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The Role of Intelligent Transport System to Safe Road in Iran, Qatar, and China: A Comparative Analysis

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Abstract

Developing countries bear a disproportionate share of the responsibility for road traffic accidents (RTAs), accounting for over 80% of these incidents (WHO, 2018). To ensure a safe road for all users, this study compares using Intelligent Transport Systems (ITS) to detect and prevent accidents in China, Iran, and Qatar by meticulously examining existing research reports. This paper focuses on the materials, data, and tools, emphasising validation and reliability. Additionally, procedural aspects are scrutinised to understand the feasibility of ITS deployment in diverse contexts. The evaluation matrix meticulously assesses contextual differences in cultural variances, stakeholder coordination, adaptability to local conditions, and budget constraints. The paper also identifies distinctive features and commonalities, highlighting each nation's strategies, challenges, and successes. The key findings underscore technological integration, ITS implementation, challenges in infrastructure development, a shared focus on safety enhancement, government involvement, strategic planning, and ongoing research and development activities.

Keywords: *Intelligent Transport Systems, Road Safety, Road Accidents, China, Qatar, and Iran.*

1. Introduction

Vehicles are commonplace in urban and rural regions because of the world's growing population and rising living level. An important metric, the vehicle-to-capita ratio (VpC), showed a sharp increase in emerging nations from 2004 to 2014. Africa and the Middle East saw 52% and 49%, respectively, while East Asia saw a 95% increase, and Brazil saw a 73% increase [1]. As the tenth worst killer on a worldwide scale, road traffic accidents are a direct result of this vehicle rise, and developing nations are particularly hit hard by them [2]. Concern was heightened in 2018 when the World Health Organization (WHO) ranked road traffic accidents (RTAs) as the ninth leading cause of mortality globally. The World Health Organization [3] released its Global Status Report on Road Safety, which revealed a disturbing statistic: the annual death toll from road accidents had risen to a terrifying 1.35 million. The importance of this problem is highlighted by the fact that car accidents are the leading cause of death for people aged 5 to 29. Developing countries bear a disproportionate share of the responsibility for road traffic accidents (RTAs), accounting for over 80% of these incidents [3]. Intelligent Transportation Systems (ITS) are crucial in enhancing safety in everyday transportation [4]. The growing need for better mobility and safer roads has driven developing countries to significantly improve their infrastructure, especially in modernising the transport infrastructure [5].

For developing nations, Intelligent Transportation Systems (ITS) are a lifesaver when it comes to finding transportation solutions that are safer, more efficient, and environmentally friendly [2]. Reduced traffic deaths, reduced serious injuries, improved road security, less congestion, route optimisation for reduced environmental impact, and effective management of modern transportation systems are some benefits of intelligent transportation systems (ITS) [6]. Integrating surveillance, detection, and response systems allows ITS to monitor traffic conditions effectively and facilitates rapid emergency response [4]. For instance, the Advanced Traffic Management System (ATMS) component of ITS enables real-time coordination and response to incidents, reducing road accidents and enhancing road safety [4]. The importance of ITS to road safety was corroborated by the work of Diderot et al. [2], who identified ITS contribution to road safety as estimating future and present traffic conditions using information, communication, and sensor technologies. Several vital steps must be taken to successfully implement Intelligent Transport Systems (ITS) in developing countries. These include creating a standardised framework for various ITS applications and their components, establishing traffic management centres, devising automated data collection methods, promoting collaboration between researchers, industries, and government institutions, implementing traffic rules and regulations, monitoring transportation performance, setting ambitious performance goals, and optimising transportation network efficiency using real-time data and advanced tools [7]. Research conducted by Bushman et al. in 2003, as cited by Bayly et al. [8], found that ITS in construction zones across the United States reduced rear-end collisions by 7% and fatal accidents by 33%. A study by Turner et al. (1998), as

