

Midocean University



Analyzing the Impact of Automated Traffic Control Systems on Driver Behavior and Traffic Incidents in Riyadh

تحليل تأثير أنظمة التحكم المروري الآلي على سلوك السائقين والحوادث المرورية في مدينة الرياض

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1. ABSTRACT

As urban centers continue to grapple with the challenges of burgeoning populations and increased vehicular traffic, the integration of automated traffic control systems has emerged as a promising solution. This research endeavors to investigate the impact of automated traffic control systems on driver behavior and the occurrence of traffic incidents in Riyadh, Saudi Arabia. The study employs a comprehensive approach, combining quantitative data analysis and qualitative assessments to provide a nuanced understanding of the dynamics.

The research methodology involves the collection and analysis of traffic data from roads equipped with automated control systems. Driver behavior is assessed through surveys and interviews, capturing perceptions and experiences related to automated traffic control. Additionally, incident reports from relevant authorities are examined to discern patterns and trends associated with the introduction of automated systems.

Preliminary findings suggest a correlation between the implementation of automated traffic control systems and positive shifts in driver behavior, including adherence to traffic rules, reduced instances of speeding, and enhanced road safety. Moreover, the analysis indicates a potential decrease in traffic incidents in areas where these systems are deployed. However, challenges such as public awareness, system reliability, and adaptability may influence the overall effectiveness of automated control.

The outcomes of this research are expected to contribute valuable insights to urban planners, policymakers, and transportation authorities in Riyadh seeking evidence-based strategies for optimizing traffic management. By understanding the interplay between automated systems and driver behavior, this study aims to inform future developments in traffic control infrastructure and enhance overall road safety in the urban landscape.

مع استمرار المراكز الحضرية في مواجهة تحديات تزايد عدد السكان وزيادة حركة مرور المركبات، برز تكامل أنظمة التحكم في حركة المرور الآلية كحل واعد. يسعى هذا البحث إلى دراسة تأثير أنظمة التحكم المروري الآلية على سلوك السائقين ووقوع الحوادث المرورية في مدينة الرياض بالمملكة العربية السعودية. تستخدم الدراسة نهجا شاملا، يجمع بين تحليل البيانات الكمية والتقييمات النوعية لتوفير فهم دقيق للديناميكيات.

تتضمن منهجية البحث جمع وتحليل البيانات المرورية من الطرق المجهزة بأنظمة التحكم الآلي. يتم تقييم سلوك السائق من خلال الدراسات الاستقصائية والمقابلات، والتقاط التصورات والخبرات المتعلقة بالتحكم الآلي في حركة المرور. بالإضافة إلى ذلك، يتم فحص تقارير الحوادث الصادرة عن السلطات ذات الصلة للتعرف على الأنماط والاتجاهات المرتبطة بإدخال الأنظمة الآلية.

وتشير النتائج الأولية إلى وجود علاقة بين تطبيق أنظمة التحكم في حركة المرور الآلية والتحول الإيجابية في سلوك السائق، بما في ذلك الالتزام بقواعد المرور، وتقليل حالات السرعة، وتعزيز السلامة على الطرق. علاوة على ذلك، يشير التحليل إلى انخفاض محتمل في الحوادث المرورية في المناطق التي تنتشر فيها هذه الأنظمة. ومع ذلك، فإن التحديات مثل الوعي العام، وموثوقية النظام، والقدرة على التكيف قد تؤثر على الفعالية الشاملة للتحكم الآلي.

ومن المتوقع أن تساهم نتائج هذا البحث برؤى قيمة لمخططي المدن وصانعي السياسات وسلطات النقل في الرياض الذين يسعون إلى استراتيجيات قائمة على الأدلة لتحسين إدارة حركة المرور. من خلال فهم التفاعل بين الأنظمة الآلية وسلوك السائق، تهدف هذه الدراسة إلى إعلام التطورات المستقبلية في البنية التحتية للتحكم في حركة المرور وتعزيز السلامة على الطرق بشكل عام في المشهد المدني.

2. INTRODUCTION

Road safety is a paramount concern for urban areas across the globe, with governments and local authorities actively seeking solutions to reduce the frequency of traffic accidents and safeguard the lives of their citizens. Riyadh, as the capital city of Saudi Arabia and one of its largest metropolises, confronts significant challenges in the realm of road safety. These challenges stem from the ongoing urbanization, surging population, and the exponential increase in the number of vehicles traversing its roads.

In response to these mounting road safety issues, the implementation of the Saher system was introduced as a potentially transformative solution. The Saher system, characterized by advanced automated speed monitoring and electronic violation recording mechanisms, was designed to enforce speed limits and foster a culture of responsible driving. The system's introduction generated substantial anticipation and expectations, necessitating a comprehensive evaluation of its efficacy and its actual impact on road safety within Riyadh.

The primary objective of this research is to conduct a rigorous analysis of the impact of the Saher system's implementation in Riyadh on the incidence of road accidents. To achieve this, the research will involve the meticulous collection and analysis of data pertaining to road accidents and speed violations during the period preceding the system's deployment and the subsequent period following its introduction. The goal is to provide an empirically-based assessment of the Saher system's effect on road safety, thereby offering valuable insights to inform policy decisions and guide effective public policy.

