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Assessment of *Saher* System in Enhancing Traffic Control and Road Safety: Insights from Experts for Dammam, Saudi Arabia

Abdullatif Mohammed Alobaidallah, Ali Alqahtany * and Khandoker M. Maniruzzaman

Department of Urban and Regional Planning, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam 31441, Saudi Arabia

* Correspondence: amalqahtany@iau.edu.sa

Abstract: Road traffic accidents pose a significant global public health and economic challenge. In Saudi Arabia, rapid motorization and urbanization have contributed to one of the world's highest traffic fatality rates. This study evaluates the effectiveness of the Saher traffic enforcement system in the Dammam Metropolitan Area (DMA) by gathering insights from road safety experts through structured questionnaires and interviews. Findings indicate that Saher has improved traffic law compliance and enhanced perceptions of road safety. Key accident causes include driver distractions, speeding, and sudden lane changes, with younger drivers being disproportionately involved. Experts recommend expanding Saher's capabilities by increasing camera numbers, strategically rotating their locations, and addressing violations like aggressive driving. They also stress the need for better coverage near schools and high pedestrian zones. Proposed strategies include integrating Saher into urban planning, combining automated enforcement with public education, and enhancing traffic infrastructure, such as signage and signal systems. This study offers actionable insights for policymakers to improve road safety and promote sustainable urban mobility in Saudi Arabia.

Keywords: Saher; road safety; traffic accidents; traffic management; traffic control; Dammam

1. Introduction

Road safety is a global issue that affects public health, social interactions, economics, and transportation. Road traffic accidents have become a major public health problem worldwide. According to annual reports from the World Health Organization (WHO) and the International Transport Forum (ITF), around 1.35 million people are killed and up to 50 million are injured in traffic accidents each year, resulting in global costs exceeding USD 520 billion [1,2]. This trend indicates that traffic-related fatalities far exceed the targets set by the United Nations' Sustainable Development Goals (SDGs) [3]. Road traffic accidents are ranked among the top 10 leading causes of death globally, just after diabetes mellitus, with vulnerable road users accounting for 50% of the fatalities [4]. The main factors contributing to road traffic accidents include drivers, vehicles, road conditions, the environment, and other unidentified causes [5].

The Kingdom of Saudi Arabia (KSA) is the largest country in the Arab world, covering approximately 2.1 million square kilometers and with a population of around 34 million. The country is divided into 13 administrative regions [6]. Over the past four decades, rapid population growth and economic development, particularly after the discovery of oil, have led to higher travel demands, increased motorization, and a rise in traffic accidents [7,8]. According to the World Health Organization (WHO), KSA's road traffic fatality rate (deaths per 100,000 population) exceeds 25, which is significantly higher than that of many developing nations and neighboring Gulf countries.

Traffic-related injuries account for more than 80% of hospital deaths and approximately 20% of hospital bed occupancy [9]. Road traffic injuries are the third leading cause of death in KSA, responsible for 11% of total deaths in the country and costing around 4.3% of the national GDP [10].

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Addressing traffic safety in urban infrastructure is a difficult challenge influenced by multiple factors. Some pertain to drivers, while others involve vehicles or the driving environment. While the safety of the environment and vehicles plays a crucial role in accident prevention, traffic management remains a primary factor in injuries and fatalities in car accidents [11]. In 2009, Saudi Arabia introduced an automated system to manage and control traffic, utilizing digital cameras linked to electronic systems, known locally as Saher. This system connects to the National Information Center at the Ministry of Interior [12]. Saher is an "Automated System" designed to manage traffic across major cities in Saudi Arabia using a network of digital cameras. These cameras monitor traffic violations, such as running red lights and speeding, capturing clear images of the license plates of offending vehicles. The photos are automatically sent to a traffic violation processing center, where, after retrieving the owner's information from the national database, a ticket is issued. The Saher program is one of the recent enforcement initiatives aimed at improving traffic system efficiency and reducing road traffic accidents [12].

Numerous studies have highlighted the effectiveness of both fixed and mobile speed cameras in reducing road traffic accidents [13–15]. However, the impact of these cameras in enforcing speed limits is typically confined to the areas immediately surrounding the observation points [16]. Additionally, variations in speed among vehicles, often caused by sudden braking in monitored zones, have been found to increase the likelihood of accidents [17]. Another common criticism of red-light cameras at urban intersections is that while they may decrease right-angle collisions, they can lead to a higher frequency of rear-end accidents [18,19]. A study by Al Turki [20] found that while the number of accidents and injuries decreased during the first decade of the Saher system's operation, fatalities remained low. The study also pointed out that Saher primarily targets speeding and running red lights, which account for only 31% of traffic collisions. As a result, the system is not fully comprehensive, as it overlooks the remaining 69% of violations, such as lane changes and reckless driving, which contribute to road accidents.

1.1. Literature Review on Use of Expert Opinion for Traffic Safety

Expert surveys have proven instrumental in evaluating the effectiveness of the Saher system for enhancing road safety in the Dammam Metropolitan Area of Saudi Arabia. The primary objective of these surveys is to gather qualitative insights from professionals in traffic safety, law enforcement, and urban planning. This approach helps identify specific challenges and opportunities associated with the Saher system, facilitating a deeper understanding of its impact on road safety.

The methodology for these expert surveys involved structured questionnaires designed to explore various dimensions of road safety. Questions focused on the effectiveness of the Saher system, public attitudes, and operational challenges. Experts were selected based on their relevant experience, ensuring that the feedback collected was both informed and pertinent [21].

Experts indicated that the Saher system has successfully reduced certain traffic violations, such as speeding and running red lights. However, they noted that fatalities have not significantly decreased, suggesting that the system does not comprehensively address all factors contributing to road accidents [21]. Furthermore, many experts highlighted that the perception of the Saher system as primarily a revenue-generating tool undermines its effectiveness. They emphasized the need for improved public communication regarding the system's role in enhancing safety [22]. Insights also revealed that drivers often adapt their behavior in response to enforcement measures, potentially increasing risks in areas where enforcement is less visible [23].

Several challenges were identified through expert feedback. Experts pointed out issues with data quality and consistency in reporting traffic incidents, which can hinder accurate evaluations of the Saher system’s effectiveness [24]. Additionally, there is a clear need for a holistic approach to traffic safety that combines enforcement with stronger public education campaigns [25].

To address these challenges, experts recommended enhancing community engagement and awareness initiatives to improve public perception of the Saher system [21]. They also called for continuous assessment of the system's effectiveness, incorporating expert feedback to adapt

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strategies for improving overall road safety [26]. Moreover, the integration of advanced technologies for better data collection and analysis was suggested to enhance the overall effectiveness of automated enforcement systems [27].

In conclusion, the application of expert surveys has been vital in gaining a nuanced understanding of road safety issues associated with the Saher system. By leveraging insights from professionals, researchers can better identify challenges, improve public perceptions, and formulate effective strategies to enhance road safety in Dammam. This approach not only highlights the strengths and limitations of existing enforcement measures but also informs future interventions aimed at reducing traffic accidents and fatalities.

1.2. Components of Saher System

Saher is an automated traffic management system (ATES) that utilizes e-systems to oversee and regulate traffic across major cities in Saudi Arabia. It operates through a digital camera network connected to the National Information Center (NIC) [28]. The typical type of cameras used in the network are shown in Figure 1.