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cited by Bayly et al. [8], found that implementing integrated traffic control systems in the United States resulted in a 15-16% reduction in accidents and generated an economic impact of $4.3 million. Based on a study cited by Bayly et al. (2007) and Rumar et al. (1997), as cited by Bayly et al. [8], complete traffic control systems could potentially result in a 30% reduction in injury accidents in urban regions. In their prior investigation, Lind et al. (2003) as cited in Bayly et al. [8], projected that the implementation of education and enforcement measures, including in-vehicle tutoring and red light and speed cameras, could potentially decrease road fatalities by 3% and 7%, respectively. According to Detroit et al. [2], sub-Saharan Africa, a developing region, faces several challenges in implementing Intelligent Transport Systems (ITS). These challenges include financial constraints, low electricity generation capacity, inadequate internet access and telecommunication infrastructure, social and cultural limitations, and a shortage of technical expertise for deploying ITS. Mokaddem et al. [7] also identified comparable yet slightly different obstacles developing countries face in adopting Intelligent Transportation Systems (ITS). These challenges encompass insufficient infrastructure, rapid urbanisation and expansion, limited interest among policy decision-makers and institutions, inadequate awareness among users and transport professionals, legal frameworks and institutions, non-compliance with the rule of law, and the readiness and maturity of ITS technology.

One of the Gulf States, Qatar, is installing an ITS system to deal with the growing problem of accidents caused by a high volume of vehicles [5]. Also, The Tehran-Karaj Freeway has seen the deployment of ITS systems to detect and prevent road accidents in Iran [9]. In addition, Intelligent Transportation Systems (ITS) have gained prominence due to the pressing need for safer traffic in China's mixed-traffic areas [10]. The success of ITS deployments varies among different nations because of their distinct socioeconomic and infrastructural conditions [5,9,10]. It is crucial to compare the use of Intelligent Transportation Systems (ITS) for accident detection and prevention in Iran, Qatar, and China due to the many issues connected with managing an ever-increasing vehicle number. This study examines case studies and reports to determine how ITS is now being used to detect and prevent road accidents in China, Iran, and Qatar with specific focus on road infrastructure applications only. It will also assess the similarities and variations in the deployment of ITS technology in these three countries, considering their respective contexts. By reviewing data from these examples, this paper will help to understand better how ITS contributes to road safety and draw conclusions that policymakers and practitioners can use to improve road safety worldwide.

1.1. Materials/Data/Tools (Validation and Reliability)

An extensive online search was conducted using the following electronic databases: Google Scholar, Research Gate, Journal of Transportation Technologies (JTTS), PubMed, IEEE Xplore, Procedia, and Web of Science. The goal was to obtain a comprehensive literature review on intelligent transportation systems (ITS) concerning road safety in Iran and Qatar, as well as any similarities or differences in their respective contexts. Keywords such as "Intelligent Transport Systems," "Road Safety," and the names of specific countries like "Iran," "Qatar," and "China" were utilised in the search, which had to be included in the title, abstract, or keywords. Specifically, only English-language resources on road safety and ITS implementation in China, Iran, and Qatar were chosen. The validity of the papers was assessed based on journals that publish them. Materials which did not fulfill inclusion criteria or that did not provide any useful information for the objectives of this review were excluded. The evaluations were limited to empirical articles or materials that were published between 2007 and 2021. All the materials that were considered for the paper are shown in Figure 1.

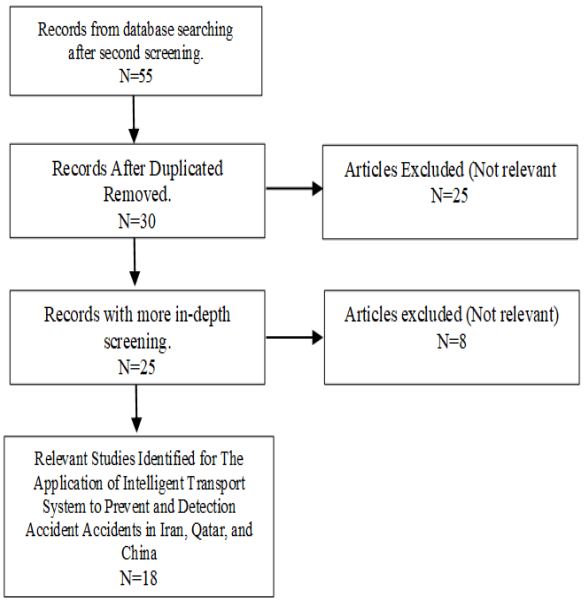

Figure 1. Overview of the literature selection process. Source: Own composition.

1.2. Data Analysis

The first research objective was analysed through systematic methodology. The study relied on a critical analysis of existing research reports from the respective countries. The method involved a meticulous examination of materials, data, and tools used in articles and reports that pertains to Qatar, Iran, and China, represented. The focus was on the validation and reliability of materials, data sources, and tools, ensuring they aligned with the study's objectives. Additionally, the procedural aspects of each research report were scrutinised to understand the steps taken in implementing ITS, including methodologies employed and sequences of actions in data collection and analysis. This approach provided insights into the unique strategies, challenges, and contextual differences in the deployment and impact of ITS in each nation.

