Research and Application of Urban Road Traffic Safety Risk Evaluation Based on Regional Disaster System Theory

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Abstract. Urban road traffic risk restricts the construction of safe cities. In order to scientifically evaluate urban road traffic safety risks, the regional disaster system theory is taken into consideration, and the coupling role of various parts in the regional disaster system is fully considered, and the regional disaster safety risk assessment ideas are proposed; analyzing the main factors affecting urban road traffic safety risks, we form a framework of urban road traffic safety risk influencing factors based on regional disaster system ideas from four aspects: hazard, disaster bodies, disaster environment and emergency response capabilities; taking a city as an example, we analyze the influencing factors of road traffic safety risks in that city, construct an index system of urban road traffic safety risk assessment, and verify the feasibility and effectiveness of the risk assessment ideas and the framework of risk influencing factors. The results show that the risk assessment ideas and the framework of risk influencing factors have certain rationality, and provide a theoretical basis for effectively preventing the occurrence of urban road traffic accidents.

1. Introduction

Urban road traffic accidents occur frequently due to various factors such as dense and diverse road bodies, highly concentrated road conflicts and complicated traffic environment. With the continuous emergence of new urban construction concepts such as ecological cities, and safe cities, citizens' longing for a happy life is reflected. In urban construction, urban road traffic safety is a very important indicator. Therefore, constructing an urban road traffic safety risk evaluation index system that can both reflect the city's development direction and effectively prevent and control risks is important for the scientific and reasonable evaluation of urban road traffic safety risks, especially for reducing urban road traffic risks.

Developed countries began to use the system thought, in the 1990s through the fault tolerance means to enhance the level of traffic safety management, and other series, and based on the concept of fault tolerance and ideas such as the implementation of sustainable development, such as Sweden's "zero vision of death", "sustainable security" in the Netherlands, etc. S Rankavat [1] and others studied the risk perception of pedestrians in traffic accidents in different locations, and concluded that factors such as the number of lanes, sidewalk width, sidewalk maintenance, speed and traffic volume were significantly related to pedestrian risk perception. Domestic scholar Wang Tao [2] and others used gray cluster evaluation method to establish a gray cluster evaluation model for urban road traffic safety, and applied it to Shijiazhuang city roads as an example. Yanan Zhang [3] and others proposed the value of connection degree as the basis for evaluating the advantages and disadvantages of urban road traffic safety.
The above research is instructive and useful for analyzing urban road traffic safety. However, from the perspective of research, foreign scholars mainly focus on a specific influencing factor of people, cars, roads and other systems in urban road traffic safety; Domestic scholars mainly focus on using related theories to establish new evaluation models or using new evaluation methods to evaluate road traffic safety risks in target cities. However, these studies have given little consideration to the coupling effects of the current state of urban development and the influencing factors of urban areas. In view of this, this article fully considers the current situation of urban development in which disaster risks occur, extends the regional disaster system idea to urban road traffic safety risk assessment, provides theoretical support for the improvement of urban road traffic safety, and further provides a reference for safe city construction.

2. Thoughts on risk assessment based on regional disaster system theory

2.1. The main ideas of regional disaster system theory

At present, as opposed to a theory that focuses on a certain disaster factor to explain the occurrence and development of disasters, the theory of regional disaster systems based on system theory has been recognized and applied in various fields [4]. Among them, the "regional disaster system" is composed of human beings as disaster victims and the socio-economic systems formed by them and their dependent regional systems consisting of disaster environments and disaster factors, which have different degrees of impact on human sustainable development. "Man-land relationship regional system", this system recognizes and seeks the overall optimization, comprehensive balance and effective regulation mechanism of regional human-ground relationship system from the aspects of space structure, time process, overall effect, synergy and complementarity. Development and regional management provide the theoretical basis [5]. In a regional disaster system, the disaster recipient is a social system composed of humans and their activities, the disaster environment is an ecosystem, and the hazard factor is a gradual or sudden harm to human beings caused by the interaction between social systems and ecosystems developmental factors. In the system, the hazard factor is a necessary condition for the occurrence of a disaster, and determines the type and intensity of the disaster. The hazard body is a necessary condition for scaling up or reducing the disaster, and is the object of the hazard factor.