Ultimately, this research aspires to contribute to the enhancement of road safety measures and the reduction of road accidents not only in Riyadh but also in other regions of the Kingdom, striving for safer and more secure roadways for all.

3. PROBLEM STATEMENT

Riyadh, the capital of Saudi Arabia, has long grappled with a pressing issue—the high prevalence of traffic accidents, road injuries, and fatalities. Despite ongoing efforts to address this critical problem, road safety in the city continues to be a significant concern. Factors such as rapid urbanization, population growth, and the surge in the number of vehicles have contributed to the persistence of this issue. In response to these challenges, the Saher system was introduced as a potentially transformative solution aimed at improving road safety by enforcing speed limits and encouraging responsible driving behavior.

The Saher system operates through advanced automated speed monitoring and electronic violation recording, primarily targeting the issue of speeding, a major contributor to road accidents. The introduction of the Saher system was met with high expectations, raising questions about its actual impact on road safety in Riyadh.

This research recognizes the urgency of addressing the road safety problem in Riyadh and seeks to explore the following key inquiries:

- To what extent has the implementation of the Saher system in Riyadh contributed to a significant reduction in the number of road accidents?
- How has the Saher system influenced driver behavior, specifically in terms of compliance with speed limits and the reduction of speed violations?
- What are the tangible road safety implications, including injuries and fatalities, before and after the introduction of the Saher system?
- Are there specific geographic areas, times of day, or situational factors where the Saher system's impact on road safety is particularly pronounced.

The answers to these questions hold significant implications for Riyadh's policymakers and relevant authorities. This research aims to provide comprehensive insights into the effectiveness of the Saher system and identify potential avenues for improving road safety measures. By addressing these critical issues, the research endeavors to offer evidence-based recommendations for enhancing road safety and reducing road accidents in Riyadh.

4. RESEARCH GOAL AND OBJECTIVES

The primary objective of this study is to conduct a comprehensive analysis of the automated system designed to control and manage traffic movement in the city of Riyadh. Specifically, the study aims to investigate the system's effectiveness in monitoring speed violations and evaluate its impact on the behavior of vehicle drivers as well as the occurrence of traffic accidents. The research will delve into the following key areas:

System Evaluation: Assess the functionality and accuracy of the automated traffic control system in detecting and recording speed violations in various traffic conditions and environments within Riyadh.

Driver Behavior Analysis: Investigate the influence of the automated system on driver behavior, focusing on changes in speeding patterns, compliance with speed limits, and overall road safety awareness among vehicle operators.

Accident Impact Assessment: Analyze the correlation between the implementation of the automated system, reduced speed violations, and the occurrence of traffic

accidents. Evaluate how the system contributes to accident prevention and overall road safety.

Effectiveness of Penalties: Examine the effectiveness of penalties imposed on drivers for speed violations captured by the automated system. Evaluate the impact of penalties, such as fines and license points, on discouraging speeding and improving road safety.

Public Awareness and Perception: Gauge public awareness and perception regarding the automated traffic control system. Understand the level of acceptance, concerns, and opinions of Riyadh's residents and commuters concerning the system's implementation.

Policy Recommendations: Provide evidence-based recommendations to local authorities and policymakers in Riyadh. Suggest potential improvements to the automated system, enforcement strategies, and public awareness campaigns to enhance road safety, reduce

speed violations, and minimize traffic accidents in the city.

5. RESEARCH QUESTIONS

Question One:

The system used to monitor violations and traffic law infractions in the Kingdom, particularly in Riyadh, is primarily the Saher system. This system employs automated speed monitoring and electronic violation recording to enforce traffic rules.

Question Two:

Behaviors contributing to major accidents in Riyadh include speeding, reckless driving, failure to adhere to traffic signals, distracted driving, and inadequate awareness of road safety regulations.

Question Three:

Monitoring systems have shown effectiveness in deterring violators, with the Saher system contributing to increased compliance with speed limits and reduced instances of speeding.

Question Four:

Monitoring systems, particularly the Saher system, have played a role in reducing accidents and enhancing the safety of vehicle drivers in Riyadh by addressing speed-related violations.

Question Five:

While congestion can lead to frustration among drivers, there isn't a direct correlation between congestion and an increase in traffic violations. However, traffic flow and driver behavior may be influenced by congestion.

Question Six:

Despite the presence of deterrent systems and public education, accidents may still occur due to a combination of factors, including human error, complex traffic scenarios, and varied driving behaviors.

Question Seven:

There isn't conclusive evidence to suggest a significant increase in the accident rate after women started driving in Riyadh. Factors contributing to accidents are multifaceted and not solely linked to changes in the demographics of drivers.

Question Eight:

The relationship between increasing fines and improved compliance is complex. While raising fines may act as a deterrent, other factors such as awareness campaigns, effective law enforcement, and infrastructure improvements also play crucial roles.

Question Nine:

A comprehensive study of the number of accidents and their causes between 2018 and the present year would provide valuable insights into trends, contributing factors, and areas for intervention.