A systematic analysis was conducted to achieve the second objective. The assessment involved a matrix-based examination based on critical criteria formulated. Each criterion was individually scrutinised for the three countries, focusing on extracting relevant information from the research reports. The analysis aimed to identify distinctive features and commonalities in the deployment frameworks, considering Qatar, Iran, and China's unique cultural, organisational, environmental, and financial contexts.

2. Results

2.1. The Current Applications of Intelligent Transportation Systems in reducing road accidents in Qatar, Iran, and China

The research objective is rooted in a detailed examination of the current state of ITS and its application in reducing and detecting road accidents across three diverse countries: Qatar, Iran, and China. This analysis delves into the unique strategies, challenges, and contextual differences in the deployment and impact of ITS in each nation.

2.1.1. Qatar

In Figure 1, the increase in deaths caused by road crashes between 2001 and 2007 was a primary concern to traffic law enforcers and other interested stakeholders in Qatar [11].

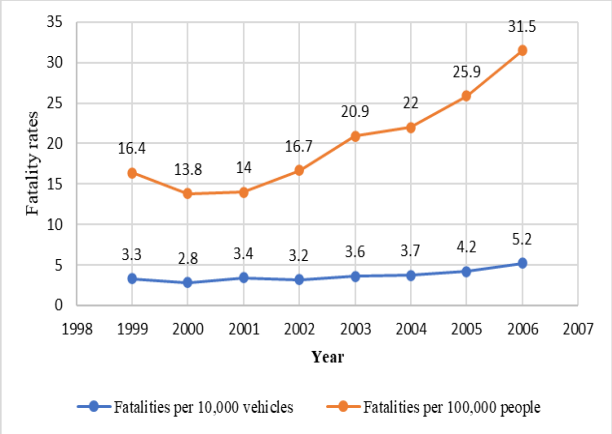

Figure 1: Qatar Fatality Rates, Jamieson et al. [11]

The fatality rates lead to the implementation of different strategies by law enforcement agencies in Qatar, such as driver education programs and technological breakthroughs in speed enforcement to tackle the issue (Jamieson, 2008).

Even more intriguing is the fact that, before the implementation of ITS, the mortality rate in Qatar was roughly four times the (anticipated) worldwide average for emerging nations [11].

To reduce road fatalities to an annual figure of 130 by 2022, Qatar put an Intelligent Transportation Systems (ITS) master plan into action. According to Shaaban et al. [5], the strategy has helped to produce an ITS action plan and set ITS standards for building and maintaining road infrastructure. The integration of Intelligent Transportation Systems (ITS) to effectively control traffic flow and prevent the occurrence of traffic accidents is prioritised in Qatar's National ITS Master Plan [5]. Improving road safety has become a top priority, and the National Intelligent Transportation Systems (ITS) Master Plan lays out a detailed set of fifteen steps to achieve that [5]. Currently, eight solutions are being implemented for traffic control in Doha, which includes Transportation Management Centers (TMCs), Adaptive Urban Traffic Control Systems (AUTCS), Closed-Circuit Television (CCTV) cameras, speed cameras, Dynamic Message Signs (DMS), Lane Control and Variable Speed Limit Signs (LCS/VSL), Weigh-in-Motion (WIM) Systems (WIM), and Overheight Vehicle Detection Systems (OVDS strategies) [5].

Optimal operational performance is hindered by the present state of ITS subsystem integration near Doha, which exhibits inadequacies. Taken as a whole, these innovations strengthen the foundation for real-time monitoring, traffic violation identification, and rapid response, moving Qatar closer to improving the safety, security, and effectiveness of its transportation network for its citizens.

Although progress has been made in implementing Qatar's Intelligent Transportation Systems (ITS), some obstacles still need to be addressed [5]. The current system faces challenges when different components fail to work together, resulting in a lack of synergy. It has been identified that outdated technology cannot keep up with the modern demands of the system, leading to further complications [5]. The system's shortcomings are also attributed to cultural and legal factors [5]. Moreover, certain systems display errors due to the unusual traffic situations that are common nationwide. The lack of coordination among the twelve essential stakeholders is still a concern. Additionally, fiscal constraints greatly impede the improvement of the system in Qatar [5].

