



A three-pronged approach to road traffic safety management system driven by technology, management, and culture

Yang Pan^a, Jianguo Chen^{*a}, Lizhuang Fang^b

^aSchool of Safety Science, Tsinghua University, Beijing 100084, China;

^bKey Laboratory of the Ministry of Public Security for Road Traffic Safety, Traffic Management Research Institute of the Ministry of Public Security, Wuxi 214151, China

*Corresponding author: chenjianguo@tsinghua.edu.cn

Abstract. In recent years, the number of road traffic accident fatalities in China has remained at a relatively high level compared to developed countries in Europe. The existing road traffic safety management measures in China primarily focus on assigning responsibility to individuals who violate traffic regulations. However, the successful international experiences of road traffic governance indicate that a socialized road traffic safety governance approach based on the "Vision Zero" strategy can significantly reduce the occurrence of road traffic accidents. This paper reviews the principles and measures of road traffic safety governance in three countries, namely Sweden, Netherlands and United Kingdom. This research also includes their planning and evaluation of emerging road traffic technologies. Based on this review, the paper proposes a three-pronged approach to road traffic safety resilience governance in China, driven by technology, management, and culture. This approach aims to provide a theoretical framework for road traffic safety governance.

Keywords: Road traffic safety management; vision zero; emerging technologies; socialized governance; promotion of safety culture

1 INTRODUCTION

In recent years, China's road transportation has experienced robust development. According to the "2022 Statistical Bulletin on the Development of the Transportation Industry" published by the Ministry of Transport of the People's Republic of China, the total length of roads in China has reached 5.3548 million kilometers, with 177,300 kilometers high-speed highways, solidifying its position as the world's leader [1]. By the end of 2022, the number of licensed drivers of motor vehicles in China has reached an impressive 502 million, and the number of motor vehicles in operation has exceeded 417 million [2]. It is projected that by 2025, the total road length, licensed drivers, and motor vehicles in China will surpass 5.5 million kilometers, 550 million individuals, and 460 million vehicles, respectively [3].

© The Author(s) 2024

L. Moutinho et al. (eds.), *Proceedings of the 2023 International Conference on Management Innovation and Economy Development (MIED 2023)*, Advances in Economics, Business and Management Research 260, https://doi.org/10.2991/978-94-6463-260-6_75

However, with the rapid growth of road transportation in China, traffic safety issues have become increasingly prominent. The latest data from the "China Statistical Yearbook" (2022 edition) shows that in 2021, there were 273,098 road traffic accidents in China, causing 62,218 deaths (equivalent to one person dying in a traffic accident every 8 minutes), with a total direct economic loss of about 1.45 billion yuan. This represents an increase of 11.6%, 0.8%, and 10.7% compared to the data in 2020 [4-5]. In comparison to developed countries, China's traffic accident mortality rate is relatively high. For example, in 2018, China's death rate per 10,000 vehicles was 1.93, significantly higher than that of the UK (0.46), the Netherlands, Sweden, and New Zealand (all below 1), as well as the United States (1.38) [6]. Developed European and American countries have achieved lower road traffic mortality rates, partially due to the implementation of the "Vision Zero" strategy in road transportation since the 1990s. The "Vision Zero" strategy in these countries recognizes that road users will inevitably make mistakes, and therefore, road systems need to be forgiving. These countries work collectively to address road safety issues by formulating comprehensive and systematic road traffic safety policies and measures [3]. Summarizing the road traffic management systems and experiences of these countries provides valuable insights for enhancing road traffic safety governance in China.

This paper presents an overview of the principles and measures for road traffic safety governance in Sweden, Netherlands and the United Kingdom, and proposes a three-pronged approach driven by technology, management, and culture to improve road traffic safety governance in China, considering the national context. This framework provides a macro-theoretical foundation for addressing road traffic safety issues in China.