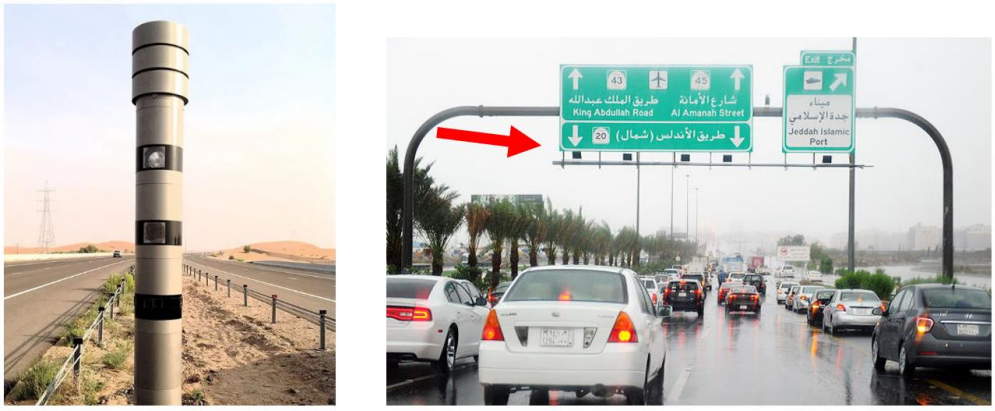

Figure 1. (a) Road Side Camera and (b) Overhead Cameras for Traffic Management in Saudi Arabia [29].

The system comprises the following key components:

- Traffic Management System (TMS): An advanced e-system that optimizes traffic flow by automatically controlling traffic signals based on real-time vehicle monitoring at intersections.
- Auto Vehicle Location System (AVL): A tracking system that locates traffic department vehicles, enabling faster response times and improved field operations.
- License Plate Recognition System (LPR): Installed at city entry and exit points, this system identifies vehicles for statistical analysis and detects stolen or wanted cars through license plate recognition.
- Variable Messaging Signs System (VMS): A network of electronic signboards providing real-time traffic updates to help drivers avoid congestion.
- Closed-Circuit TV System (CCTV): A live monitoring system that oversees traffic conditions on major roads.
- Law Enforcement System (LES): A system of cameras, including fixed and mobile radars, that automatically detects traffic violations and issues citations.

This integrated system enhances traffic efficiency, safety, and law enforcement through real-time monitoring and automated control mechanisms.

1.3. Comparison of Saher with Similar Systems Around the Globe

The effectiveness of ATES has been extensively studied across the globe, offering valuable insights into their impact on road safety. These systems have been implemented in various forms, including speed cameras, red-light cameras, mobile enforcement units, and automated number plate recognition (ANPR) systems, each tailored to address specific traffic safety challenges. By comparing

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the performance of ATES in different countries, we can identify best practices and lessons that could enhance the effectiveness of the Saher system in Saudi Arabia.

In the United Kingdom, the National Safety Camera Program stands out as one of the most successful implementations of ATES. This program, which began in the early 2000s, led to a 29% reduction in casualties at camera sites and significantly increased public awareness of speed limits and traffic laws [30]. The program's success was attributed to a combination of fixed and mobile speed cameras, coupled with public education campaigns that emphasized the safety benefits of compliance. However, the program also faced criticism for being perceived as a revenue-generating tool, which underscores the importance of transparent communication and community engagement in maintaining public trust.

Similarly, in Australia, the Victorian Mobile Speed Cameras have been highly effective in reducing speeding violations and improving road safety. A longitudinal study found that these cameras contributed to a 45% decrease in fatal crashes over ten years [31]. The flexibility of mobile enforcement units allowed authorities to target high-risk areas dynamically, ensuring that drivers remained vigilant even in areas without fixed cameras. This approach highlights the importance of adaptive enforcement strategies that can respond to changing traffic patterns and emerging safety concerns.

In the United States, red-light cameras have been widely deployed to reduce intersection crashes. Studies in cities like New York and San Francisco have shown that these cameras can reduce intersection-related accidents by up to 40% [32]. However, the effectiveness of red-light cameras has been limited by public skepticism, with some communities viewing them as revenue-generating tools rather than safety measures. This highlights the need for public education campaigns to emphasize the safety benefits of ATES and address misconceptions about their purpose.

In Ireland, the implementation of ATES systems has led to a 20% reduction in serious accidents, with urban areas experiencing even greater improvements in driver awareness and compliance [33]. The Irish approach combines fixed and mobile enforcement units with public awareness campaigns, creating a comprehensive strategy that addresses both enforcement and education. This dual approach has been particularly effective in reducing risky driving behaviors, such as speeding and distracted driving.

In the Middle East, countries like Qatar and the United Arab Emirates (UAE) have also implemented ATES with notable success. In Qatar, the introduction of fixed-speed cameras led to a significant reduction in overspeeding violations, with urban areas experiencing a drop from 36% to 13% and rural areas from 28% to 4% [34]. Similarly, in the UAE, automated enforcement systems have been effective in reducing tailgating and reckless driving, which account for 50% of crashes in the region [35]. These systems have been complemented by public awareness campaigns that emphasize the importance of seatbelt use and adherence to speed limits.

The Danish Road Safety Initiative provides another example of successful ATES implementation. This initiative, which combines speed cameras with public awareness campaigns, has led to a 28% reduction in traffic offenses [36]. However, the impact on fatal accidents has been less pronounced, suggesting that enforcement alone may not be sufficient to address all road safety challenges. This underscores the importance of integrating behavioral interventions and infrastructure improvements with enforcement measures to achieve sustained improvements in road safety.

In contrast, the Saher system in Saudi Arabia has shown mixed results. While it has contributed to a reduction in traffic violations and accidents, its focus on speeding and red-light violations addresses only 31% of road traffic collisions, leaving other factors like reckless driving and improper lane changes unaddressed [24]. Additionally, the system's effectiveness has been limited by public perception issues, with some drivers viewing it as a punitive measure rather than a safety tool.

In recent years, Saudi Arabian authorities have launched several initiatives to improve road safety, including implementing the Saher traffic enforcement system. Various studies have proposed an urban development model and framework highlighting the importance of an effective traffic management system in the Kingdom [37–39]. However, the overall effectiveness of these interventions in enhancing road safety remains inadequately documented and established. To address this gap, this study seeks to analyze traffic accident patterns in Saudi Arabia, with a particular focus on the Dammam Metropolitan Area (DMA), and to assess the safety impact of the

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Saher system. The study employs a before-and-after evaluation approach to measure the effectiveness of Saher, using an analytical descriptive method. The evaluation is based on the insights of the experts specializing in road safety, particularly those with expertise in the Saher system, to provide a comprehensive understanding of its impact on traffic safety. The results of this study are anticipated to provide valuable insights for safety authorities to enhance road safety and monitor traffic conditions effectively. The structure of the paper is as follows: Section 2 outlines the study area features and the methodology used in the study. Section 3 presents the study's findings, along with a discussion of the key outcomes. Finally, Section 4 offers the conclusions drawn from the study and suggests future recommendations.