2.2. Risk evaluation ideas

Different scholars from different perspectives have conducted research on disaster risk assessment from different perspectives. Most scholars domestic and abroad have focused on a certain influencing factor acting on disaster risk, and rarely comprehensively consider the interaction of other parts of the regional disaster system. Georgina [6] made reducing the vulnerability of the disaster bodies as the key to reducing disasters. Birkmann [7] ranked the hazard factors with exposure and vulnerability as the root cause of the risks. The risk of hazards is closely related. Domestic scholars provide scientific basis for the formulation of comprehensive disaster reduction countermeasures in terms of the danger factors of disasters, the instability of the disaster environment, and the vulnerability of disaster bodies [4]. Therefore, regional disaster risk analysis should not only consider the risk of disaster factors, the instability of disaster environment and the vulnerability of disaster bodies, but also include the exposure of disaster bodies and the ability to cope with regional disasters.

In summary, based on the main ideas of the regional disaster system theory, according to domestic and foreign scholars' research on the content of hazard assessment, fully considering the various impact parts of the disaster, the risk assessment ideas based on the regional disaster system theory ideas are presented in Figure 1. Under the current situation of regional development, the magnitude of regional hazard is determined by the interaction of the risk of hazards, the exposure and vulnerability of regional disaster bodies, and the instability of the disaster environment.
3. **Construction of urban road traffic safety risk index framework**

The analysis of urban road traffic safety risks needs to combine the main ideas of the regional disaster system theory with the current status of urban regional development. The analysis and research of urban road traffic safety risks can better improve the scientific rationality of urban road traffic safety assessment. The factors influencing urban road traffic safety are mainly analyzed from the following aspects:

3.1. **Analysis of urban road network structure**

Urban road network structure has a close impact on road traffic safety. In the urban road traffic system, different road network structures have different characteristics. Therefore, according to different road network structures, different traffic management methods must be distinguished, and corresponding management and technical measures should be taken according to these different characteristics.

3.2. **Analysis of traffic subject structure**

The main structure of traffic is an important factor affecting the risk of urban road traffic safety, and the composition of urban road traffic is an important indicator of the main structure of traffic. The composition of urban road traffic refers to the types of urban road traffic flow, including large and small passenger cars, large and small trucks, non-motorized vehicles, pedestrians, etc. On most urban roads, mixed pedestrians, vehicles and non-motor vehicles are quite common, which makes the traffic composition of Chinese urban roads more complicated and has a greater impact on urban traffic safety.

3.3. **Analysis of urban road traffic environment**

The urban traffic environment mainly refers to the urban climate and geographical environment, population density, economic level, vehicle ownership and traffic management level. The impact of urban climate on urban road traffic is mainly reflected in strong convection weather. The traffic management department adopts appropriate management methods according to the climate and geographical conditions of the city. The higher the urban population density, the greater the urban road pressure, the higher the impact on urban traffic safety. The economic level and the number of vehicles owned by the city will affect the condition of road traffic and the related urban road safety environment. The emergency management measures taken directly affect the traffic safety status and traffic safety management level.
3.4. Urban road traffic safety risk indicator framework

Based on the above analysis of the factors affecting the development of urban road traffic safety, the factors affecting the risk of urban road traffic safety are analyzed, and the evaluation ideas of the regional disaster department are used to evaluate the factors of disasters. The four aspects of the disaster environment and disaster emergency response are to fully consider the basic conditions of urban road traffic, road demand trends, and road dynamic changes, and scientifically screen basic urban road traffic safety indicators. Based on the main ideas of the regional disaster system, a framework of factors affecting the risk of urban road traffic safety based on the regional disaster system is shown in Figure 2.

4. Example application

4.1. Data collection

This paper selects a city in western China as the evaluation object. The urban road traffic is composed of the complicated trunk road traffic system running through the whole province and the cross-linking surrounding provinces. The dense and diverse urban traffic bodies and the complicated traffic environment make the urban road traffic safety risk higher. This evaluation selects relevant data of the city in 2018 from field research, local yearbook, local statistical yearbook and people's government website.

4.2. Urban road traffic safety risk assessment system

This article fully considers the current status of urban regional development, and establishes an urban road safety risk evaluation index system as shown in Table 1 according to Figures 1 and 2 and referring to relevant specifications.

The weight of the factors affecting the risk of urban road safety is determined by the AHP.
basic steps of the analytic hierarchy process include constructing a hierarchical structure model, using expert scoring methods to form its judgment matrix, and checking the consistency of the judgment matrix. According to the calculation step [4] of the analytic hierarchy process, the characteristic roots of the discriminant matrix are obtained, and the weight values of all influencing factors of road safety risk are determined through the consistency check, as shown in Table 1.

