Article

Anti-Collision and Warning Facilities at High-Speed Interchange Diversion Noses in China

Zhiming Zhang [1] and Haitao Wang [2,*]

[1] Tianjin Highway Group Co., Ltd. Tianjin, 300000, China
[2] China Railway Fourth Bureau Third Company, Tianjin, 300000, China
* Correspondence: 315501765@163.com

Abstract: This paper explores the effect of the anti-collision and warning facilities installed at high speed interchanges in China. This was inspired by the realization that the number of fatalities on China roads prior to 2004 was unacceptable and hence the need to install anti-collision devices on both highway interchanges and on vehicles so as to enhance road safety. The study found out that the installation of anti-collision devices on the highways as well as car manufacturers installing anti-collision devices on newer versions of vehicles has led to lesser impact accidents on the roads and hence reduced the number of fatalities from China roads. Though the number of accidents increased, their impact was not as severe as compared to when the anti-collision devices had not been installed. The paper concluded that the application of anti-collision and warning facilities at high-speed interchange diversion noses has significantly improved to a reduction in the number of fatalities from road accidents in China.

Keywords: Anti-Collision Devices (ACD); Interchanges; Transport Safety

1. Introduction

Anti-collision devices are technologies and systems designed to prevent collisions between vehicles and other objects [1]. These devices are increasingly important in the modern world as traffic volumes continue to rise, leading to a higher risk of accidents and collisions. In China, where the number of vehicles on the road is steadily increasing, anti-collision devices play a critical role in ensuring road safety and reducing the number of accidents. One of the most common types of anti-collision devices in China is the automatic emergency braking system (AEBS). This system uses sensors to detect potential collisions and can automatically apply the brakes to prevent or reduce the impact of a collision. By reacting faster than a human driver, these systems can help avoid accidents caused by human error, distractions, or delayed reactions. Another important anti-collision device in China is the lane departure warning system. This system uses cameras or sensors to monitor the vehicle's position on the road and alerts the driver if the vehicle starts to drift out of its lane [2]. By warning the driver of potential lane departures, these systems can help prevent collisions caused by drifting into adjacent lanes or off the road.

In addition to these technologies, China is also investing in advanced driver assistance systems (ADAS) that combine multiple safety features, such as adaptive cruise control, blind-spot detection, and parking assistance, to enhance overall road safety. Overall, anti-collision devices in China are crucial for preventing accidents, reducing injuries, and saving lives on the road. As the number of vehicles continues to grow and traffic congestion worsens, the importance of these technologies will only increase. By investing in anti-collision devices and promoting their adoption, China can work towards creating a safer and more efficient transportation system for its citizens. In China, road accidents are a leading cause of death for people below the age 29 [3]. In the year 2020 alone, there were 244,674 accidents in China resulting in 61,703 fatalities and 250,723 motor vehicle related

Received: 3 April 2024
Revised: 21 April 2024
Accepted: 2 May 2024
Published: 8 May 2024

injuries [4]. This is a very high fatality rate considering that [1] noted that between 2010 and 2019 there was a total of 2,125,994 reported traffic accidents on Chinese roads which led to 2,292,026 injuries to drivers, passengers and pedestrians and 615,515 fatalities. Similarly in the same period property estimated to be worth USD 11.5 billion was damaged as a direct consequence of road accidents in China [1]. This shows road safety is an issue that needs immediate government intervention as well as a heavy investment in both physical and logical infrastructure to curb road carnage. The statistics on both rural and urban roads show a common trend. Though the number of accidents on the roads kept rising, the number of fatalities per annum has been gradually going down from 2013 when the government installed anti-collision devices.