2 Overview of Foreign Road Traffic Safety Management Principles and Measures Based on the "Vision Zero" Strategy

2.1 Sweden's Road Traffic Safety Management System [4-5]

In 1997, Sweden became the first country to legislate and promote the "Vision Zero" strategy for road traffic, which aims to eliminate fatalities and serious injuries on the road. After a decade of implementing the "Vision Zero" strategy, Sweden has become one of the countries with the lowest road traffic mortality rates in the world, with a rate of 3 deaths per 100,000 population, lower than the European Union (5.5 per 100,000) and the United States (11.4 per 100,000) [2-3].

The key to the success of Sweden's "Vision Zero" strategy lies in the adoption of systematic evaluation of road traffic safety issues and the subsequent implementation of corresponding policies and laws. The strategy highlights the importance of road and infrastructure design, research, and application of emerging vehicle technologies, as well as road traffic law enforcement in road traffic safety governance. Through the improvement of road and vehicle design, Sweden has reduced the death rate by 63%. The transformation of narrow rural roads has resulted in a 90% reduction in fatalities [4-5]. Sweden has made significant advancements in emerging road traffic safety technologies. In 2019, 85% of new cars in Sweden were equipped with automatic braking

technology, and 63% were equipped with lane departure warning systems [6]. Road traffic law enforcement in Sweden primarily focuses on speeding, drunk driving, drug-impaired driving, phone use while driving, and seat belt use. Since 2020, Sweden has managed speed limits through various monitoring methods, including approximately 2,200 speed cameras nationwide, as well as increased manual monitoring of speeding behavior by law enforcement officers. Drunk driving and drug-impaired driving are significant contributors to road traffic accidents in Sweden. To combat this, Sweden has installed breathalyzer-equipped gates in port inspection systems. When drivers approach these gates and breathe, the instrument quickly analyzes the alcohol concentration in their breath. The use of drugs or legal medications that could impair driving is strictly prohibited. Swedish road traffic regulations require drivers to maintain sufficient attention while driving. By 2018, the use of handheld mobile phones while driving was explicitly prohibited. The proportion of cars with seatbelt reminder or warning functions in Sweden has steadily increased, leading to a continuous rise in seatbelt usage rates. In 2020, the seatbelt usage rate for drivers was 97.6%, and for children and adults in the rear seats, it was 96.8% and 86.2%, respectively.

2.2 Netherland's Road Traffic Safety Management System [7-9]

Similar to Sweden, the Netherlands formulated the "Sustainable Safety Start-up Program" based on the "Vision Zero" strategy in 1997 [3]. Dutch government has proposed several principles for road traffic safety governance to support the "Vision Zero" goal [7-9]: (1) An ideal road network should be used, with separate lanes for motor vehicles, non-motorized vehicles, and pedestrians. If it is difficult to achieve complete road separation across the entire network, safety speeds should be designed. (2) From a mechanical design perspective, fast-flowing traffic should be physically or temporally separated from slow-moving traffic. If different traffic modes must coexist, the speeds of all traffic should accommodate the most vulnerable mode. In the future, dynamic solutions can be provided through emerging technologies, such as enforcing speed reductions when different types of vehicles are mixed. (3) Based on the psychological design principle, the road traffic system should be designed to cater to the cognitive and emotional needs of older adults. It should provide clear and concise information communication methods, create a comfortable and friendly traffic environment, and reduce anxiety and stress. In principle, such a traffic system can be applicable to almost all age groups. (4) Under the principle of effective implementation of responsibilities, the Dutch government takes ultimate responsibility for the "Vision Zero" traffic safety system. Road space planners, road management departments, law enforcement personnel, legislators, safety education officials, and other traffic professionals share the operational responsibilities.

2.3 United Kingdom's Road Traffic Safety Management System [10]

The United Kingdom's road traffic safety strategy emphasizes the primary goal of road traffic safety governance to provide road safety assurance to everyone through education, training, and demonstrating correct road traffic safety behaviors, enabling lifelong

learning for all road users. The UK approaches road traffic safety governance from three levels: safer road users, safer vehicles, and safer roads and environments [10].