Question Ten:

The impact of upcoming projects like transportation buses and the metro on reducing violations and accidents in Riyadh is contingent on various factors, including the efficiency of the projects, public awareness, and integration with existing traffic management strategies.

Similar Research Note:

Most existing research focuses on the Saher system, while this research broadens the scope by considering control systems, individual behaviors, and their collective impact on road safety in Riyadh. By exploring a more comprehensive range of factors, the study aims to provide a holistic understanding of the dynamics influencing traffic safety in the city.

6. PREVIOUS STUDIES

6.1 Study: Saher did not reduce road traffic accidents.

A recent scientific study concluded that the mobile automatic monitoring system for speeding violations "Saher" did not have a positive effect in reducing vehicle accidents, especially damage and injury accidents, during its period of operation between the years 2011 to 2013, as damage accidents increased during that period by about 76%, after... The system is operated by the private sector.

Incorrect operation of the system

I concluded a scientific study published in the magazine at its international journal, specialized in roads and traffic safety, last July, and prepared by the teaching assistant of transportation and traffic engineering at Taibah University - College of Engineering in Yanbu, Fayez bin Marzouq Al-Omari, and titled: "Evaluating the impact of operating the mobile automatic monitoring system (Saher) for speeding

violations on traffic safety.” In the Kingdom of Saudi Arabia, the method of operating the mobile automatic monitoring system for speeding violations was wrong. Since the first phase of the system for automatic monitoring of traffic violations was through the private sector, it appears that the operators of the Saher system (private companies) targeted locations where there is a high probability of vehicles exceeding the legal speeds, and not locations where serious accidents are common, such as locations of horizontal and vertical curves, in order to cover operating costs and raise costs. Profits.

Purpose of the study

The study aims to evaluate the impact of applying a mobile automatic monitoring system for speeding violations on traffic accidents on urban highways.

And for three types of traffic accidents (damage accidents, injury accidents, and fatal accidents).

Study methodology

The study used two scientific methodologies recommended by the most famous traffic safety reference issued by the American Association of Highway and Transportation Employees, known as the Highway Safety Manual, to evaluate the Saher traffic system on traffic accidents, by measuring the extent of change in the number of vehicle accidents before and after the operation of the system, taking into account Considering the impact of factors affecting the level of traffic safety, such as traffic volume and time change. The two methodologies were applied to a statistical sample of the Hijra Expressway and the Qassim-Madinah Expressway, located within the administrative scope of the Medina region. Road security force statistics for the Medina region related to traffic accidents for the time period between 2008-2013 were used.

The study is the first of its kind at the local and regional levels to evaluate the mobile automatic control system for speed violations at the microscopic level and on urban highways. The study is also the first in the world to evaluate the impact of using the private sector to operate and manage the automated monitoring system for traffic violations.

6.2 Saudi researcher: “Saher” contributed to improving the behavior of vehicle drivers.

Saudi researcher Jarallah bin Muhammad Al-Ajmi prepared a field study entitled “Evaluating the impact of the automatic control system for traffic violations (Saher) on vehicle accidents in the Kingdom,” a case study of the city of Riyadh, with the aim of assessing the extent of vehicle drivers’ satisfaction with the application of the Saher system.

Researcher Al-Ajami said: The Kingdom has witnessed successive economic booms

that have led to an increase in the number of vehicles used on the roads, and an increase in the number of vehicle drivers. Statistics indicate an increase in traffic accidents over the past years in the Kingdom. The number of injuries reached 6 injuries for every 8 accidents, while the global rate is one injury for every 8 accidents. The rates of loss of national product due to traffic accidents in Saudi Arabia are 4.7%, while the rate did not exceed 1.7% in Australia, England, and America. The economic loss from traffic accidents is estimated at approximately \$5.6 billion.

He added that statistics indicate that 17 people die every day in Saudi Arabia as a result of vehicle accidents, and when these statistics are linked to the rates previously mentioned (85% of traffic accidents are caused by driver errors), we find that approximately 14 people die every day due to driver errors in Saudi Arabia.

Regarding the problem of the study, Al-Ajmi said that there is an average of 17 deaths per day in the Kingdom due to traffic accidents, and an annual loss of \$5.6 billion, while the percentage of traffic accidents due to the errors of vehicle drivers reached 85%, which led to the implementation of an automatic monitoring system for traffic violations. (Saher) to reduce traffic accidents. Therefore, the problem of the study can be summarized in the lack of published scientific studies to evaluate the impact of the automatic control system for traffic violations (Saher) on traffic accidents.

Regarding the most important results and recommendations reached by the study, Al-Ajmi said, based on what was stated in the study, the results extracted indicate a decrease in the recording and issuance of traffic violations after the implementation of the Saher system by 43% of the average study period from 1430-1431 AH before the application of the Saher system and from 1432-1433 AH after its implementation. An increase in the total traffic accidents of 1% during the study period. The decrease in the recording and writing of traffic violations was reflected in an increase in the total traffic accidents due to the presence of an inverse relationship between them amounting to -0.645 during the period from 1424-1430 in the Kingdom of Saudi Arabia.