According to [5] the increase in the number of motor vehicles in China roads poses an increased risk of collisions. In the last 10 years, the number of vehicles have increased from 205 million in 2015 to over 360 million in 2023 and hence an increased risk of accidents to a level higher than any other country in the world. Despite this increase, the number of fatalities from road accidents have decreased significantly with increase in anti-collision technology and devices fitted on the newer vehicles [2]. Empirical studies, [2, 6] have linked China's unique socio-economic factors such as population, road network, number of vehicles as well as the large number of non-vehicle road users as a key contributing factor to the high fatality rate. However, recent studies [7-9] have linked the reduction in road accident fatalities to the use of technology to curb vehicle collisions.

2. Statement of the Problem

Road accidents in China have been a major concern for the government and the public due to the high number of fatalities and injuries. According to [10] over 600,000 people have perished on china roads since 2010. One of the main reasons for the high number of road accidents in China is the rapid increase in the number of vehicles on the roads. With the rise in income levels, more people are able to afford cars and motorcycles, leading to congestion and traffic jams in urban areas [9]. This, in turn, increases the likelihood of accidents occurring due to reckless driving, speeding, and disregard for traffic rules. Another contributing factor to road accidents in China is the lack of stringent enforcement of traffic laws. Many drivers in China are known to flout traffic regulations, such as running red lights, speeding, and driving under the influence of alcohol. The lack of enforcement by authorities has led to a culture of impunity among drivers, making the roads even more dangerous for all road users [11].

Furthermore, the poor infrastructure and road conditions in some parts of China also contribute to the high number of accidents.Many roads in rural areas are poorly maintained, with potholes, lack of proper lighting, and inadequate road signs. This makes it difficult for drivers to navigate safely, especially at night or during adverse weather conditions. In response to the alarming road accident statistics, the Chinese government has implemented various measures to improve road safety [12]. These include stricter enforcement of traffic laws, increased fines for traffic violations, public awareness campaigns, and investing in better road infrastructure. However, more needs to be done to reduce the number of road accidents and make China's roads safer for all users. In conclusion, road accidents in China remain a significant issue that requires urgent attention. By addressing the root causes of accidents, enforcing traffic laws, and improving road infrastructure, China can work towards reducing the number of fatalities and injuries on its roads [13].

Contradicting literature has been put forward about the contribution of technology to reduction of road accidents. Several studies [2][6] have linked china's unique socio-economic factors such as population, road network, number of vehicles as well as the large number of non-vehicle road users as a key contributing factor to the high fatality rate. However, recent studies [7][8][9] have linked the reduction in road accident fatalities to the use of technology to curb vehicle collisions. This study therefore sought to answer the question; What is the effect of anti-collision and warning facilities at high-speed interchange diversion noses and their contribution to road safety in China?

3. Purpose of the study

The key objective of the study was to establish the effect of anti-collision and warning facilities at high-speed interchange diversion noses and their contribution to road safety in China.

4. Literature Review

Motor vehicle accidents (MVAs) are a significant public health concern worldwide, resulting in fatalities, injuries, and economic costs. The trend of MVAs in China and Uganda from 2010 to 2015 showed a decrease in frequency, which can be attributed to various factors. The support provided by the national government, increased investments in health and traffic infrastructure, and the focus on network system management all played a crucial role in reducing road traffic injuries (RTIs) during this period [12]. However, from 2015 to 2019, the frequency of MVAs in both countries experienced fluctuations with an overall upward trend. The construction of three-dimensional crossings in metropolitan areas, the continuous progress of urbanization leading to increased traffic mobility, and the presence of interleaved areas in interchanges were identified as factors contributing to the rise in accidents (Mao et al., 2019).

The increase in the number of new drivers and vehicles, particularly in China where there were over 33 million registered vehicles in 2017, has intensified the traffic safety situation [2]. As the number of vehicles on the roads continues to rise, so does the risk of accidents if appropriate measures are not taken. To combat the rising trend of MVAs, governments, policymakers, and relevant stakeholders need to focus on implementing effective road safety measures. This includes improving road infrastructure, enhancing traffic management systems, promoting road safety awareness among drivers and pedestrians, and enforcing traffic laws rigorously. Additionally, investing in innovative technologies such as intelligent transportation systems can also help in reducing the incidence of MVAs. In conclusion, while the frequency of MVAs in China and Uganda showed a decreasing trend in the past decade, recent years have seen a concerning increase in accidents. By addressing the underlying causes and implementing comprehensive road safety strategies, both countries can work towards reducing the burden of road traffic injuries and creating safer road environments for all.