Recently, the DfT THINK team has developed road safety education resources specifically tailored to children aged 3-6, 7-12, and 13-16, integrated into everyday teaching. The Driver and Vehicle Standards Agency (DVSA) encourages young learner drivers to expand their practice on roads, increasing practice sessions in driving on rural roads, independent driving, and nighttime driving before their first driving test. In addressing dangerous driving behavior among adult drivers, such as disobeying traffic signals, drunk driving, drug-impaired driving, and overloading, the UK government collaborates with law enforcement to establish joint enforcement road policing project teams. These teams collect relevant data and analyze the relationships between this data and traffic accidents, congestion, and crime. In the prevention of drunk driving, the UK plans to use alcohol interlocks based on international experiences. When the device detects a high level of alcohol in the driver's breath, the car will be prevented from starting. In 2015, England and Wales enacted legislation to prohibit drug-impaired driving, imposing driving restrictions for the consumption of seven illegal drugs, including tetrahydrocannabinol (commonly known as cannabis), and for prescription drugs taken at levels exceeding the therapeutic range. As road users age, their knowledge, experience, and abilities tend to decline. The UK government encourages vehicle manufacturers to provide safer vehicles for various age groups, genders, or body types. In physical crash tests for vehicles, test dummies representing elderly individuals will be used in the future to test the injury thresholds for road traffic accidents.

The UK government is actively engaged in international negotiations on vehicle standards. At present, the UK government's focus is on reducing the threat posed by heavy goods vehicles to vulnerable road users such as cyclists and pedestrians. Efforts are being made to modify the design of heavy goods vehicles to improve their visibility, consider the installation of side guards on both sides of heavy goods vehicles, and research the safety of engineering trailers and car transporters. Emerging technologies such as Anti-lock Braking Systems (ABS), Electronic Stability Control (ESC), and Adaptive Cruise Control (ACC) are gradually being adopted by drivers, but these technologies will not replace the driver. Autonomous driving technology will surpass these technologies, assuming the driving tasks of the driver, with the potential to make road traffic safer and more convenient. The UK government will conduct research combining Internet technology with autonomous driving technology to promote the safe testing and sales of autonomous vehicles.

The UK's Smart Motorways provide road users with rapid notifications, variable speed limits, and open hard shoulders, among other services. Smart Motorways in the UK are providing additional traffic capacity and reducing traffic congestion. The All-Lane Running Smart Motorway scheme (which includes variable speed limits, the permanent use of hard shoulders as driving lanes, and the provision of emergency stopping areas at regular intervals) has brought safety benefits, with the M25 All-Lane Running Smart Motorway providing a high-speed lane for over 11,000 vehicles every day, meaning more people are traveling on safer roads. The UK Department for Transport recognizes that vehicles parked on sidewalks can pose safety issues for pedestrians, especially for wheelchair users or visually impaired individuals, and those pushing baby

strollers. Future efforts will aim to maintain better order on sidewalks and decide on parking restrictions based on local conditions.

3 Research on A three-pronged approach to road traffic safety management system driven by technology, management, and culture

3.1 Current Status of Road Traffic Safety in China

Currently, there are still some shortcomings in China's road traffic safety governance. The government-led and public participation in socialization are lacking in the areas of emerging road traffic technologies, management, and cultural education. In terms of emerging technologies, such as intelligent vehicle-road coordination and autonomous driving, there is a lack of corresponding policy support, legal regulations, and resource allocation. Some internationally and domestically successful road traffic emerging technologies, such as autonomous driving technology, have not been fully promoted domestically. The deployment of cutting-edge emerging technologies in road traffic safety, such as the impact of complex road sections, temporary traffic control, adverse weather conditions, and mixed traffic, lacks guidance from the government. In terms of management, there is insufficient collaboration among various sectors of society, and socialized management with full societal participation is lacking. For example, the Traffic Safety Committee mainly focuses on regulating production and transportation safety, lacking comprehensive coordination in overall traffic safety. The involvement of public security and traffic police departments in road planning and construction is insufficient, leading to the failure to eliminate some traffic safety hazards in advance. The responsibility for the construction and regulation of road traffic infrastructure in rural areas is also unclear. In terms of cultural education, the targeted traffic safety education for high-risk groups is not strong enough, and there is room for improvement in the systematic and flexible content of propaganda and education [11-13].