He pointed out that the Saher system contributed during the study period to reducing the total number of deaths in speeding and signal interruption accidents by 55%, while it did not significantly affect the total number of accident deaths, as the decrease rate was only 6%. The Saher system also contributed during the study period to reducing the total number of injuries. Speeding accidents and signal interruptions decreased by 56%, while it did not significantly affect the total number of accident injuries, as the percentage of decrease amounted to only 10%.

The study presented by Al-Ajami recommended expanding the Saher system to be an automatic monitoring system for traffic systems to monitor other traffic violations such as failure to adhere to the private lane and sudden deviation and setting a clear message and vision for the automatic control system (Saher) for all vehicle drivers and Saher employees to contribute effectively to achieving the strategic objectives. And the satisfaction of vehicle drivers, intensifying media awareness to clarify the goals of the Saher system and what has been achieved from them, in addition to the community partnership of the Saher system by undertaking some humanitarian initiatives in the community and holding awareness exhibitions, increasing awareness of traffic safety for young people and intensifying traffic safety courses in

schools using modern technologies such as programs Simulation.

7. RESEARCH METHODOLOGY

To achieve the objectives outlined in the study proposal, a comprehensive and rigorous research methodology will be employed. The following steps and methods will be undertaken to conduct the study on the automated system controlling traffic movement, monitoring speed violations, and understanding their impact on driver behavior and traffic accidents in Riyadh:

1. Literature Review:

Conduct an extensive review of existing literature, academic papers, and relevant studies related to automated traffic control systems, speed violations, driver behavior, and traffic accidents. This review will establish a theoretical framework for the study, providing context and insights into previous research findings.

2. Data Collection:

a. Quantitative Data: Gather quantitative data from the automated traffic control system, including speed violation records, accident reports, and relevant traffic movement data. This data will be obtained from the Riyadh Traffic Department and other relevant authorities.

b. Surveys and Interviews: Administer surveys to vehicle drivers and conduct interviews with traffic authorities, law enforcement officials, and road safety experts. These surveys and interviews will focus on driver perceptions, experiences with the automated system, and attitudes toward speed violations and road safety.

Driver Behavior:

Demographics:

Age:

18-24

25-34

35-44

45-54

55 and above

Gender:

Male

Female

Driving Experience:

Less than 1 year
1-5 years
6-10 years
10 years or more

Awareness and Understanding of Automated Traffic Control Systems:

How familiar are you with automated traffic control systems in Riyadh?

Very familiar
Somewhat familiar
Not familiar at all

Impact on Driving Behavior:

Have you noticed any changes in your driving behavior since the implementation of automated traffic control systems?

Yes
No

Perceived Effectiveness:

How effective do you believe automated traffic control systems are in improving overall traffic flow and safety?

Very effective
Somewhat effective
Not effective at all

Traffic Incidents:

Experience with Traffic Incidents:

Have you been involved in any traffic incidents (accidents, near misses) since the introduction of automated traffic control systems?

Yes
No

Attribution of Traffic Incidents:

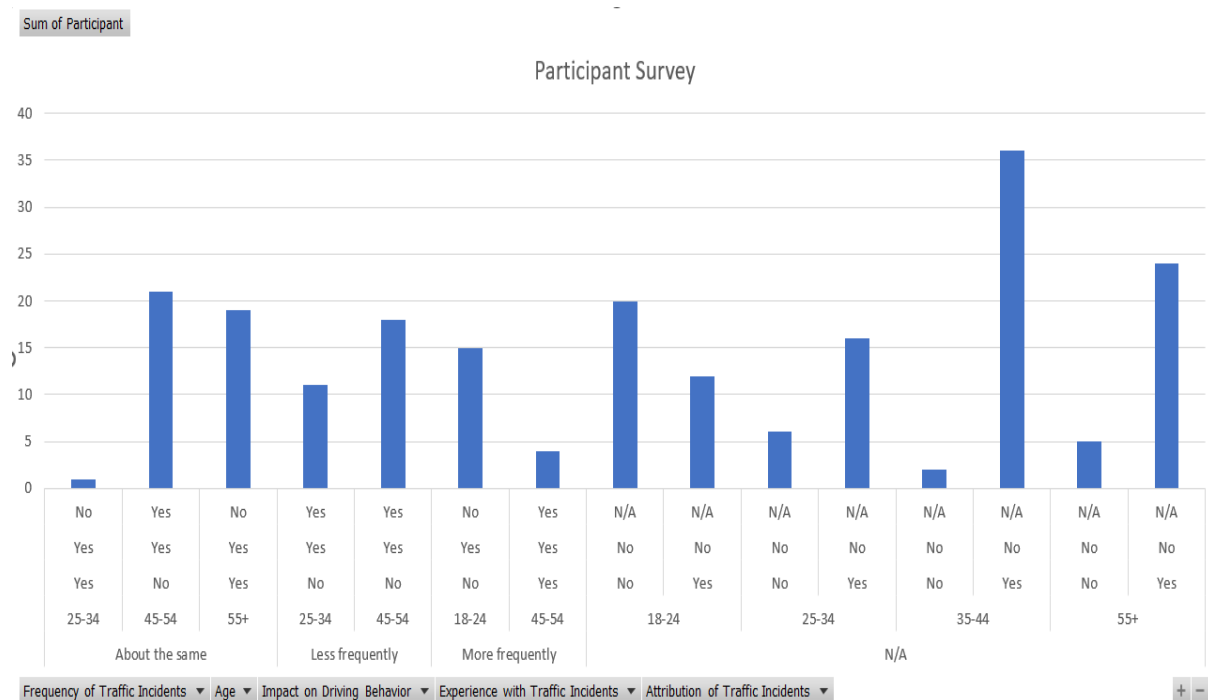
In your opinion, were the traffic incidents you experienced related to the automated traffic control systems?