In recent years, there has been growing concern regarding the safety of non-motor vehicles on the roads in China. While most studies have traditionally focused on the safety of motor vehicles, it is evident that there is a significant need to pay more attention to the safety of non-motor vehicles (NMVs) as well. The research conducted by [14] highlighted the increasing frequency of non-motor vehicle accidents (NMVAs) in China since 2011, indicating the urgent need for effective intervention measures to address this issue. The role of non-motor vehicles in the road traffic environment in China cannot be understated. Factors such as economy, region, culture, and urbanization have all contributed to the prevalence of non-motor vehicles on the roads. However, several reasons have been identified for the increasing number of NMVAs in China. Firstly, non-motor vehicles, such as electric bicycles and tricycles, have poor self-protection performance and stability compared to motor vehicles. This makes the riders more vulnerable to injuries in the event of accidents, especially if they are driving recklessly or illegally. The small size and relatively high speed of non-motor vehicles further compound the risk factor [15].

Secondly, the rapid urbanization in China has led to increased traffic congestion, putting non-motor vehicle riders at a higher risk of accidents. Additionally, the boom in takeout and express delivery services has led to a surge in the use of e-bikes, further increasing the likelihood of accidents involving non-motor vehicles [13]. Thirdly, there is a lack of stringent control measures for non-motor vehicles. Unlike motor vehicles, individuals using non-motor vehicles do not require a driving license, leading to a myriad of illegal practices such as speeding, running red lights, and not wearing safety helmets. This lack of regulation significantly raises the chances of traffic injuries involving non-motor

vehicles [15][16]. Furthermore, factors such as cyclist distraction, adverse weather conditions, and the physical elements of the road can also contribute to NMVAs [10]. These external factors, combined with the aforementioned reasons, highlight the complex nature of non-motor vehicle safety on Chinese roads.

The road design in China is also another contributing factor to high speed accidents that are often fatal. According to [18] road interchanges are critical components of traffic infrastructure that help to efficiently manage the flow of vehicles at intersections. In China, the design of road interchanges has a significant impact on the occurrence of traffic accidents. By understanding the relationship between interchange design and traffic accidents, measures can be taken to improve road safety. One of the key factors in road interchange design is ensuring proper signage and signalization [1]. Clear and visible road signs are essential for guiding drivers and preventing confusion that can lead to accidents. Additionally, traffic signals need to be strategically placed and timed to control the flow of vehicles and minimize the risk of collisions. Inadequate signage and signalization can result in driver error, increasing the likelihood of accidents [9].

Another important aspect of road interchange design is the layout of lanes and merging areas. Interchanges with complex lane configurations and short merging distances can create challenging driving conditions that increase the risk of accidents. Proper lane markings, adequate merging lanes, and streamlined traffic patterns are essential for promoting smooth and safe traffic flow [2]. In China, road interchange design should prioritize simplicity and efficiency to reduce the potential for accidents. Moreover, the visibility of road interchanges plays a vital role in preventing accidents. Poor visibility due to factors such as inadequate lighting, obstructions, or inclement weather can impair drivers' ability to see and react to traffic conditions effectively. Enhancing visibility through proper lighting, clear sightlines, and regular maintenance can help to reduce the incidence of accidents at interchanges. In conclusion, road interchange design has a significant impact on traffic safety in China. By incorporating elements such as clear signage, efficient lane layouts, and improved visibility, the risk of accidents can be mitigated. It is crucial for authorities and designers to prioritize safety in the planning and construction of road interchanges to protect the lives of motorists and promote a smooth and efficient traffic flow [10].