3.2 A three-pronged approach to road traffic safety management system driven by technology, management, and culture

Based on the successful experiences in road traffic safety management in the aforementioned countries and the current status of road traffic safety in China [12-13], the future road traffic safety governance in China should adopt A three-pronged approach to road traffic safety management system driven by technology, management, and culture with the government leading and coordinating the participation of the whole society in road traffic safety management (Figure 1).

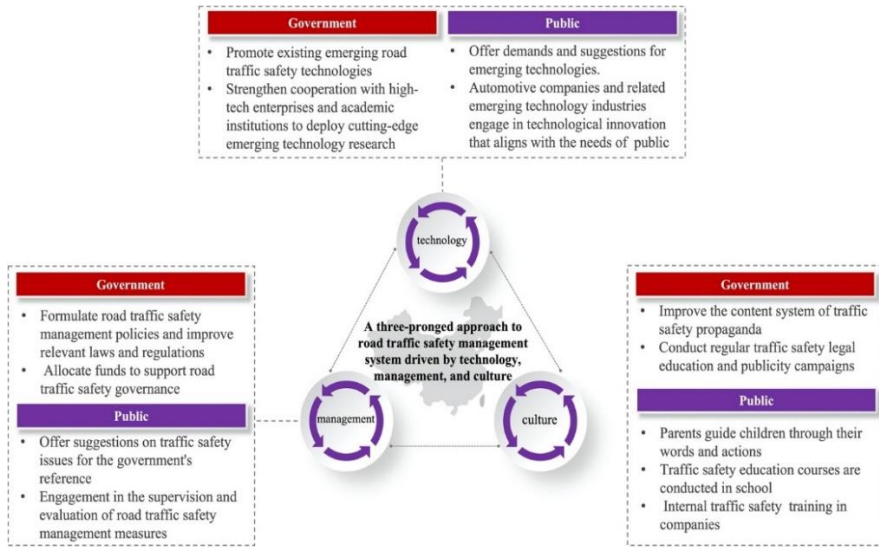


Fig. 1. A three-pronged approach to road traffic safety management system driven by technology, management, and culture

(1) Technology-Driven Road Safety Governance

The government should lead the promotion of existing emerging technologies, such as advancing vehicle networking and control, promoting the use of wearable control devices in key vehicles to aid traffic police in anticipating traffic risks and providing evidence for law enforcement. Virtual reality (VR) and augmented reality (AR) technologies can be utilized to provide immersive interactive traffic law enforcement training. The installation of automated emergency braking systems, blind-spot detection systems, and lane departure warning systems in motor vehicles can be encouraged. Monitoring cameras and 5G communication technology can be employed to monitor accident situations and emergency rescue traffic conditions, providing real-time information to rescue institutions to enable rapid response strategies. Additionally, relevant laws and regulations concerning emerging technologies should be improved. Government cooperation with high-tech enterprises and academic institutions should be undertaken to deploy forward-looking research in road traffic safety. For instance, based on the physiological and psychological characteristics of road users, combined with machine learning methods, road facilities and environments can be designed. Different road users, such as drivers, pedestrians, and cyclists, exhibit differences in perception, attention, and behavioral norms. Utilizing these differences and leveraging big data, a more secure and adaptive traffic safety system can be designed. Advancing the cutting-edge research in road traffic through machine learning and big data analysis requires the government to promote data sharing among industries and demographics through policy incentives and financial support to enhance collaborative innovation.

All sectors of society and various age groups should actively participate in the collection of demands and suggestions for emerging road traffic safety technologies under the government's guidance. The public should creatively propose new solutions to

address road traffic safety challenges based on their demands for safety and convenience, as well as their knowledge and skills. When proposing demands and suggestions for emerging road traffic safety technologies, the public should pay attention to the needs of vulnerable road users, contributing to a more inclusive road traffic safety system. Vehicle manufacturers and related emerging technology industries should respond proactively to public opinions, regularly collecting, organizing, and analyzing public demands and suggestions for emerging road traffic safety technologies, and collaborate in research and development to create technologies that cater to the practical needs of the public. In the process of emerging technology development, various road traffic participants should be invited to participate in testing and provide feedback.