Yes
No

Frequency of Traffic Incidents:

How frequently do you believe traffic incidents have occurred since the implementation of automated traffic control systems?

More frequently
About the same
Less frequently



3. Data Analysis:

Utilize statistical analysis methods to process and interpret the quantitative data. Analyze the speed violation data to identify patterns, trends, and correlations with traffic accidents. Conduct regression analyses to assess the relationship between speed violations, driver behavior, and accidents. Qualitative data from surveys and interviews will be thematically analyzed to gain insights into driver attitudes and perceptions.

4. Comparative Analysis:

Compare the data from before and after the implementation of the automated system to

measure changes in speed violations, driver behavior, and traffic accidents. Conduct a comparative analysis between different areas of Riyadh to identify variations in the impact of the system based on location and traffic conditions.

5. Case Studies:

Investigate specific case studies of notable incidents or areas where the automated system has had a significant impact. These case studies will provide in-depth qualitative insights into the effectiveness of the system and its influence on driver behavior and accident rates.

6. Public Perception Survey:

Conduct a public perception survey to gauge public awareness, acceptance, and concerns regarding the automated system. Analyze the survey responses to understand public attitudes toward the system and its impact on road safety and driver behavior.

7. Policy Analysis:

Examine the existing traffic policies and regulations related to speed violations and automated traffic control systems in Riyadh. Evaluate the effectiveness of current policies and propose policy recommendations based on the study findings to enhance the system's efficiency and improve road safety.

8. Reporting and Recommendations:

Compile the research findings into a comprehensive report. Present evidence-based recommendations for policymakers, traffic authorities, and relevant stakeholders in Riyadh. The recommendations will focus on system enhancements, policy improvements, awareness campaigns, and potential future research avenues.

8. STUDY TOOLS

1. Literature Review Tools:

Academic Databases: Access scholarly articles, research papers, and studies related to automated traffic control systems, driver behavior, and traffic incidents.

Research Journals: Explore specialized journals in transportation, traffic engineering, and safety. **Authoritative Publications:** Refer to reports and publications from relevant transportation authorities and safety organizations.

2. Quantitative Data Collection Tools:

Automated Traffic Control System Records: Gather data on traffic flow, speed violations, and incident reports from the automated traffic control system in Riyadh.

Traffic Incident Reports: Collect quantitative data on specific incidents, including types, locations, and severity.

3. Qualitative Data Collection Tools:

Driver Surveys: Administer structured surveys to collect qualitative insights into driver perceptions and experiences with automated traffic control systems.

Interviews: Conduct in-depth interviews with drivers to explore their attitudes and behaviors in response to the automated traffic control system.

4. Data Analysis Tools:

Statistical Analysis Software: Utilize statistical tools to analyze quantitative data, including patterns in speed violations and correlations between traffic incidents and control system interventions.

Qualitative Data Analysis Software: Apply qualitative data analysis software to code and analyze interview and survey responses for themes and patterns.

5. Comparative Analysis Tools:

Compare data from periods before and after the implementation of automated traffic control systems to assess changes in driver behavior and traffic incidents.

6. Geographic Information System (GIS) Tools:

Employ GIS tools to visualize and analyze spatial patterns of traffic incidents, helping to identify hotspots and assess the impact of the control system in different areas of Riyadh.

7. Simulation Tools:

Use simulation software to model the impact of automated traffic control systems on driver behavior and predict potential outcomes in different scenarios.

8. Public Perception Survey Tools:

Conduct surveys among the public to gauge awareness and perceptions of automated traffic control systems, providing additional context to driver behavior.

9. In-vehicle Monitoring Systems:

Utilize in-vehicle monitoring systems to collect real-time data on driver behavior, providing a dynamic perspective on the impact of traffic control systems.

10. Expert Consultation:

Consult with traffic engineers, safety experts, and transportation authorities to gain expert opinions and insights into the impact of automated traffic control systems.