In 2003, following the realization of the impact of the increasing traffic congestion and a rise in the number of accidents in China and the growing need to save lives on the road, the government saw the growing need to implement anti-collision devices on road interchanges to enhance safety and reduce accidents [10]. The installation of anti-collision devices such as guardrails, crash cushions, and crash barriers are effective measures to prevent vehicles from colliding with each other or with roadside obstacles. These devices create a physical barrier between vehicles, reducing the risk of collisions and minimizing the impact of accidents. By strategically placing these devices on road interchanges, the chances of dangerous accidents can be significantly reduced. One of the major benefits of installing anti-collision devices on road interchanges is the prevention of serious injuries and fatalities [16].

Anti-collision devices are designed to absorb the impact and redirect the vehicle, reducing the severity of the accident and minimizing the risk of injuries to motorists and passengers [9]. This is particularly important on road interchanges where high speeds and heavy traffic can result in devastating accidents if proper safety measures are not in place. Furthermore, anti-collision devices can also help improve traffic flow and reduce congestion on road interchanges. By reducing the likelihood of accidents and ensuring the safety of motorists, these devices can help maintain a smooth and continuous flow of traffic, preventing delays and bottlenecks that can result from accidents. In conclusion, implementing anti-collision devices on road interchanges in China is essential for enhancing road safety, reducing accidents, and improving traffic flow. By investing in these safety measures, authorities can significantly reduce the number of injuries and fatalities on highways and ensure a safer and more efficient transportation system for all road users [12].

5. Materials and Materials

The statistics used to validate this paper was derived from the unified National Road Traffic Accident Information System" is used for the statistics of road traffic accidents in China, which covers accidents causing deaths, accidents causing serious injuries or minor injuries and Property loss accidents handled by the rule procedures. Secondly, supporting data was obtained from the National Bureau of Statistics of China [8, 10, 12]. Data was analyzed using MS Excel and the results presented using graphs, tables and charts.

6. Results

The findings presented in figure 1 show the gender composition of road accident fatalities in china with the main classification being either urban or rural population. The findings show that rural males in china have the highest mortality rates in road accidents between 2004 and 2020. The urban males came second followed by rural female road users. The group with the lowest mortality rate in this survey was the urban female road users who had the lowest accident fatality rate througnout the survey period. The trend analysis also shows that there was a general decline in the number of fatalities from road accidents between 2004 and 2020 showing that the road safety campaigns involving the use of physical and technology based anti-collision devices have been effective in reducing the fatalities from road accidents by reducing the impact of such accidents.