(2) Management-Driven Road Traffic Safety Governance

The Ministry of Transport and its affiliated transport bureaus assume responsibility for formulating the framework of road traffic safety governance. They establish clear principles, goals, and strategies for road traffic safety governance, establishing a mechanism for resource allocation to ensure rational distribution of resources. Relevant policies and regulations are developed to regulate and guide road traffic safety implementation, including the research, formulation, and revision of the "Road Traffic Safety Law" and the "Regulations on the Implementation of the Road Traffic Safety Law." The Ministry of Transport can allocate more funds for road repairs, improvements, and traffic sign updates. It can also invest in surveillance cameras, smart traffic lights, and road traffic monitoring systems for real-time traffic monitoring and management. Different road traffic participants possess unique perspectives and experiences on road traffic safety issues, enabling them to provide more comprehensive suggestions and opinions. The public should actively participate in traffic safety public forums organized regularly by the government and can also offer opinions through online surveys and social media channels. Public engagement in supervising and evaluating road traffic safety management measures is an effective means of complementing and improving governance. The public can organize traffic safety research groups to independently and objectively assess traffic safety governance measures using scientific methods. As road traffic safety governance measures are implemented, the public, as different road traffic participants, can provide practical feedback on the process.

(3) Culture-Driven Road Traffic Safety Governance

The government cultivates a road traffic safety culture that aligns with the core values of society, with the aim of achieving sustainable development in road traffic safety governance. This entails considering road safety as a collective responsibility and obligation of society, such that road safety behaviors are internalized as daily habits and conscious actions. The active and widespread participation of the public becomes a significant force in enhancing road traffic safety governance. Improving the content system of road traffic safety publicity includes comprehensive use of the internet and social media platforms to disseminate accurate and easily understandable information on road traffic laws, safe driving experiences and techniques, road traffic safety risks faced by vulnerable groups, and potential safety risks posed by emerging technologies. The government coordinates regular and normalized road traffic safety legal education and publicity. Apart from continuing to organize theme activities on the "National Traffic Safety Day" (December 2), the government arranges offline training, exhibitions,

lectures, and drills related to road traffic safety laws and regulations to enhance the experiential and practical aspects of the publicity and education efforts. Utilizing emerging technologies such as mobile applications and online platforms, interactive learning resources on road traffic safety laws are provided to the public.

At the family level, parents can help their children form a proper awareness of road traffic safety and develop good behavioral habits through their words and actions. Parents should strictly abide by traffic rules themselves and actively engage in traffic safety education activities with their children. These activities may include watching traffic safety promotional videos, reading books or stories about traffic safety, and engaging in discussions with children to answer their questions regarding road traffic safety issues. For children and teenagers, campus road traffic safety education should be provided, which includes arranging traffic safety courses and organizing innovative experiential and interactive activities to cultivate students' proper awareness of road traffic safety and behavioral habits. Universities can deliver knowledge on traffic regulations, safe driving techniques, emergency handling, and road traffic psychology to enrolled students who already possess driver's licenses to enhance their safety consciousness. Encouragement should be given to enterprises and institutions to conduct road traffic safety education, including organizing road traffic safety training courses, disseminating knowledge on road traffic safety risks. Companies can strengthen educational initiatives at the source and utilize smartphones to push road risk information, including traffic congestion, weather changes, and accident alerts to their employees.

4 Conclusions

Through a comprehensive review of the road traffic safety governance principles, measures, and relevant emerging technologies in three countries, namely Sweden, Netherlands and the United Kingdom, this study summarizes the successful experiences of these countries in road traffic safety governance at the levels of technology, management, and cultural promotion. Based on the experiences of these countries in road traffic safety governance, this paper proposes a three-pronged approach to road traffic safety resilient governance system for China. At the technological level, the government should coordinate the planning of policy support and resource allocation for emerging road traffic safety technologies, promote existing road traffic safety emerging technologies, and deploy prospective research on road traffic safety. At the management level, a socialized road safety governance model guided by the government and involving public participation should be established. Various departments and industries should collaborate to address road traffic safety issues. At the cultural level, a road traffic safety culture in line with the core values of society should be fostered, encouraging broad public engagement and promoting the sustainable development of road traffic safety governance.