2.1.2. Iran

Global Status Report on Road Safety identified Iran has a higher-than-average yearly crash death rate of 20.5 per 100,000 people [3]. In response to higher road crashes, many strategies, including ITS, are being deployed [9]. According to Hamid et al. [9], Iran had over 27,000 annual traffic accident fatalities before ITS was implemented.

While road safety advocates in Iran applauded ITS's introduction, the absence of a comprehensive national plan has cast doubt on the technology's ability to improve road safety in Iran [13]. One of the primary applications of Intelligent Transportation Systems (ITS) in Iran to detect and prevent road accidents is the implementation of Automatic Number Plate Recognition (ANPR) systems, which work in tandem with Global Positioning System (GPS), cameras to monitor and decrease infractions and speed cameras [9].

As of 2016, about 400 traffic and 200 speed cameras were installed in Iran to ensure road safety. Installing Intelligent Transport Systems (ITS) plays a crucial role in reducing road accidents in the country. However, vandalism and neglect have resulted in only about 1,000 out of the 1,800 speed detection cameras on Tehran's freeway network being operational at any given time, rendering them ineffective in measuring speeds [4]. Computerised license plate recognition systems are in place to inform drivers of potential fines and the deadline for payment for traffic violations via text message. However, the legal structure and verification process require stringent efficiency and effectiveness standards, which are presently absent [14].

Despite the limited implementation of ITS in Iran, there have been significant improvements. According to Behruz et al. [9], speed violations, a common cause of road accidents, decreased by 72%, and highway-related deaths in Tehran were reduced by 40% six months after installing 100 cameras with radar technology. This finding highlights the crucial role that ITS plays in improving road safety in Iran.

Although there have been some successes with the few systems implemented in Iran, there are still many obstacles, and key performance indicators have shown numerous areas of weakness. Behruz et al. [9] identified public adoption of intelligent transport systems as one of the primary hurdles. Although a control centre in Iran keeps tabs on in-vehicle GPS and disabling or covering the device with aluminium foil is common practice to make GPS infractions easier [9]. Attempts to turn off GPS devices and culturally motivated resistance are two challenges to integrating GPS into transportation systems. An additional obstacle is the need for more development of the

telecoms system and other essential infrastructure required to support a robust ITS system [9].

2.1.3. China

In 2010, road accidents in China resulted in 65,225 fatalities and 2,540,755 injuries, with a direct property loss of 930 million Yuan. China's traffic safety levels lag significantly behind those of developed nations since vehicle-related fatalities are more than 2-3 times higher than developed countries [16].

China has been dedicated to expanding intelligent transportation systems (ITS) for a long time. The implementation of ITS in China started in the 1970s and reached critical milestones in the 1980s following five-year plans. The success of ITS deployment is contextualised by the government-led investment approach, which was originally initiated by the building and optimisation of the highway network [15]. In light of China's complex traffic situation, the advancement of intelligent transportation systems is of the utmost importance. The National Highway Traffic Regions have made great strides in standardisation, systemisation, and practical applications since the Ministry of Transport conducted a strategic study on ITS design in the 1990s [16]. Many Chinese cities have been pioneers in ITS deployment and have evolved significantly, including Tianjin, Qingdao, Jinan, Shanghai, Guangzhou, Zhongshan, Shenzhen, and Chongqing [10]. According to Wu et al. [10], the primary methods currently employed in China to detect and prevent road accidents using intelligent transportation systems (ITS) include traffic flow data collection like integrated VMS, emergency response systems, traffic control centres, electronic dispatching, traffic signal control, speed cameras, Closed-circuit television (CCTV) surveillance, electronic license plate (ETC), electronic sensors, roadside information systems, and Urban Traffic Control (UTC) systems such as the Split Cycle Offset Optimisation Technique (Scoot) and Sydney Coordinated Adaptive traffic system (SCATS).