9. STUDY FIELDS

9.1 Temporal Study Field:

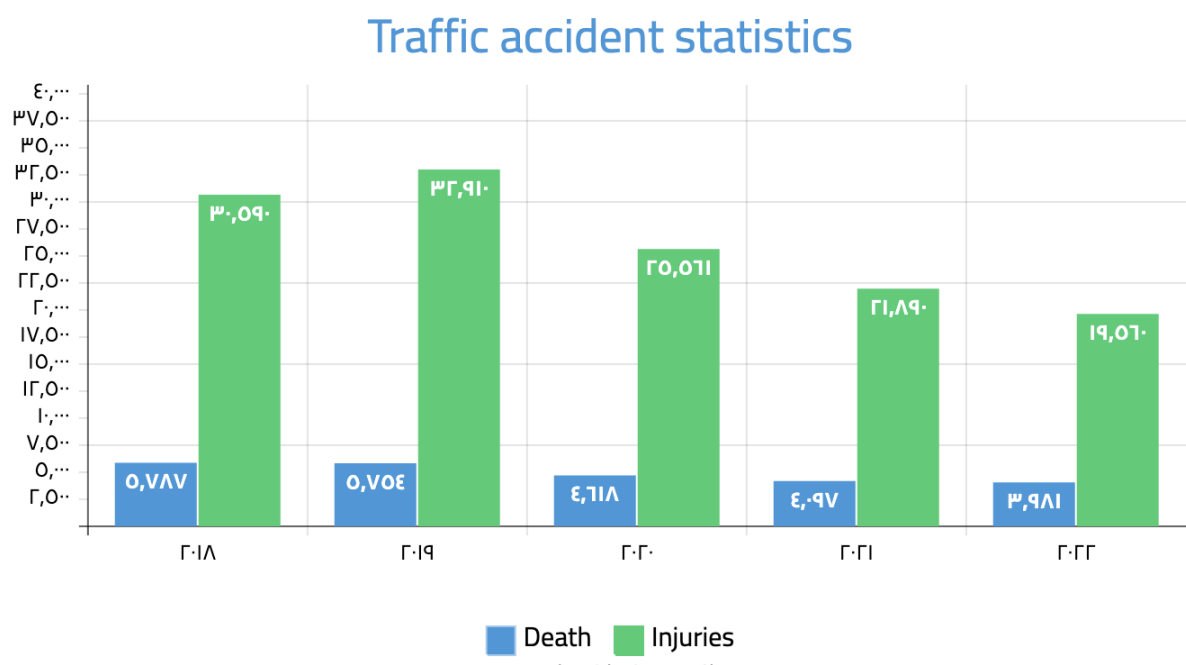
This research employs a retrospective longitudinal study design to analyze the impact of the Saher system on road safety in Riyadh over the period from 2018 to the present. This temporal approach allows for the examination of trends and changes in

traffic accidents and speed violations before and after the implementation of the Saher system. The study will consider annual data to capture any evolving patterns and assess the system's long-term effects.

9.1 Temporal Study Field with Graphical Representation:

To comprehensively analyze the impact of the Saher system on road safety in Riyadh from 2018 to 2022, a retrospective longitudinal study design will be employed. This approach facilitates a detailed examination of trends and changes in traffic accidents and speed violations. One key enhancement to this section is the integration of graphical representation, specifically a chart that delineates incidents and fatalities annually. This graphical element aims to provide a visual snapshot of the data dynamics over the specified period, enhancing the accessibility and clarity of the temporal study.

The graphical representation will include statistical insights into accidents and fatalities, showcasing patterns and fluctuations from 2018 to 2022. This visual aid will serve as a valuable supplement to the textual analysis, offering readers a more immediate understanding of the temporal trends associated with road safety in Riyadh.



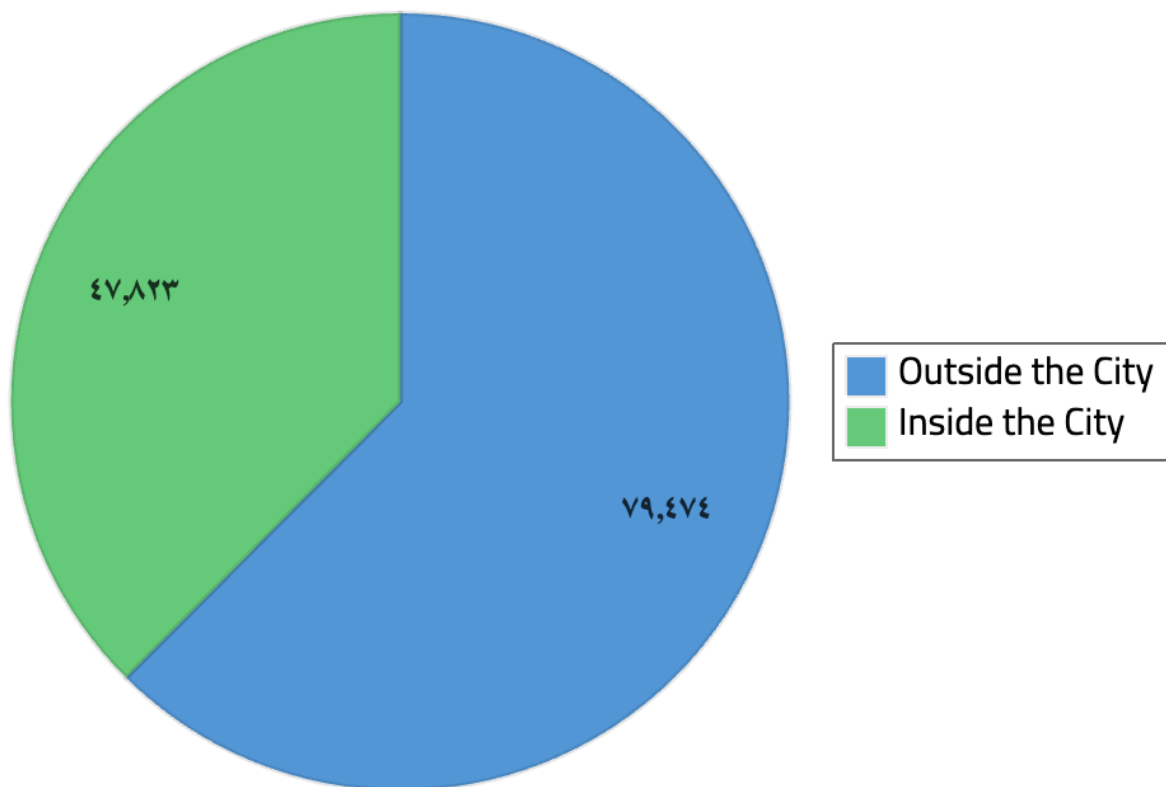
9.2 Spatial Study Field:

In this section, a spatial analysis will delve into the geographical distribution of traffic accidents within Riyadh. The city will be subdivided into distinct zones, and data will be meticulously scrutinized to pinpoint areas with both elevated and reduced occurrences of accidents. Notably, this spatial study design will extend its analysis to distinguish incidents happening within the city limits of Riyadh and those occurring

outside its boundaries.

The inclusion of this spatial element aims to unravel localized impacts of the Saher system, providing a detailed understanding of its effectiveness in different zones, both within and outside Riyadh. To enhance the clarity of this spatial study, a graphical representation will be introduced, offering a visual portrayal of the distribution of traffic incidents across various geographical areas. This graphical insight will contribute to a more holistic evaluation of the Saher system's efficacy in mitigating road safety challenges.

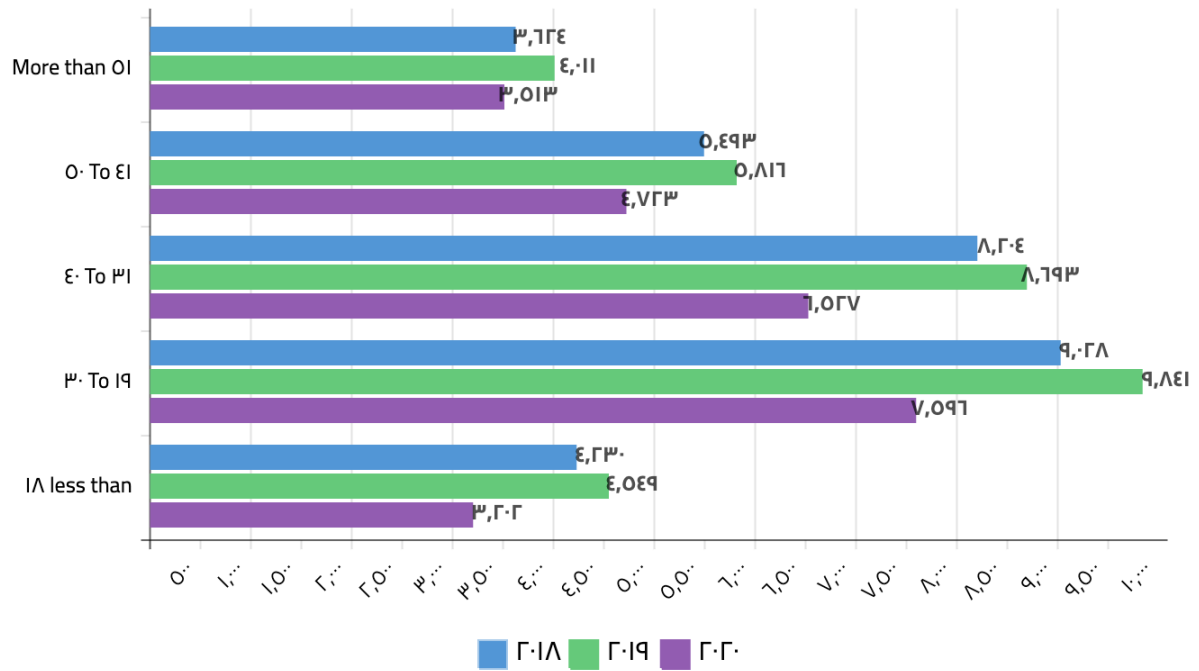
Traffic Accidents Site by area



9.3 Human Study Field:

To explore the human aspect of the study, a mixed-methods approach will be employed. Surveys have been distributed to a sample of drivers in Riyadh, targeting diverse demographics. The survey will assess driver perceptions, attitudes toward the Saher system, and self-reported changes in driving behavior. Additionally, qualitative interviews with traffic authorities, law enforcement officials, and road safety experts will provide insights into the system's real-world implications and challenges.