Acknowledgment

The authors gratefully acknowledge the financial support provided by the National

Science Foundation of China ("Multi-dimensional Analysis of Policy Driven by Big Data", 72293571). This work was also supported by Director Fund of Key Laboratory of The Ministry of Public Security for Road Traffic Safety (2022ZDSYSZRJJ 01) in China.

References

1. TowardZeroDeaths.org. Toward Zero Deaths: A National Strategy on Highway Safety [J/OL]. https://www.towardzerodeaths.org/wp-content/uploads/2019/12/TZD_National_Strategy.pdf (2023-07-25) [2023-07-25]
2. World Health Organization. Global status report on road safety [R]. Geneva, 2018. https://www.who.int/health-topics/road-safety#tab=tab_1
3. Jinming L, Wei L. International Road Traffic "Vision Zero" and Safety System Approach Case Studies and Enlightenment [J]. *Traffic & Transportation*, 2017, 2:4-7. <https://www.cnki.com.cn/Article/CJFDTOTAL-YSJT201702002.htm>
4. Kristianssen A C, Andersson R, Belin M Å, et al. Swedish Vision Zero policies for safety—A comparative policy content analysis [J]. *Safety science*, 2018, 103: 260-269. <https://www.sciencedirect.com/science/article/pii/S0925753517309013>
5. Belin M Å. Public road safety policy change and its implementation-Vision Zero a road safety policy innovation [M]. Karolinska Institutet (Sweden), 2012. <https://openarchive.ki.se/xmlui/handle/10616/40987>
6. Schagen, I N L G. Sustainable Safety 3rd edition background report I – Current situation, societal trends and ideals [R]. Den Haag, 2018. https://swov.nl/system/files/publication-downloads/dv3_en_kort_rapport.pdf
7. Weijermars W, Wegman F. Ten years of sustainable safety in the Netherlands: an assessment [J]. *Transportation research record*, 2011, 2213(1): 1-8. <https://journals.sagepub.com/doi/10.3141/2213-01>
8. Ecola L, Popper S W, Silbergliitt R, et al. The road to zero: A vision for achieving zero roadway deaths by 2050 [J]. *Rand health quarterly*, 2018, 8(2):11. <https://www.nsc.org/road/resources/road-to-zero/road-to-zero-home#:~:text=The%20Road%20to%20Zero%20Coalition%2C%20managed%20by%20the,fatalities%2C%20which%20recently%20increased%20after%20years%20of%20decline>
9. Karin Edvardsson Björnberg, Sven Ove Hansson, Matts-Åke Belin, Claes Tingvall. The Vision Zero Handbook: Theory, Technology and Management for a Zero Casualty Policy [M]. Springer Nature, 2023. <https://link.springer.com/referencework/10.1007/978-3-030-23176-7>
10. Department for Transport. The Road Safety Statement 2019 A Lifetime of Road Safety [R]. 2019. <https://static1.squarespace.com/static/61d570b3a2957b5f755587d2/t/6213d0379766576f976aa077/1645465659364/road-safety-statement-2019.pdf>
11. https://www.mem.gov.cn/gk/zfxxgkpt/fdzdggknr/202207/t20220728_419231.shtml [J/OL]. (2023-07-25) [2023-07-25]
12. https://www.gov.cn/zhengce/zhengceku/2022-07/29/content_5703363.htm [J/OL]. (2023-07-25) [2023-07-25]
13. He Y, Fan Y, Yan L, et al. Visualization and analysis of global Vision Zero studies and policy orientation in china[J]. *International journal of environmental research and public health*, 2022, 19(22): 14841. <https://www.mdpi.com/1660-4601/19/22/14841>

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