2. Study Area and Research Methodology

2.1. Characteristics of the Study Area

The Dammam Metropolitan Area (DMA) has been selected as the study area for this research. Located along the Arabian Gulf coastline, it lies approximately 400 km from Riyadh, the capital of Saudi Arabia. As the third-largest metropolitan area in the country—following Riyadh and Jeddah—DMA is one of seven major urban centers that collectively accommodate half of Saudi Arabia's 33 million residents. It comprises three key cities: Dammam, Khobar, and Dhahran, as shown in Figure 2.

Dammam, the capital of the Eastern Province, serves as the region's administrative center. Khobar functions as the business hub, while Dhahran is recognized for its contributions to modern science and technology, particularly in the petroleum sector, as it is home to the headquarters of the Arab American Oil Company (ARAMCO) [40]. Over the past few decades, DMA has experienced rapid population growth, with its population surging from 365,000 in 1974 to 1.75 million in 2004, now exceeding 1.8 million residents spread across approximately 380,000 hectares [41–43].

Strategically positioned at the crossroads linking Saudi Arabia with Kuwait, Bahrain, Qatar, the United Arab Emirates, and Oman, DMA serves as a key transportation and communication hub. The metropolis hosts several notable landmarks, including the Saudi ARAMCO headquarters, King Abdulaziz Seaport, King Fahd International Airport, and King Fahd Causeway, which connects Saudi Arabia to Bahrain. Its well-developed road network consists of highways, major and minor arterials, and collector roads. Key thoroughfares include King Saud Road, Prince Muhammad Bin Fahd Road, and King Abdullah Road. Traffic management in DMA primarily relies on roundabouts and signalized intersections, although the city has been actively developing signal-free corridors by implementing U-turns at regular intervals in place of traffic signals. One such example of this strategy is King Faisal Road. The overall road network of DMA is illustrated in Figure 2.

Figure 2. Map of Dammam Metropolitan Area with Major Road Network [44].

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2.2. Data Collection and Analysis

This study employed a structured questionnaire to gather expert insights on road safety, the Saher system, enforcement cameras, and road infrastructure conditions in the Dammam Metropolitan Area (DMA). The questionnaire was divided into six sections: (1) respondent demographics, (2) expert perspectives on DMA's road safety situation, (3) causes of car accidents in DMA, (4) current status of Saher in DMA, (5) Saher's role in overall road safety, and (6) recommendations for improving road safety and the Saher system. Most questions were close-ended, using a five-point Likert scale (strongly agree to strongly disagree) or yes/no/neutral options. To ensure validity, the questionnaire was piloted with colleagues for accuracy before being finalized.

The questionnaire was administered online via the QuestionPro platform. Data from the questionnaire and interviews were analyzed using quantitative and qualitative methods [45]. Experts were selected through purposive sampling, targeting individuals involved in road safety decisions and traffic management, including those from planning bodies (e.g., municipalities, ministries), engineering organizations (e.g., Saudi Aramco, engineering consultants), public health, and law enforcement.

Data analysis is conducted using SPSS, with descriptive and cross-tabulation analyses performed to examine relationships among variables, providing insights into patterns and associations within the dataset. Additionally, regression analysis is carried out to determine the trend of traffic accident data over time, allowing for an assessment of potential changes and contributing factors. This analysis aims to evaluate the effectiveness of the Saher system in reducing traffic accidents by identifying significant trends and variations before and after its implementation. The findings from these statistical methods offer a comprehensive understanding of the system's impact on road safety and accident prevention [46].

3. Results and Discussion

3.1. Demographic Details of the Experts

Table 1 provides an overview of the key characteristics of the 34 traffic and road safety experts who participated in this study, highlighting their demographic, educational, and professional backgrounds. The age distribution suggests a well-balanced representation of mid-career and senior professionals, with the largest group (35.3%) aged between 41 and 50 years, followed by 26.5% aged 51–60 years, 23.5% aged 30–40 years, and 14.7% over 60 years old, indicating a mix of seasoned experts and relatively younger professionals contributing fresh perspectives. As the traffic department currently has no female employees, all respondents were male, reflecting the existing workforce structure in this sector. Most participants (70.6%) were Saudi nationals, while 29.4% were non-Saudis, suggesting a strong local representation with additional insights from international experts. In terms of educational qualifications, 35.3% held a master's degree, followed by 29.4% with doctoral degrees and 26.5% with bachelor's degrees, demonstrating a high level of academic proficiency among respondents. The occupational breakdown reveals that 47.1% of experts were from the government/public sector, emphasizing the strong influence of state agencies in traffic management and policy-making, while 20.6% represented the private sector, 17.6% were retired personnel bringing extensive experience, and 14.7% were from security forces, highlighting the law enforcement perspective on road safety. The study further indicates that 29.4% of respondents had over 25 years of work experience, reinforcing the credibility of their insights, as they have witnessed the evolution of DMA's road infrastructure and traffic systems over time. Additionally, the majority had 10 to 15 years of driving experience, implying that their expertise extends beyond theoretical knowledge to firsthand familiarity with road conditions, traffic behavior, and safety challenges. The combination of diverse professional backgrounds, extensive experience, and high educational qualifications suggests that the study benefits from well-informed, credible perspectives, ensuring a comprehensive analysis of road safety in the Dammam Metropolitan Area.

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Table 1. Demographic Details of the Respondents.

Characteristics	Categories	No. of Responses	Percentage Response
Age (Years)	30–40	8	23.5%
	41–50	12	35.3%
	51–60	9	26.5%
	Above 60	5	14.7%
Nationality	Saudi	24	70.6%
	Non-Saudi	10	29.4%
Educational Level	Bachelor's	9	26.5%
	Master's	12	35.3%
	Doctorate	10	29.4%
	Other	3	8.8%
Employment Type	Private	7	20.6%
	Government/Public	16	47.1%
	Security Forces	5	14.7%
	Retired	6	17.6%
Work Experience (years)	10-15 years	10	29.4%
	16-20 years	9	26.5%
	21-25 years	5	14.7%
	More than 25 years	10	29.4%
Driving Experience (Years)	Less than 10 years	3	8.8%
	10-15 years	12	35.3%
	16-20 years	8	23.5%
	21-25 years	5	14.7%
	More than 25 years	6	17.6%

3.2. Expert Views on the Road Safety Situation in DMA

The study participants were asked to assess their sense of safety while driving in and around the DMA. Overall, nearly 74% of experts reported feeling safer, with varying degrees of agreement ranging from excellent to good. The results are presented in Figure 3. The participants were asked to assess the current road infrastructure in Dammam, providing insight into expert users' views on the available transportation infrastructure. The analysis of the results reveals that a significant proportion of participants are satisfied with the existing infrastructure, with nearly 66% expressing satisfaction as excellent and good. However, a considerable number of experts (12.5%) believe that the current road infrastructure is inadequate from a safety perspective. The breakdown of this analysis is shown in Figure 3.