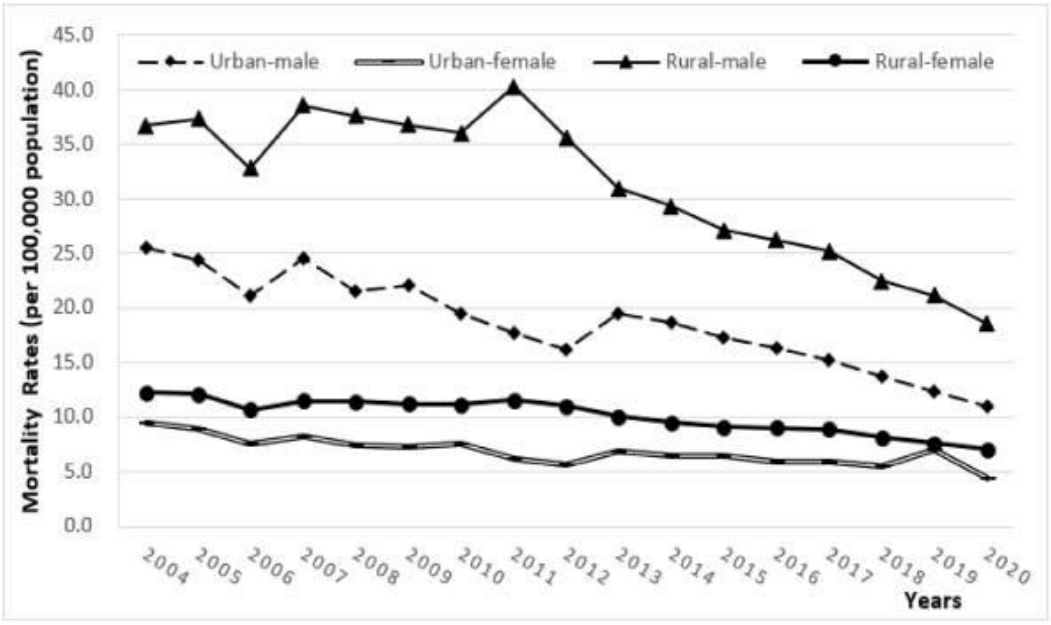

Figure 1. Gender statistics from road accidents [3]

The findings presented in figure 2 show an analysis of the distribution of road accident fatalities in terms of regions; East, Central and Western regions. The findings show that though in 2004 the Eastern region recorded the highest fatalities, road safety campaigns reversed the trend in two years such that from 2006, the eastern region has maintained the lowest road accident fatality rates in the country consistently up to the year 2020. The western region has experienced a high rate of fatal accidents since the year 2007 up to 2020. This can be attributed to the rural road network in the region which has a higher accident fatality rate than other areas. The central region has maintained a relative trend over the period. Overall, there was a downward trend in the number of fatalities showing the road safety campaigns involving the installation of ACDs on road infrastructure and modern vehicles.

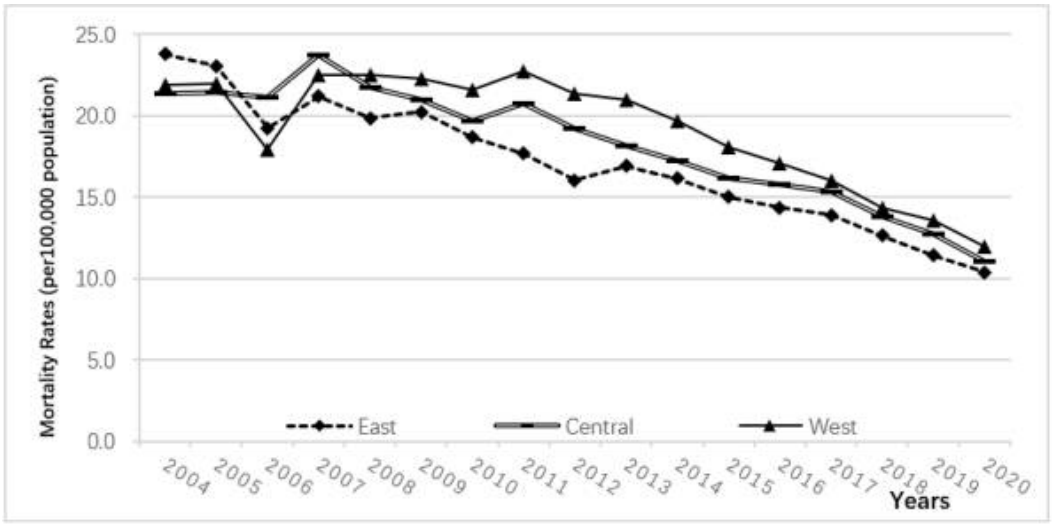

Figure 2. Regional survey of road accident fatalities[3]

The findings presented in figure 3 show that the most affected group in terms of fatalities is the over 65 years. This age group is old and feable and hence vulnerable to road accident fatalities. This was followed closely by the 45 – 64 years group and 15 – 44 years age group. There were very few cases of fatalities of persons below the age of 15 years. Though there was a peak in 2006 for the over 65 years age group, the fatality rates in this age group have relatively remained constant over the period of the survey. The younger groups however recorded a decrease in the number of fatalities as shown in figure 3 below;