The presence of state-of-the-art experimental platforms in China indicates the country's commitment to promoting ITS-related scientific and engineering progress [15]. Integral to China's national strategies and big special projects, ITS plays a crucial role in lowering accident rates within the road safety framework. The emphasis on integrated traffic management, emergency systems, vehicle-road network synergy, and active vehicle safety is evidence of an all-encompassing and holistic strategy [15]. Multiple ITS application deployments have been fruitful, improving road safety in different contexts [10]. A significant ITS, or intelligent transportation system, was deployed before and during the Olympic Games in Beijing to improve traffic flow and safety. According to Chen et al. [16], no traffic event requiring game-changing management occurred during the games. Chen et al., [16] attribute a decreased vehicle mortality rate from 5.87 to 2.0 (55% decrease) to the comprehensive ITS system deployed. Additional information showed that, because of the Chinese government's efforts to reduce traffic fatalities, the ratio of deaths per thousand motor vehicles fell from 1.4 in 2007 to 0.6 in 2011 [17]. Some evidence of the impact of speed cameras installed on road accident reduction was that the number of people killed in car accidents in Guangdong Province in 2005 fell by 32.5 percent compared to 2004 levels after the province began deploying speed cameras [18]. Estimates indicate that Beijing's intelligent traffic management system will detect 60% of all vehicle violations leading to accidents, with off-site enforcement replacing on-site enforcement as the principal means of enforcement [18]. China's historical development and government-led investment strategy demonstrate its commitment to making roads safer by strategically deploying ITS technologies. Dedicated short-range communication, integrated information services, and operation and management are just a few areas where ITS has proven to help reduce accidents. With an eye toward the future, the 12th Five-Year Plan lays out a vision for intelligent transportation systems (ITS) in China, a strategy to improve road safety and decrease accidents by implementing new technologies [18]. Although China has implemented various ITS systems and has made significant contributions, a study by Zhu et al. [15] has demonstrated that the current level of ITS in China still lags behind the growing transportation demand.

2.2. Comparative Analysis

This section delves into the intricate landscape of ITS deployment in three distinct countries – Qatar, Iran, and China.

2.2.1. Differences in ITS Deployment in the Three Countries

Table 1 presents an evaluation matrix assessing the contextual differences in deploying Intelligent Transportation Systems (ITS) for accident detection and prevention in Qatar, Iran, and China. The criteria examined include historical context, infrastructure, technological adoption, cultural variances, stakeholder coordination, adaptability to conditions, budget constraints, and public awareness and education.

Table 1: Evaluation Matrix of Contextual Differences in deployment of ITS systems for Safe Roads

Criteria	Qatar	Iran	China
Historical Context:	Adopted system in late 2000s	Adopted system in the early 2000s	Adopted ITS in the 1970s
Infrastructure	Modern and integrated	Improving	Advanced
Technological adoption	Early adoption of cutting-edge	Gradual	Rapid
Cultural Variances	Significant role; adjustments crucial	Cultural differences present challenges.	Cultural context not explicitly highlighted.
Stakeholder Coordination	Challenges in coordination	Organisational issues impact performance	Multifaceted approach; potential diversity.
Adaptability to Conditions	Challenges due to extreme weather	Challenges in uncoordinated development	Historical development; no explicit challenges
Budget Constraints	Impact on infrastructure projects	Not explicitly discussed; inferred challenges	Government-led; financial details not explicit

Source: Shaaban et al. [5], Behruz et al., [9]; Zhu & Liu [15]

Historical Context: The rate of Intelligent Transportation Systems (ITS) deployment is a significant factor within the transportation infrastructure of the three nations, as highlighted in the studies conducted by Shaaban et al. [5], Behruz et al. [5], and Zhu & Liu [15]. The adoption of information systems in Qatar occurred relatively late in the 2000s, as evidenced by the study conducted by Shaaban et al. [5]. This stands in contrast to China, which has been adopting such systems since the 1970s, as highlighted by Zhu and Liu [15], and Iran, which adopted

these systems in the early 2000s, as indicated by Behruz et al. [9].

Level of Infrastructure: The comparison analysis of China's advanced ITS infrastructure, Qatar's contemporary and interconnected system, and Iran's improving systems presents significant factors to consider for effectively implementing Intelligent Transportation Systems (ITS). The level of advancement is evident in different types and numbers of ITS systems in all three countries [5].

Cultural Variances: In Qatar, the success of ITS programs is intricately linked to cultural considerations, such as driver's negative behaviour when it comes to compliance with the information given by ITS systems such as LCS and DMS [5], necessitating adjustments to traffic laws and overcoming cultural barriers for seamless operation. In Iran, cultural differences pose explicit challenges, as evidenced by issues such as covered license plates and damage to surveillance equipment influenced by cultural norms [9,14]. Although not explicitly detailing cultural challenges, China emphasises the need to adapt its strategies to local conditions, indicating a recognition of potential cultural variations [15].