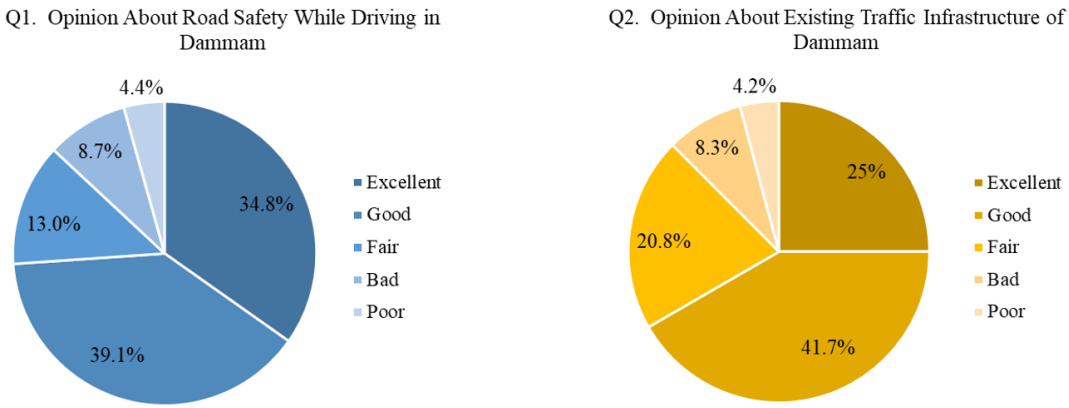

Figure 3. Expert's Opinion about Road Safety and Existing Traffic Infrastructure in Dammam.

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Highway accesses are crucial for safety, so experts were consulted to evaluate them. The analysis revealed that approximately 52% of the experts were satisfied with the accesses, while 28% rated the entrances and exits as bad and poor quality. Meanwhile, 20% of the respondents considered it fair. A detailed analysis of this question is shown in Figure 4. Also, experts were asked to evaluate the traffic signs, lane markings, and traffic lights. The analysis of the results shows that nearly an equal percentage of experts are either satisfied 54%) or dissatisfied (42%) with the traffic signs and lane markings in DMA, as shown in Figure 4. This indicates a clear need for improvement in this area.

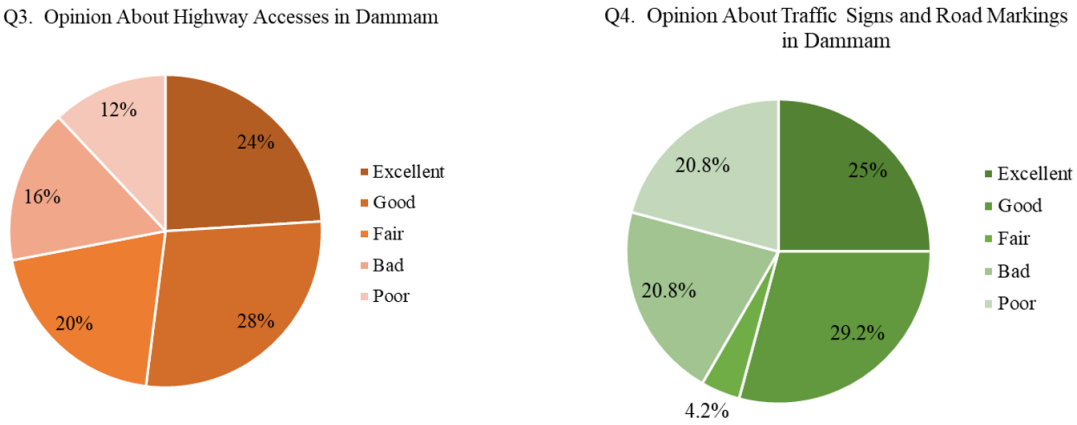

Figure 4. Expert's Opinion about Highway Access and Provision of Traffic Signs in Dammam.

Responding to Q5, most experts (46%) expressed dissatisfaction with the operation of traffic lights in DMA, as shown in Figure 5. They believe that the fixed timing plans of the DMA signals need to be revised. This highlights the need for improvements in traffic signal operations in the region. Building on the earlier questions in this section, Q6 focused on the role of traffic police in ensuring road safety within DMA. This question was essential for understanding experts' perceptions of the traffic police's effectiveness in promoting road safety. The analysis showed that while the majority of respondents were satisfied with the traffic police's role, nearly 26% expressed strong dissatisfaction and considered it bad or poor. Another 17% of participants considered it fair and satisfactory, as illustrated in Figure 5.

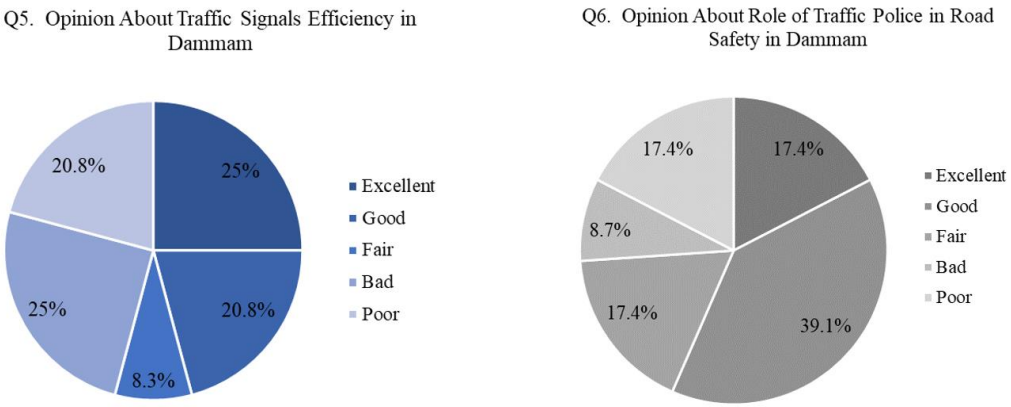

Figure 5. Expert's Opinion about Traffic Signal Efficiency and Role of Traffic Police in Road Safety in Dammam.

A follow-up question to Q6 was designed to gauge whether DMA is satisfied with the traffic police's presence. Approximately 43% of experts felt that greater coverage from the traffic police is needed to enforce road safety within DMA. Meanwhile, nearly 26% of experts considered it fair. Overall, the findings suggest that experts believe more emphasis should be placed on increasing the traffic police's presence for enforcement purposes. The analysis of this question is shown in Figure 6.

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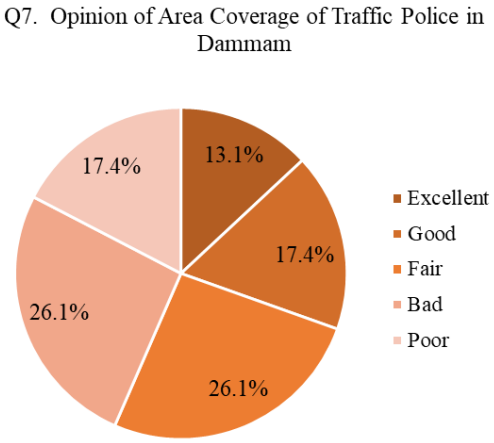

Figure 6. Expert's Opinion about Area Coverage of Traffic Police in Dammam.

3.3. Experts' Perspectives on the Causes of Car Accidents in DMA

Following the second section of the questionnaire, three questions were posed to identify the potential causes of car accidents in DMA. The first question in this section aimed to gather opinions on the primary causes of accidents in the area. Expert respondents identified driver distractions (such as using cell phones, 34%) as the highest followed by speeding (29%), and sudden lane changes (23%) as the leading causes. A detailed breakdown is shown in Figure 7. Experts believe that young individuals under the age of 25 are more likely to be involved in road incidents. Specifically, respondents identified the age group of 17-25 years (38%) as most prone to road accidents. Additionally, drivers under the age of 17 were also seen as vulnerable to serious accidents, as 15% of experts highlighted this group, as shown in Figure 8.