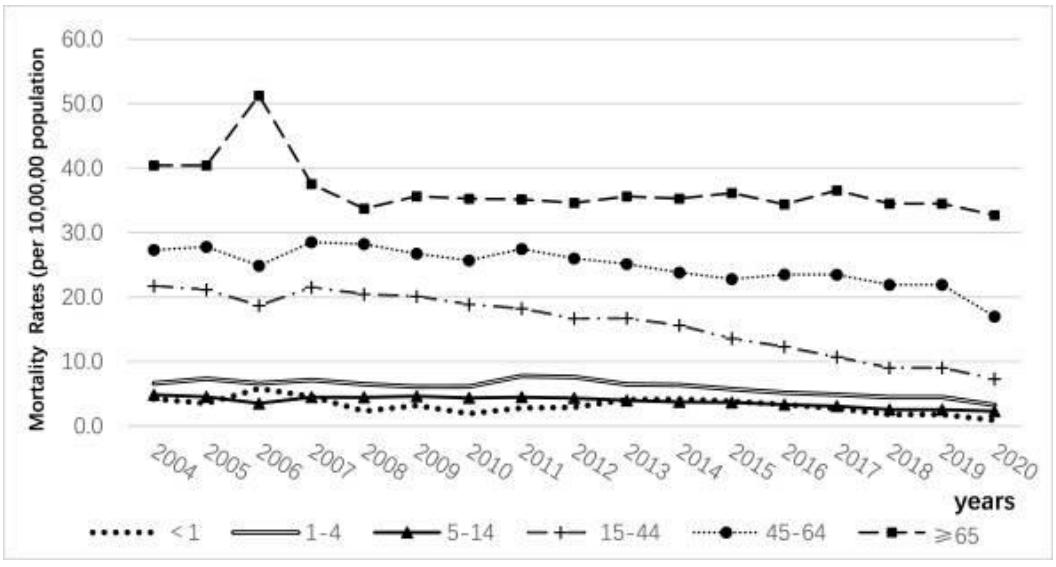

Figure 3. Age analysis for road accident fatalities [3]

The findings presented in figure 4 show the weighted number of fatalities per 100,000 in china from 2004 to 2020. The findings show a downward trend where the mortality rate has dropped significantly from 22.2 per 100,000 in 2004 to 11.0 per 100,000 in 2020. This has been achieved through the combined efforts of road safety campaigns and installation of ACD in the road infrastructure as well as installation of ACDs in newly manufactured vehicles such as the Automatic Emergency Braking system installed in most modern vehicles. The findings are presented below