Stakeholder Coordination: Challenges in stakeholder coordination emerge prominently in Qatar, where a well-organized structure is crucial to clearly defining roles and responsibilities [5]. ITS specifications, standard operational procedures are essential for preventing duplications and ensuring seamless stakeholder collaboration [5].However, most ITS subsystems in Qatar were deployed before the National ITS guidelines was introduced [5].

In Iran, organisational issues within agencies pose challenges, impacting the performance of ITS [9]. China adopts a multifaceted approach involving the government, universities, and research institutions [15]. While this approach provides a cohesive strategy, potential challenges may arise due to the diversity of stakeholders involved.

Adaptability to Local Conditions: Adaptability to local conditions is a significant consideration in Qatar, where extreme heat and humidity challenge the effectiveness of imported ITS systems. Extensive testing in the local context is deemed vital to ensuring accuracy and efficiency [5]. In Iran, uncoordinated infrastructure development suggests potential difficulties in adapting ITS systems to the existing infrastructure. Specific challenges in GPS integration and Intelligent routing systems further underline the need for contextual adaptability [9]. China's historical development of ITS, including testing in significant cities, reflects an understanding of local conditions. However, the review does not explicitly mention challenges or differences in adapting ITS to specific local factors.

Budget Constraints: Budget constraints impact infrastructure projects in both Qatar and Iran. The significant decline in oil prices has profoundly impacted Qatar, given that oil serves as the primary revenue generator for the state. As a result, there was a significant decrease in Qatar's funding for infrastructure, which harmed the implementation and efficiency of ITS [5,9]. Behruz et al. (9) state that the implementation authorities in Tehran regard the cost of General Packet Radio Service (GPRS) for data transmission in the context of traffic safety in ITS to be excessively high. This highlights the potential challenge that these expenses may present, as they are limited by finance, which might affect the overall practicality and execution of ITS. Moreover, Iran's limited use of ITS technologies indicates financial limitations. Furthermore, the need to modernise systems, as stated by Behruz et al. (9), indicates the possibility of limitations in these finances. The government predominantly drives China's investment model, ensuring its deployment aligns with national policies and economic plans. Nevertheless, the study lacked information regarding the financial elements and specific data about budget limits. This prompts inquiries on the possible influence of financial considerations on the implementation and effectiveness of Intelligent Transportation Systems (ITS) in China [15].

2.2.2. Similarities in ITS Deployment

Although Qatar, Iran, and China have contextual differences, they share similarities in deploying ITS technologies for detecting and preventing road accidents.

Technological Integration: All three countries, Qatar, Iran, and China, emphasise integrating advanced technologies within their respective ITS frameworks to detect and prevent road accidents [5,9,15]. This shared focus suggests a recognition of the pivotal role that technological advancements play in enhancing road safety.

Challenges in Infrastructure Development: Qatar, Iran, and China grapple with challenges related to infrastructure development in the context of ITS implementation. Budget constraints impact projects in Qatar and Iran, influencing decisions on design and deployment. While not explicitly discussed in China, the multifaceted approach involving various stakeholders may also present challenges in coordinating infrastructure development efforts [5,9].

Focus on Safety Enhancement: The three countries share a common emphasis on reducing road accidents through the implementation of ITS. Qatar's comprehensive ITS systems, Iran's performance evaluation of ITS regarding safety, and China's strategic alignment with national safety goals underscore the shared commitment to improving overall road safety through accident detection and prevention [5,9,15].

Government Involvement: Government-led initiatives play a crucial role in the deployment of ITS across Qatar, Iran, and China. While the level and nature of involvement may vary, the overarching theme of government support and strategic planning is evident in each case [5,9,15]. This highlights the recognition of ITS as a critical component of national transportation strategies.

Strategic Planning and National Initiatives: The deployment of Intelligent Transport Systems (ITS) is aligned with broader national strategies and initiatives in all three countries, including Qatar, Iran, and China. In Qatar, ITS is integrated into the National ITS Master Plan. In Iran, the emphasis is on addressing challenges and contributing to social welfare. China focuses on national strategies, including the Five-Year Plans, with a concerted effort to align ITS deployment with broader economic and developmental goals. These efforts strongly emphasise Strategic Planning and National Initiatives using ITS [5,9,15].

Research and Development: Research and development are crucial in implementing Intelligent Transportation Systems (ITS) in Qatar, Iran, and China. Chinese universities and research institutions actively engage in the current research areas related to ITS. Identifying key performance indicators and challenges in specific applications in Iran reflects ongoing research efforts. In Qatar, the continuous testing and adaptation of systems to local conditions demonstrate a solid commitment to advancements in ITS technologies. These efforts are described in more detail in references [5, 9, 15].