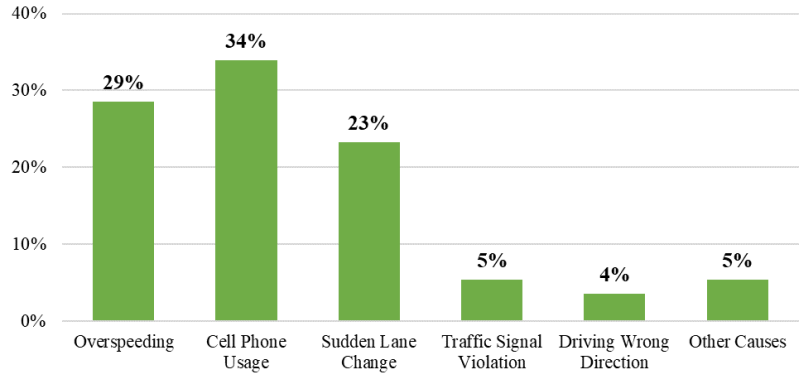

Figure 7. Major Reasons of Road Accidents in Dammam.

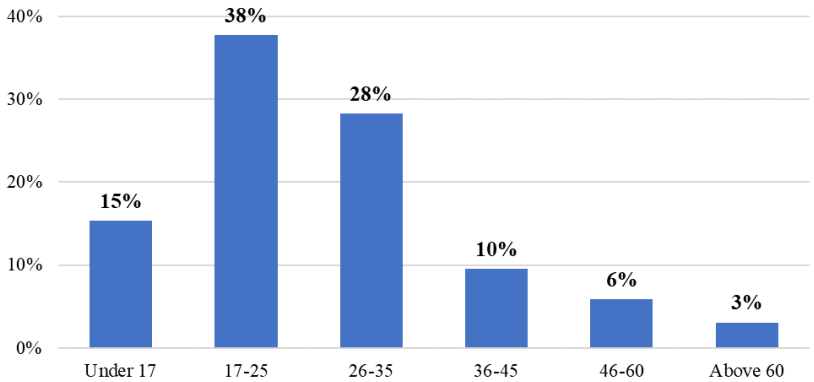

Figure 8. Age Groups Involved in Traffic Accidents.

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Additionally, a cross-table analysis of Q1 and Q2 of this section reveals a strong correlation between the 17-25 age group and both speeding and driver distractions while driving. The findings from this questionnaire align with the trends identified in the literature review regarding speeding and distractions among young drivers. The analysis prepared in the SPSS statistical tool is presented in Table 2. The final question in this section addressed the existing safety policies and their potential weaknesses. Experts were asked if they believed the current traffic police road safety policies (including operations, regulations, etc.) had any shortcomings. The analysis of this question revealed that experts held mixed opinions, with some believing the policies were sufficient, while others suggested improvements were necessary, such as stronger enforcement, updating signal operations, and revising speed limits.

Table 2. Cross Table Analysis for Age Group and Major Causes of Accidents.

		Major Causes of Road Accidents					
		Over Speeding	Cell Phone Usage	Sudden Lane Change	Traffic Signal Violation	Driving Wrong Direction	Other Causes
Age Group of Violators	Under 17 (Illegal)	5%	6%	3%	0%	1%	1%
	17-25 years	13%	16%	12%	2%	2%	3%
	26-35 years	9%	9%	5%	1%	1%	3%
	36-45 years	1%	1%	0%	0%	0%	0%
	46-60 years	0%	0%	1%	1%	0%	0%
	Above 60 years	1%	1%	1%	0%	0%	0%

3.4. Experts' Views on the Current Status of Saher in DMA

Section four of the questionnaire survey focused on participants' perceptions of the current status of Saher in DMA. To gather insights, five questions were asked. The section began with a question about the impact of Saher on road safety in DMA. The analysis revealed that 84% of participants expressed strong satisfaction with the results of the Saher cameras. These findings indicate that, according to expert opinions, enforcement cameras play a crucial role in road safety. The results of the first question are shown in Figure 9. The second question asked experts about the sufficiency of the number of cameras in DMA. The results showed that 59% of participants believed the current number of cameras is sufficient for addressing road safety, while 10% had no opinion. The remaining respondents felt that the number of cameras should be increased in DMA. The results are presented in Figure 9.

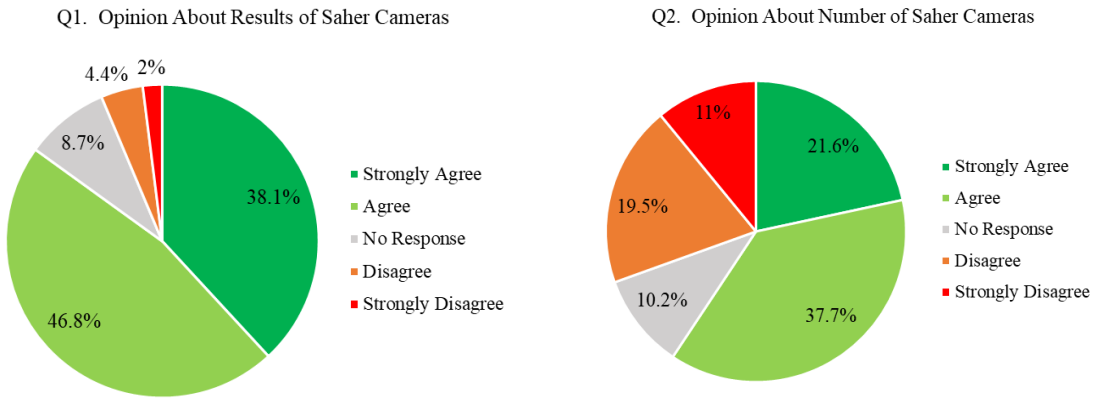

Figure 9. Expert's Opinion about Results of Saher System and Number of Cameras in Dammam.

The third question in this section asked experts about the adequacy of the current types of Saher enforcement cameras (Fixed, Mobile, and CCTV). The results indicated that 59% of respondents are confident in the existing types of Saher cameras, while approximately 32% of respondents suggested

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the introduction of different types within the Saher program. Figure 10 presents the results for this question. Q4 addressed the appropriate placement of cameras in DMA. The analysis of the questionnaire revealed that approximately 52% of respondents believed the current camera locations on the roads were appropriate, while around 26% felt additional locations should be considered. About 22% of participants did not have an opinion on where the cameras should be placed. The complete results are shown in Figure 10.

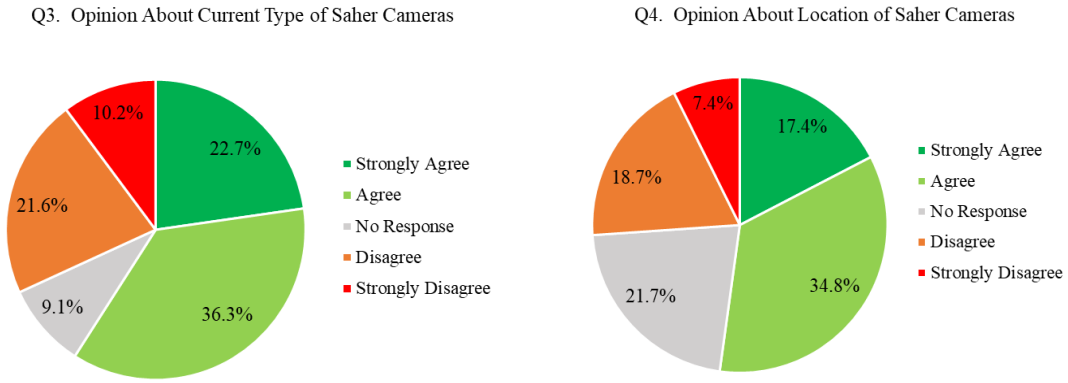

Figure 10. Expert's Opinion about the Type and Location of Saher Cameras in Dammam.