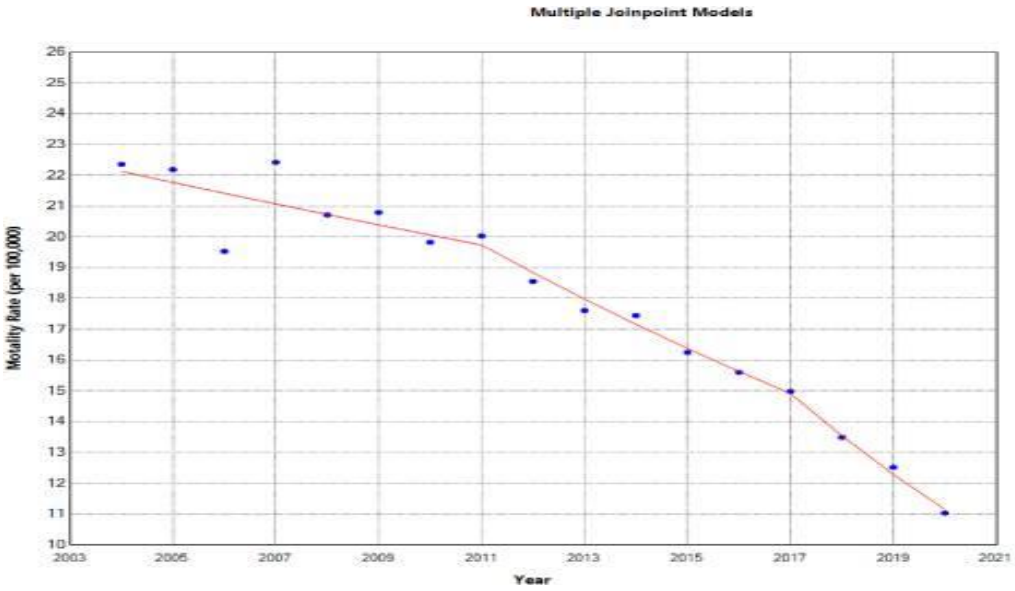

Figure 4. Weighted average MVA fatalities per 100,000 people[2]

7. Discussion of the findings

The findings presented in figures 1,2,3 and 4 show a consistent trend of a reduction in the number of road accident fatalities in all the parameters surveyed. In terms of gender, the males had the highest mortality rate with the rural population being more affected as compared to the urban male population. The lowest fatality rate was experienced amongst the urban female population. In terms of age, persons above the age of 65 tended to have the highest fatalities during road accidents as compared to the younger generation. The analysis also showed a very low fatality rate among persons below the age of 15 years. The regional analysis showed that the Eastern region as the safest as from 2006 while the western region was lagging in terms of road safety. This can be attributed to the larger network of rural roads in the western region as compared to the other regions of the country. Safety campaigns and installation of ACDs on the road infrastructure as well as incorporating anti-collision technology in modern vehicles which reduce the risk of fatalities by reducing the impact of collisionsin cases of accidents. These efforts have paid off in reducing the number of fatalities by half from 22.2 per 100,000 in 2004 to 11.0 per 100,000 in 2020 which is a commendable. These findings are comparable to [1] who found out that anti-collision devices had significantly reduced the number of fatalities on china's roads between the period 2010 to 2019.

8. Conclusions

The paper sought to establish the effect of anti-collision and warning facilities at high-speed interchange diversion noses and their contribution to road safety in China. Road accidents in China have costed over 600,000 lives in the last 10 years which is a great loss to the country in terms of human resource and close to USD 12 billion losses in terms of property. This loss can be attributed to the increase in the road infrastructure coverage, increase in the number of vehicles as well as a general increase in non-vehicle (motorcycles, bicycles and pedestrians) road users over the last decade. The Chinese government has since the year 2004 moved in to install anti-collision devices in highways and high speed interchanges so as to reduce collisions. Vehicle manufacturers have also installed anti-collision devices on newer versions of vehicles manufactured after 2005 contributing significantly to curbing the problem of road carnage. Statistics show that despite the increase in the number of accidents on the roads steadily from 2004 onwards, the number of fatalities have dropped significantly with collision being less severe due to the physical and logical use of anti collision devices. Though the number of road user has increased

significantly over time, as well as the number of collisions, the number of fatalities has consistently reduced in the last 10 years. This paper can therefore conclude that the application of anti-collision and warning facilities at high-speed interchange diversion noses has significantly improved to a reduction in the number of fatalities from road accidents in China.

