improvements in traffic safety. The findings showed a significant reduction in conflict points, demonstrating that both road widening and bus stop relocation effectively contributed to accident prevention and improved traffic efficiency. The improved traffic flow reduced instances of abrupt braking and unsafe lane changes, which are common precursors to collisions.

By cross-checking the two models, we confirmed that the recommended safety measures successfully reduced accident risks and improved overall road conditions.

III. Conclusion

In conclusion, our comprehensive analysis culminated in the identification of 54 blackspots, with Pezhakapilly emerging as the most critical location, characterized by a Weighted Severity Index (WSI) value of 483. Utilizing SPSS modeling, we pinpointed four primary contributing factors to accidents at this location: width, radius of curvature, degree of curvature, and gradient. Notably, our analysis revealed an inverse relationship between road width and radius of curvature with accident severity, indicating that increments in these factors lead to a decrease in accident severity. Conversely, a positive correlation between road gradient and accident severity was observed, highlighting the need for targeted interventions to address this specific factor. Moreover, our examination of data from the District Crime Records Bureau (DCRB) revealed that additional factors, such as consumption of drugs, climatic conditions, and age, also contribute to accident disparity. In response to these findings, we proposed a series of safety measures for the Pezhakapilly blackspot, including the strategic shifting of bus stops, installation of median dividers, and placement of accident-prone area boards. These targeted interventions aim to mitigate the identified risk factors and significantly reduce the accident severity at this critical location, ultimately enhancing road safety for all users. The simulation of the Paipra Kavala intersection in VISSIM provided valuable insights into traffic flow, conflict points, and the impact of various safety measures. By replicating the real-world geometry and traffic conditions, we accurately assessed the existing safety concerns and identified critical conflict points. Through the implementation of proposed measures—such as increasing road width, relocating bus stops, and introducing a median—we observed a significant reduction in both conflict points and potential accident risks. Implementing these measures in the actual intersection could lead to a safer and more efficient traffic system.

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