The fifth question, similar to the previous one, asked about the rotation of camera locations on the roads. While about 13% of experts were satisfied with the current camera placements, the results revealed that 74% of participants believed it would be beneficial to rotate the camera locations frequently. Figure 11 shows a detailed breakdown of the results.

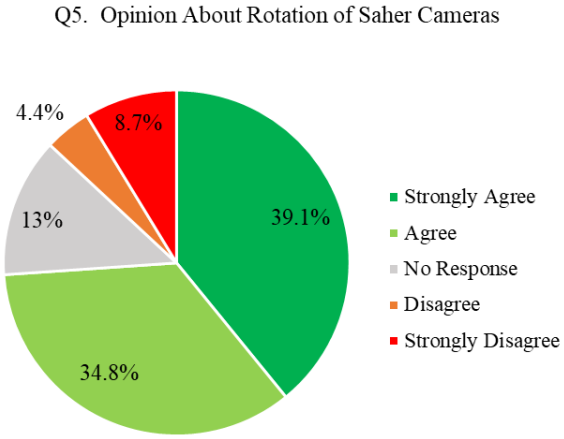

Figure 11. Expert's Opinion about Rotation of Saher Cameras.

3.5. Experts' Insights on the Role of Saher in Overall Road Safety

This section of the questionnaire comprised seven questions designed to explore the relationship between Saher cameras and road safety. The first question sought expert opinions on whether Saher cameras contribute to improving road safety by reducing car accidents. An overwhelming majority (95.65%) affirmed their positive impact, whereas only one expert expressed disagreement, responding with a simple "No."

The second question aimed to delve deeper into the potential unintended consequences of Saher cameras, specifically the risk of accidents caused by sudden stops or abrupt braking near camera locations. The responses were varied, with the largest proportion of experts (39%) expressing uncertainty about whether these incidents occur. Meanwhile, 34% of respondents believed that

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sudden braking near Saher cameras does not contribute to accidents, whereas nearly 26% suggested that such incidents could indeed result from drivers reacting abruptly upon noticing a camera.

Question three examined the psychological impact of Saher cameras, particularly their influence on drivers' sense of security while on the road. The findings indicated that most respondents (73.9%) felt safer when cameras were present, reinforcing the idea that automated enforcement plays a role in promoting cautious driving behavior. However, a minority (8.7%) stated that the presence of cameras did not make them feel safer, while 17.4% remained uncertain about their impact on personal safety.

The fourth question sought expert opinions on whether integrating undercover police officers into the Saher program could further enhance road safety. The results revealed a divided perspective: while a majority (52.2%) believed that this addition could be beneficial in deterring reckless driving and enhancing enforcement, a smaller group (17.4%) expressed skepticism regarding its effectiveness. Meanwhile, 30.4% of respondents were unsure, highlighting a need for further discussion on the potential advantages and challenges of such an integration.

The fifth question focused on the importance of improving road safety near schools and colleges, where pedestrian traffic is significantly higher, necessitating additional Saher enforcement measures. As anticipated, most experts (82.6%) supported the installation of additional cameras in these areas to enhance safety. However, 13% remained uncertain about the effectiveness of this approach, while a small percentage (4.4%) believed it may not be necessary.

Similarly, the sixth question addressed the need to improve road safety near malls, given the high volume of pedestrians in these locations. The results indicated that 65.2% of experts favored the installation of additional Saher cameras in such areas, emphasizing their role in preventing accidents and ensuring pedestrian safety. Conversely, 21.8% opposed this idea, and 13% were undecided, suggesting differing views on the necessity and effectiveness of increased surveillance in commercial zones.

The final question in this section explored the potential integration of Saher cameras into long-term urban planning and infrastructure development. The majority of experts (82.6%) agreed that incorporating Saher cameras into future master planning would be a strategic move toward sustained road safety improvements. However, a smaller proportion (8.7%) disagreed, while an equal percentage (8.7%) remained uncertain, reflecting a need for further evaluation of how automated traffic enforcement can be optimally embedded within broader urban development initiatives.

3.6. Experts' Recommendations for Enhancing Road Safety and the Saher System

In the final section of the questionnaire, experts were asked to provide not only the available options but also their recommendations to help achieve the questionnaire's objective, which is to gather insights into the experts' views and experiences concerning road safety, Saher, enforcement cameras, and the condition of road infrastructure in DMA. In the first question, experts were asked to propose enhancements to the Saher program. As shown in Figure 12, experts suggested various improvements including wider coverage, advanced warning system, public education and awareness, and undercover surveillance. The experts were also asked to provide their opinions on possible new violations to be incorporated into the existing Saher program. They suggested several new violation ideas, as depicted in Figure 13 including aggressive driving such as sudden lane changes, tailgating, and driving over hard shoulder.

The third question of this section sought to gather expert opinions on camera placement across different types of urban roadways. The results could assist stakeholders in DMA with camera distribution. Experts believe cameras should be primarily installed on high-speed highways, with arterial roads and work zone areas also recommended for priority installations. Figure 14 illustrates the suggested road types for priority Saher camera placements.

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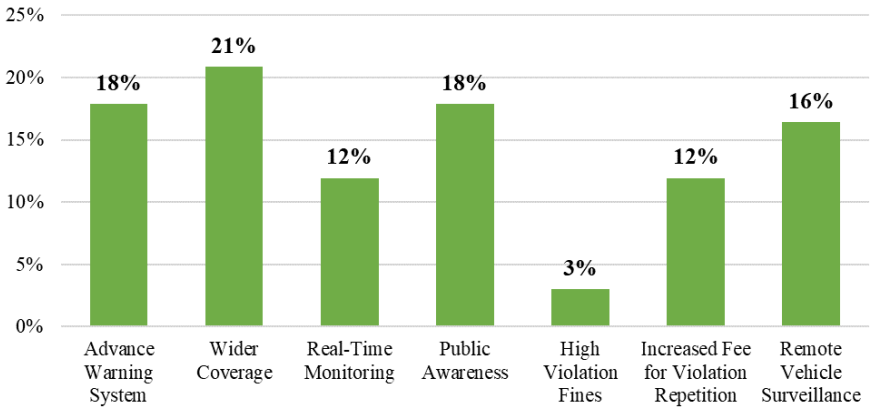

Figure 12. Suggested Improvements in the Saher Program.