Influence of World Events: The Olympics in China and the World Cup in Qatar, although they had constraints on the government budget, became the driving factors behind the accelerated deployment of ITS prior to the events in China and Qatar [5, 10].

3. Discussions

Tatari et al. [6] highlight the ability of Intelligent Transportation Systems (ITS) to decrease accidents, which is consistent with the findings of Qatar, Iran, and China. While comprehensive proof regarding the accomplishments of all ITS systems is lacking, the implementation of speed cameras on Tehran's highway resulted in a notable 40% decrease in accidents within six months. Following the implementation of speed cameras in Guangdong Province, China, accident rates in 2005 decreased by 32.5 per cent compared to the levels observed in 2004 (He et al., 2013). These findings expand upon previous evidence from Tatari et al. [6] and Bayly et al. [8] that demonstrate the potential of Intelligent Transportation Systems (ITS) in reducing accidents. Bayly et al. [8] specifically projected that adopting enforcement measures, including deploying ITS technologies, could result in a 3% and 7% decrease in road fatalities, respectively.

The critical factors for utilising Intelligent Transportation Systems (ITS) in Qatar, Iran, and China to promote safe roads align with critical factors for implementing ITS in developing nations, as outlined by Mokaddem et al. [7].

The research conducted by Diderot et al. [2] focuses on sub-Saharan countries, whereas the study by Mokaddem et al. [7] examines the challenges of Intelligent Transportation Systems (ITS) in developing countries. Addressing the issues faced in Qatar, Iran, and China, particularly about budgetary limitations, energy difficulties, and the availability of skilled workforce. These challenges pertain particularly to Iran and Qatar rather than China.

3.1. Policy Recommendations

a. **Cross-country collaboration:** China, Qatar, and Iran can exchange knowledge to address shared difficulties and share best practices in ITS deployment.
b. **Cultural Sensitivity in Adaptation:** Cultural sensitivity should be given significant priority in the deployment of ITS to adapt to local customs and increase their public acceptability and efficiency in Iran and Qatar.
c. **Enhanced Stakeholder Collaboration:** A more unified and efficient rollout of ITS in Iran and Qatar is possible with better stakeholder collaboration in the face of challenges.
d. **Adaptability Strategies:** Measures should be implemented to make ITS systems more adaptable to local conditions; this is especially important in Qatar due to the severe weather that might disrupt operations.
e. **Innovative Funding Approaches:** To overcome financial limitations, innovative ways of financing ITS development, such as public-private partnerships and other financing methods, should be investigated.
f. **Government-Led Strategic Planning:** Governments should lead Intelligent Transportation Systems (ITS) projects, coordinating deployment plans with larger national objectives and incorporating ITS preparation into important events.
g. **Support for Research and Development:** ITS technologies need to be kept up to date with the latest trends and problems, so academics and industry need to work together and support continuing research and development, as is evident in the case of China.
h. **Public Awareness Campaigns:** Iran and Qatar must launch proactive public awareness efforts to inform the public about the advantages of ITS to achieve widespread public support.
i. **Integration with Major Events:** Like in China and Qatar, ITS planning should ideally coincide with big events so that deployment can be accelerated and the benefits of ITS in enhancing road safety can be showcased.
j. **Continuous Monitoring and Evaluation:** Continuously assessing the effectiveness of ITS systems through strong monitoring and evaluation mechanisms allows for modification and adaptation based on real-time data and developing transportation needs.

3.2. Limitations and Future Research

While offering valuable insights into the implementation of ITS in Qatar, Iran, and China, this paper has limitations. The reliance on existing research articles and reports limits first-hand exploration and primary data collection. The scope of this paper is confined to specific articles and reports used, potentially missing other relevant sources and recent developments. Cultural nuances and stakeholder perspectives, crucial for understanding practical challenges during ITS implementation, may not be more adequately captured. Moreover, technology and transportation systems are dynamic, and the snapshot of this paper may only partially represent ongoing changes. To address these limitations, future research could involve primary data collection, consider a broader range of sources, and conduct longitudinal studies to track the evolving impact of ITS on detecting and preventing accidents in these countries. An in-depth exploration of cultural and stakeholder aspects could further enhance the understanding of challenges and successes in ITS deployment.