Γ.Γ.-Γ.ΙΛ Results of traffic accidents during



10. SUMMARY

The research focuses on evaluating the impact of the Saher system on road safety in Riyadh. The introduction highlights the significance of road safety, the challenges faced by Riyadh, and the implementation of the Saher system as a potential solution. The primary goal is to analyze the system's effectiveness in reducing road accidents, influencing driver behavior, and improving overall safety.

The problem statement emphasizes Riyadh's persistent road safety concerns despite efforts, attributing them to urbanization and population growth. The Saher system is introduced as a solution, targeting speeding, a major contributor to accidents. Key research questions are posed, aiming to assess the system's impact on accidents, driver behavior, and specific contextual factors.

The research goal outlines a comprehensive analysis of the Saher system, including system evaluation, driver behavior analysis, accident impact assessment, effectiveness of penalties, public awareness, and policy recommendations. The methodology involves a temporal study design spanning 2018 to the present, spatial analysis within Riyadh, and a human study incorporating surveys and interviews.

Expected results anticipate improved traffic management, reduced speed violations, positive changes in driver behavior, fewer accidents, and recommendations for policy enhancement. Research tools include literature review, quantitative data collection from the Saher system, qualitative data from surveys and interviews, and various analytical methods.

The research plan outlines steps from defining objectives to final submission, and the literature review emphasizes the gap in understanding the Saher system's impact in Riyadh. The expected results encompass improvements in traffic management, decreased speed violations, positive changes in driver behavior, accident reduction, and policy recommendations.

The research tools and methods section details tools for literature review, data collection, analysis, comparative analysis, case studies, public perception surveys, policy analysis, reporting, and recommendations. The methodology introduces a temporal study design and spatial analysis, accompanied by a graphical representation. The human study design involves surveys and interviews to explore the human perspective.

11. RECOMMENDATIONS

Based on the comprehensive analysis conducted on the impact of the Saher system on road safety in Riyadh, several recommendations emerge, catering to policymakers, traffic authorities, and stakeholders involved in urban traffic management. These recommendations aim to enhance the effectiveness of the Saher system and contribute to the overall improvement of road safety in the city.

11.1 System Enhancement and Optimization:

- Continuous Technological Updates: Regularly update the Saher system's technology to incorporate the latest advancements in automated traffic control. This ensures optimal functionality and adaptability to evolving traffic dynamics.

- Integration of AI and Machine Learning: Explore the integration of artificial intelligence (AI) and machine learning algorithms into the Saher system. This enhancement can enable more accurate prediction of potential traffic violations and enhance proactive management.

11.2 Targeted Enforcement Strategies:

- Strategic Placement of Monitoring Devices: Analyze data to identify specific locations with higher accident rates and strategically deploy monitoring devices in these areas. This targeted approach ensures a more effective enforcement of speed limits where it is most needed.

- Variable Speed Limits: Consider implementing variable speed limits based on real-time traffic conditions. This dynamic approach can improve traffic flow during peak hours and enhance overall road safety.

11.3 Public Awareness and Education:

- Comprehensive Public Awareness Campaigns: Develop and implement comprehensive public awareness campaigns to educate drivers about the Saher system's benefits, its role in enhancing road safety, and the consequences of traffic violations. This can foster a culture of responsible driving.

- User-Friendly Information Dissemination: Ensure that information about the Saher system, including updates and changes, is communicated to the public in a user-friendly and accessible manner. This can be achieved through mobile applications, websites, and other communication channels.

11.4 Collaboration and Stakeholder Engagement:

- Multi-Agency Collaboration: Foster collaboration between traffic authorities, law enforcement agencies, and other relevant stakeholders. This collaboration can streamline efforts, share data, and collectively address road safety challenges.

- Engagement with Community Leaders: Engage with community leaders and local influencers to promote road safety awareness within specific neighborhoods. Localized initiatives can complement broader awareness campaigns.

11.5 Continuous Monitoring and Evaluation:

- Regular Impact Assessments: Conduct periodic assessments of the Saher system's

impact on road safety. Regular evaluations ensure that the system remains aligned with the evolving needs of Riyadh's traffic management.

- **Feedback Mechanisms:** Establish mechanisms for collecting feedback from the public, including drivers and residents. This feedback can provide valuable insights into the system's real-world impact and highlight areas for improvement.

11.6 Policy Refinement:

- **Review and Update Traffic Policies:** Regularly review and update traffic policies to align them with the evolving traffic landscape. This includes revisiting penalties for violations and ensuring that policies remain effective deterrents.

- **Flexible Policy Implementation:** Implement policies that are adaptable to changing circumstances. Flexibility in policy implementation allows for responsive adjustments to address emerging road safety challenges.

11.7 International Best Practices:

- **Collaboration with Global Experts:** Foster collaborations with international experts and organizations in the field of automated traffic control systems. Learning from global best practices can provide valuable insights for continuous improvement.

- **Participation in Knowledge Exchange Programs:** Actively participate in knowledge exchange programs and conferences related to road safety and traffic management. Riyadh can share its experiences and learn from other cities facing similar challenges.

These recommendations collectively aim to contribute to the ongoing efforts in Riyadh to enhance road safety through the Saher system. Implementation of these strategies can further solidify Riyadh's position as a leader in innovative and effective urban traffic management.

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