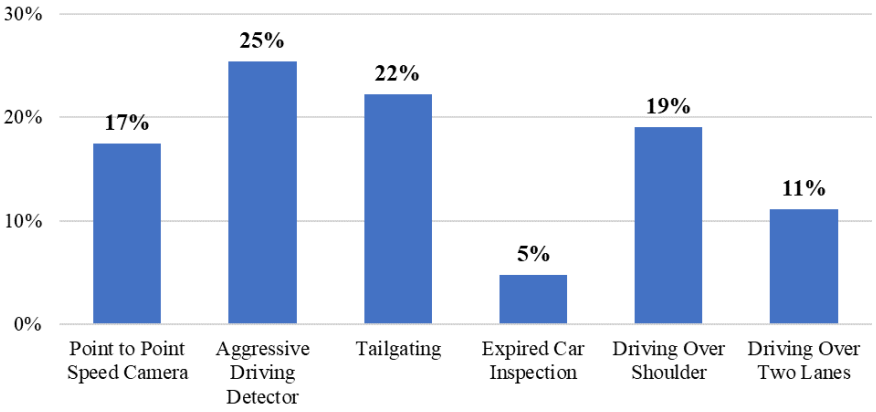

Figure 13. Suggested New Violations to be Added to the Saher Program.

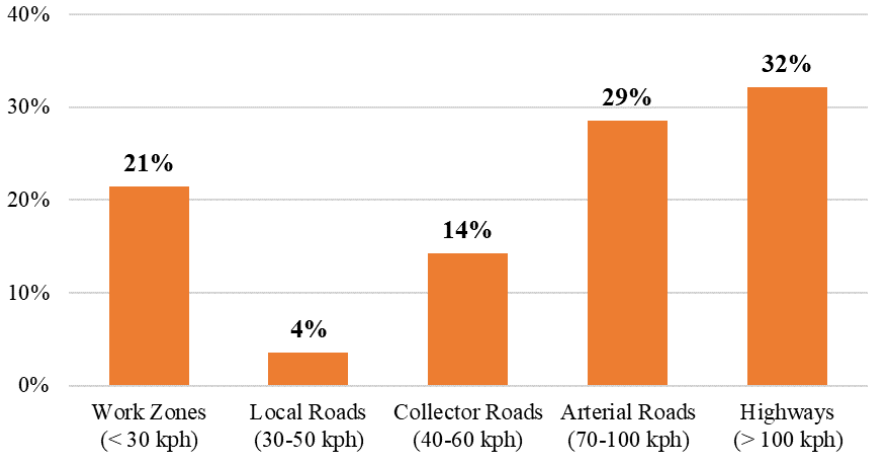

Figure 14. Recommended Roads for Installation of Saher Cameras.

Experts were also asked to recommend the most suitable land use areas for installing Saher cameras, as this is crucial for road safety. The results indicated that experts preferred targeting mixed land use areas (52%) rather than focusing solely on residential or commercial zones. Figure 15 displays the results.

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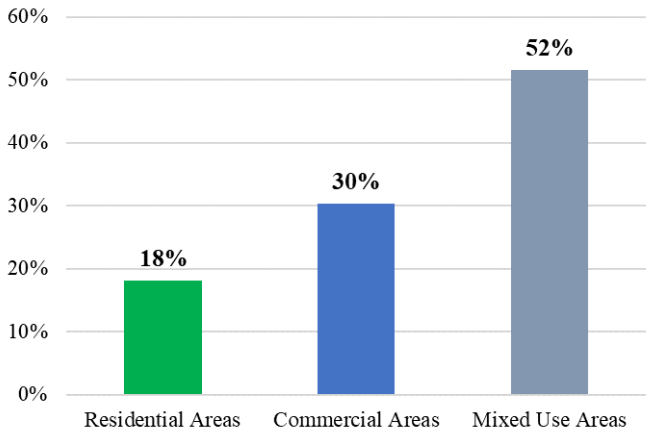

Figure 15. Suggested Areas for Installation of Saher Cameras.

In the fifth question of this section, experts were invited to identify significant shortcomings in the Saher system that could be enhanced in the future. The findings revealed that nearly all the listed defects were deemed highly important by the experts, leading to comparable percentage distributions, as illustrated in Figure 16. Finally, the experts were asked to offer additional recommendations that could support the objectives of this study. Below is a summary of the key suggestions provided by some of the experts.

- The locations for installing Saher cameras should be identified for the drivers.
- It is recommended to maintain a reasonable distance between different speed limits, such as transitioning from 90 to 80, and then to 70, as such changes can confuse drivers.
- The presence of undercover police should be increased to address tailgating and aggressive driving.
- Long-range radars should be installed on the major highways inside and outside cities.
- Automated weigh-in-motion truck scales should be used on the highways instead of fixed scales.

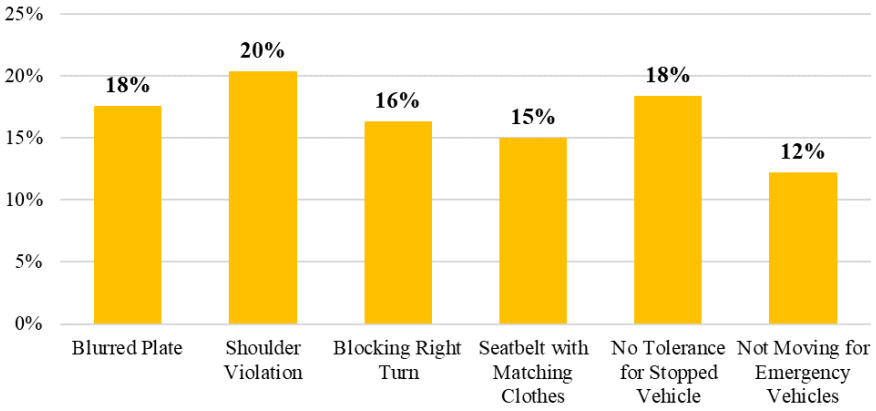

Figure 16. Significant Flaws in the Saher System.

3.7. Overview of the Analysis

Based on the results from the experts' questionnaire, it is evident that DMA has sufficient capacity to provide safer roadways for traffic and primarily requires improvements in the operational and maintenance aspects of the existing roadway infrastructure. Over the past 15 years, there has been a notable enhancement in road safety across the Eastern Region. Data obtained from official governmental sources [47,48] indicate a consistent decrease in the number of reported injuries resulting from traffic accidents, as illustrated in Figure 17 below. Notably, since 2014, the annual incidence of traffic-related injuries has exhibited a clear downward trend. To further analyze this pattern, a trendline was plotted, yielding an R^2 value of 0.965. This high R^2 value, being close to 1,

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signifies a strong correlation and underscores the reliability and accuracy of the data, reinforcing the conclusion that road safety measures and policies including the implementation of Saher system have been effective in reducing accident-related injuries over time.

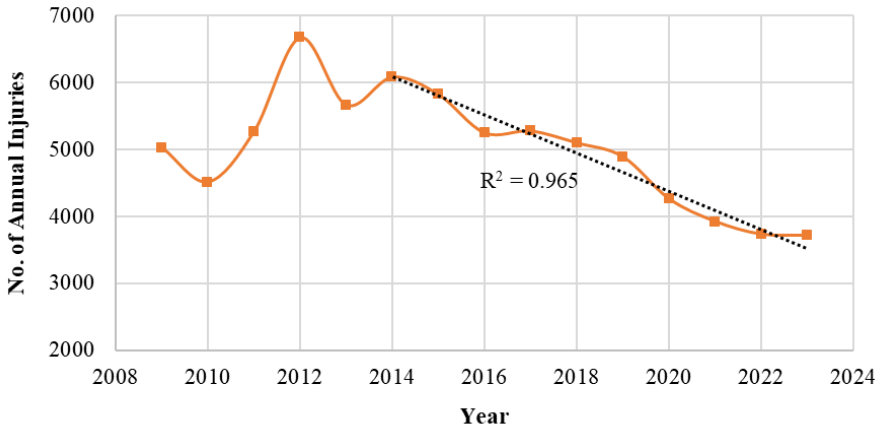

Figure 17. Number of Annual Injuries due to Traffic Accidents in Eastern Region of Saudi Arabia.