References

1. Wang H. Design of New and Old Expressway Interchange.*Transp. World*,**2021**(17),78-79.
2. Wang T., Wang Y., Xu T., Li L., Huo M., Li X., He Y., Lin Q., Mei B., Zhou X., Jiang B. Epidemiological and clinical characteristics of 3327 cases of traffic trauma deaths in Beijing from 2008 to 2017.*Medicine*,**2020**,99(1),e18567. doi: 10.1097/MD.0000000000018567.
3. Ren K., Miao L., Lyu J. The temporal trend of road traffic mortality in China from 2004 to 2020.*SSM Popul. Health*,**2023**,24,101527. doi: 10.1016/j.ssmph.2023.101527.
4. Wang W. Design of Interchanges Based on Highway Design Concept.*Commun. Sci. Technol. Heilongjiang*,**2020**,43(3),216-218.
5. World Health Organization. World Health Organization Global status report on road safety 2018. Retrieved February 27, 2022, from http://www.who.int/violence_injury_prevention/road_safety_status/2018/en.
6. Zhang X., Xiang H., Jing R., Tu Z. Road traffic injuries in the People's Republic of China, 1951–2008.*Traffic Inj. Prev.*,**2011**,12(6),614–620. doi: 10.1080/15389588.2011.609925.
7. Pai C., Hirayama S., Narahari S., Jeyabharath M., Prakash G., Kulothungan V. An insight of World Health Organization (WHO) accident database by cluster analysis with self-organizing map (SOM).*Traffic Inj. Prev.*,**2018**,19(sup1),S15–S20. doi: 10.1080/15389588.2017.1370089.
8. Zhang X., Ji W. Design of Interchanges Based on New Concept of Highway Design.*China Eng. & Consult.*,**2019**,11,99-101.
9. Zhong Z., Lin Z., Li L., Wang X. Risk factors for road-traffic injuries associated with E-bike: case-control and case-crossover study.*Int. J. Environ. Res. Public Health*,**2022**,19(9),5186. doi: 10.3390/ijerph19095186.
10. Miao Qi X., Hu X., Li X., Wang X. Analysis of road traffic injuries and casualties in China: a ten-year nationwide longitudinal study.*PeerJ*,**2022**,10,e14046. doi: 10.7717/peerj.14046.
11. Wang X., Yu H., Nie C., Zhou Y., Wang H., Shi X. Road traffic injuries in China from 2007 to 2016: the epidemiological characteristics, trends and influencing factors.*PeerJ*,**2019**,7,e7423. doi: 10.7717/peerj.7423.
12. Sun L-L, Liu D., Chen T., He M-T. Analysis on the accident casualties influenced by several economic factors based on the traffic-related data in China from 2004 to 2016.*Chin. J. Traumatol.*,**2019**,22(2),75–79. doi: 10.1016/j.cjtee.2019.02.002.
13. Chen F., Ye W., Yan S., Zhang H., Li L., Ou L. Road traffic injuries in takeaway riders in Shantou city and influencing factors (in Chinese with English abstract).*Injury Med.*,**2019**,8(4),33–40. doi: 10.3868/j.issn.2095-1566.2019.04.006.
14. Vaca S. D., Feng A. Y., Ku S., Jin M.C., Kakusa B.W., Ho A.L., Zhang M., Fuller A., Haglund M.M., Grant G. Boda bodas and road traffic injuries in Uganda: an overview of traffic safety trends from 2009 to 2017.*Int. J. Environ. Res. Public Health*,**2020**,17(6),2110. doi: 10.3390/ijerph17062110.
15. Ma C., Yang D., Zhou J., Feng Z., Yuan Q. Risk riding behaviors of urban E-bikes: a literature review.*Int. J. Environ. Res. Public Health*,**2019**,16(13),2308. doi: 10.3390/ijerph16132308.
16. Yang J., Hu Y., Du W., Powis B., Ozanne-Smith J., Liao Y., Li N., Wu M. Unsafe riding practice among electric bikers in Suzhou, China: an observational study. 2021,4(1),e003902. doi: 10.1136/bmjopen-2013-003902.
17. Useche S. A., Alonso F., Montoro L., Esteban C. Distraction of cyclists: How does it influence their risky behaviors and traffic crashes?*PeerJ*,**2018**,6,e5616. doi: 10.7717/peerj.5616.
18. Hua S. Analysis on Safety Factors of Highway Interchange Design.*Jiangxi Build. Mater.*,**2021**(09),86-87.