4. Conclusions

Iran, Qatar, and China are implementing multiple significant Intelligent Transportation System (ITS) projects to enhance the safety of road users. ITS implementation has enhanced road safety across Iran, Qatar, and China. However, the three nations display unique patterns of development. Iran's adoption is less progressed than Qatar's, whereas China's adoption is even more advanced than Qatar's. Practitioners and policymakers can learn valuable lessons from how Intelligent Transportation Systems (ITS) have been implemented in China, Iran, and Qatar. To ensure the success of ITS projects and develop effective strategies, it is crucial to have a comprehensive understanding of the historical context, infrastructure, technical acceptability, cultural nuances, budget constraints, public awareness, and the capacity to respond to various scenarios. This study contributes to the broader topic of enhancing transportation efficiency and safety through educated and context-specific decision-making.

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References

[1] United States Department of Energy (2019). Vehicles per capita: Other Regions and Countries Compared to the United States

[2] Diderot, C. D., Bernice, N. W. A., Tchappi, I., Mualla, Y., Najjar, A., & Galland, S. (2023). Intelligent Transportation Systems in Developing Countries: Challenges and Prospects. *Procedia Computer Science*, *224*, 215-222

[3] World Health Organization (WHO). (2018). Global Status Report on Road Safety. Retrieved November 13, 2023.

[4] Taimouri, A., & Emamisaleh, K. (2020). Providing Performance Evaluation Indicators for Intelligent Transportation Systems (The Case Study of Tehran-Karaj Freeway Located in Iran). Journal of Transportation Technologies (JTTS), 10, 144-153.

[5] Shaaban, K., Elamin, M., & Alsoub, M. (2021). Intelligent Transportation Systems in a Developing Country: Benefits and Challenges of Implementation Transportation Research

[6] Tatari, A., Khorasani, G., Yadollahi, A., & Rahimi, M. (2012). Evaluation of intelligent transport system in road safety. Procedia, 55, 1373-1380. ResearchGate.

[7] Mokaddem, Y. E., Jawab, F., & Saad, L. E. (2019). Intelligent Transportations Systems: Review of Current Challenges and Success Factors: The Case of Developing Countries. 12th International Colloquium of Logistics and Supply Chain Management LOGISTIQUA.

[8] Bayly, M., Fildes, B., Regan, M., & Young, K. L. (2007). Review of crash effectiveness of intelligent transport systems. ResearchGate, 027763.

[9] Behruz, H., Chavoshy, A. P., Rad, A., & Mozaffari, G. (2013). Challenges of implementation of intelligent transportation systems in developing countries: case study – Tehran. Ecology and the Environment.

[10] Wu, J., Sui, Y., & Wang, T. (2009). Intelligent transport systems in China. Proceedings of the Institution of Civil Engineers, 162(1), 25–32.

[11] Jamieson, J. (2008). The Development of a Road Safety Strategy for the Gulf State of Qatar: 2008: Adelaide: Conference Proceedings. TRID.

[12] Hamid Torfehnejad, Ezatolah Akbari, "Implementing visual monitoring system in Iran roads network" 17th ITS world congress, Busan, Korea, October 2010.

[13] Hassanpour, S., Ghanbarzadeh, K., & Nozarigilan, M. (2016). Economic analysis of intelligent systems in urban transportation (smart cameras). European Online Journal of Natural and Social Sciences: Proceedings, 5(3 (s)), pp-227.

[14] Mooren, L., Shuey, R., Hamelmann, C., Mehryari, F., Abdous, H., Haddadi, M., Ranjbar, M., Zakeri, H., & Hosseinizadeh, S. (2021). Speed Management in Iran: a review process. Journal of Road Safety, 32(3), 31–42.

[15] Zhu, T., & Liu, Z. (2015). Intelligent Transport Systems in China: Past, Present and Future. In 2015, the Seventh International Conference on Measuring Technology and Mechatronics Automation (pp. 581-584), IEEE.

[16] Chen, H., Wang, X., Zhang, X., & Shao-Li, Z. (2014). The Evaluation of Chinese Urban Traffic Management System Application Based on Intelligent Traffic Control Technology. Conference Proceedings.

[17] Li, J., & Van Zuylen, H. J. (2014). Road traffic in China. Procedia - Social and Behavioral Sciences, 111, 107–116.

[18] He, J., King, M., Watson, B. C., Rakotonirainy, A., & Fleiter, J. (2013). Speed enforcement in China: National, provincial and city initiatives and their success. Accident Analysis & Prevention, 50, 282–288.