Figure 18 shows a summary of the probable causes of road accidents and potential recommendations from experts. Distraction, speeding, and sudden lane changes are the highest cause of accidents in the opinion of the experts, and it correlates with their opinion regarding young drivers who are more prone to these accidents. Typically, these causes are common traits of young and novice drivers, and therefore experts gave their recommendations to cater for such violations and causes of accidents. Some of the popular recommendations include strong enforcement and additional violations to be considered within the Saher system.

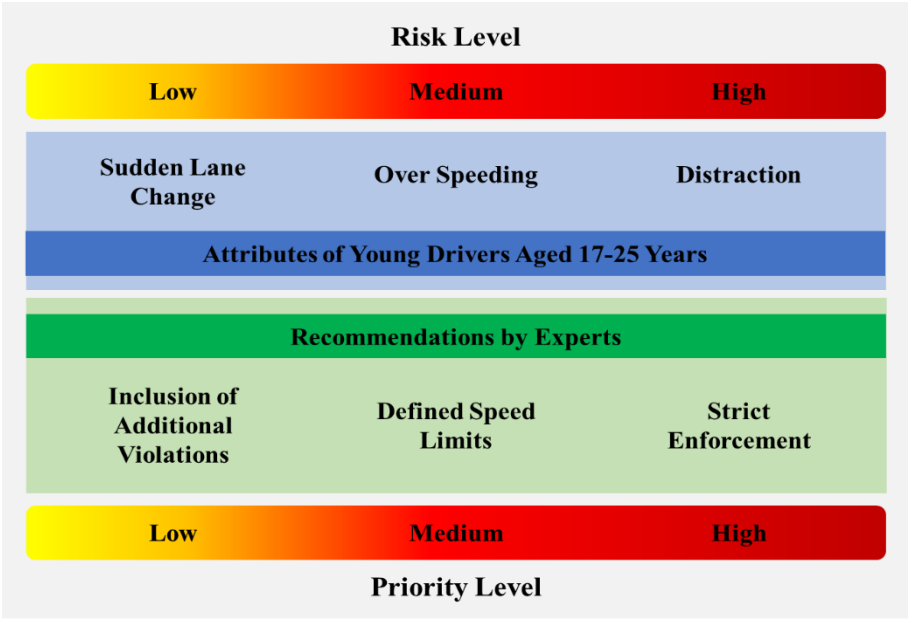

Figure 18. Risk and Priority Levels of Tasks for Traffic Management System in Dammam.

When it comes to the Saher system, the majority of the expert showed their satisfaction with the technology with only concern about the number of existing cameras inside DMA. Another major takeaway from this section analysis was that as high as 75% of experts recommended rotation of the camera positions to add more coverage under the Saher program. In terms of the overall safety aspects of the Saher program, experts showed complete faith in the system and think it can make

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roads safer in DMA. Importantly, experts believed in integrating undercover police operations with the Saher program. Also, experts emphasize putting cameras near schools and malls to aid safer pedestrian crossings.

4. Conclusions and Recommendations

This study involved a comprehensive review of existing literature, followed by an analysis of feedback from 34 experts to examine the effects of the Saher system on road safety in DMA, as well as the challenges faced by the system, including the state of the road infrastructure. The study seeks to offer a comprehensive evaluation and insights into the camera interventions currently deployed in DMA, focusing on road safety concerns. The results highlight the essential role of the Saher system in improving urban road safety and emphasize the need to use Saher for monitoring, analyzing, and enhancing urban traffic conditions. Policymakers and stakeholders in DMA can leverage the guidelines and recommendations from this study to enhance traffic enforcement and safety while ensuring financial sustainability and a phased implementation approach. Key recommendations include:

- *Developing Saher Coverage Policies:* Use accident and demographic data to ensure equitable camera placement across DMA, minimizing unintended socioeconomic disparities. Cameras should be evenly distributed, avoiding over-concentration in specific neighborhoods. Additionally, work zones, schools, and pedestrian-friendly areas should be prioritized under the Saher coverage policy.
- *Expanding Violation Categories:* The Saher system should incorporate new infractions, such as hard shoulder driving and blocking right turns, to enhance enforcement and improve road safety.
- *Establishing Consistent Evaluation Metrics (KPIs):* Define clear success indicators, such as reductions in collisions, injuries, and fatalities. Conducting cost-benefit analyses will help assess long-term program effectiveness.
- *Implementing Behavioral Interventions:* Strengthen camera enforcement with public safety campaigns and driver education programs tailored to the urban environment. Transparently share accident reduction data to build public trust and emphasize the safety benefits of enforcement over punitive measures.
- *Enhancing Legal and Administrative Support:* Update traffic laws to support camera-based enforcement, ensuring penalties are enforceable and transparent. Allocate funding for camera maintenance, upgrades, and expansion based on study insights.
- *Integrating Traffic Infrastructure Measures:* Complement camera enforcement with physical road safety improvements, such as speed humps, road narrowing, and enhanced signage. Pavement markings and advanced warning signs can further enhance overall road safety in DMA.
- *Financial Implications and Phased Implementation:* The implementation of these measures should follow a phased approach to optimize resource allocation and financial feasibility. The initial phase should focus on policy development, legal adjustments, and pilot programs in high-risk areas. The second phase should expand coverage, add new violations, and integrate behavioral interventions. The final phase should assess program effectiveness, refine enforcement strategies, and secure long-term funding for system upgrades and maintenance. A detailed financial plan should outline projected costs, revenue sources (e.g., fines, government funding, or public-private partnerships), and return on investment to ensure the program's sustainability.

By implementing these measures with careful financial planning and a strategically phased approach, the DMA can establish a more efficient, fair, and sustainable traffic enforcement system. Ensuring that resources are allocated wisely will not only enhance the effectiveness of road safety initiatives but also promote long-term public trust and compliance.

In conclusion, this study presents a solid foundation for further research, with numerous opportunities for expansion and deeper analysis. During the results and analysis phase, it became clear that while a substantial number of experts were invited to participate and provided valuable insights, there remains significant potential to involve an even broader pool of experts in future

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studies. Expanding the research scope to include a larger and more diverse public sample, particularly drivers, could lead to more comprehensive and reliable findings. Future studies could also incorporate comparative analyses between expert opinions and public perceptions, shedding light on potential discrepancies or areas of consensus.

Moreover, a comparative study of traffic management systems implemented in different countries could provide valuable insights into the strengths and weaknesses of the Saher system used in Saudi Arabia. By analyzing the successes and challenges of similar enforcement programs worldwide, policymakers can refine and optimize the Saher system to align with global best practices. This cross-national evaluation could also highlight innovative approaches that may enhance the effectiveness of automated traffic enforcement in Saudi Arabia.

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Data Availability Statement: The datasets generated and analyzed during the research are available with the corresponding author and can be furnished upon request.

Conflicts of Interest: The authors declare no conflict of interest.

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