4.3. Comprehensive Risk Calculation of Urban Road Traffic Safety

Through the analysis of regional disaster system theory, it is concluded that urban road traffic safety risks are the result of the combined effects of danger, exposure, vulnerability, environmental instability and disaster emergency response. The comprehensive risk of urban road safety is obtained according to the following formula [8]:

$$ R = \sum_{i=1}^{n} W_i \cdot \bar{x}_i $$

Where $R$ is the final risk value, $W_i$ is the weight of the first indicator, and $\bar{x}_i$ is the standardized data value of the indicator.

The calculated risk, exposure, vulnerability, instability, emergency response capability risk value, and comprehensive assessment of urban road safety risk values are shown in Table 1. The road safety risks are divided into 5 levels (between the risk assessment index 0-1) [8], as shown in Table 2. According to the comprehensive evaluation value of urban road safety risk, it is 0.5654. According to Table 2, it is concluded that the urban road safety risk is medium risk.

| System layer A | Factor layer B | Factor layer C | Indicator layer D | Weights | Risk assessment results | Comprehensive evaluation results |
|----------------|----------------|----------------|-------------------|---------|------------------------|---------------------------------|
| Hazards (B1)   | Risk (C1)      |                | Urban population density D1 | 0.0521  | 0.1999                 |                                 |
|                |                |                | Annual license revocation ratio D2 | 0.0820  |                        |                                 |
|                |                |                | Qualified rate of regular vehicle inspection D3 | 0.0175  |                        |                                 |
|                |                |                | Bad Road Ratio D4 | 0.0207  |                       |                                 |
|                |                |                | 10 thousand vehicle kilometers accident rate D5 | 0.0138  |                       |                                 |
|                |                |                | Vehicle overload accident rate D6 | 0.0442  |                       |                                 |
|                |                |                | Number of bad weather D7 | 0.0366  |                       |                                 |
|                |                |                | Growth rate of key illegal acts D8 | 0.0678  |                       |                                 |
| Urban road safety risk evaluation index system (A) | | | Number of drivers D9 | 0.0439  |                       | 0.5654                          |
|                |                |                | Vehicle ownership D10 | 0.0368  |                       |                                 |
|                |                |                | Dangerous transport vehicles D11 | 0.0641  |                       |                                 |
|                |                |                | Number of non-motorized vehicle ownership D12 | 0.0476  |                       | 0.1449                          |
|                | Exposure (C2)  |                | Land area ratio of road network D13 | 0.0222  |                       |                                 |
|                |                |                | Road density per capita D14 | 0.0235  |                       |                                 |
|                |                |                | Transportation Structure Vehicle Proportion D15 | 0.0151  |                       |                                 |
| Disaster bodies (B2) | | | Level of driver safety awareness D16 | 0.0512  |                       |                                 |
|                |                |                | Urban road network structure D17 | 0.0140  |                       | 0.1097                          |
|                |                |                | Road capacity D18 | 0.0245  |                       |                                 |
|                |                |                | Coordinated control rate of traffic signals and signs D19 | 0.0196  |                       |                                 |
Travel volume of people and cars \(D_{20}\) 0.0286
Population traffic regulations and safety knowledge penetration rate \(D_{21}\) 0.0579

| Disaster environment (B3) | Instability (C4) |
|--------------------------|------------------|
| Climate and geographical conditions \(D_{22}\) | 0.0253 |
| Vehicle management level \(D_{23}\) | 0.0202 |
| Driver management level \(D_{24}\) | 0.0306 |
| Road management level \(D_{25}\) | 0.0219 |
| Penalty for road violations \(D_{26}\) | 0.0375 |

| Disaster emergency response (B4) | Emergenc (C5) |
|-------------------------------|---------------|
| Communication and alarm capabilities \(D_{27}\) | 0.0194 |
| Time required for emergency rescue support and recovery \(D_{28}\) | 0.0256 |
| Road safety emergency evacuation time \(D_{29}\) | 0.0149 |
| Number of road safety rescue workers \(D_{30}\) | 0.0115 |
| Number of road safety plans \(D_{31}\) | 0.0086 |

According to Table 1, the main factors affecting the risk of urban road traffic safety are illegal driving, overloaded, the number of dangerous vehicles in the city, the level of driver and pedestrian safety awareness, and other factors that have a greater impact on urban road traffic risk. The actual conditions of urban road traffic safety are consistent.

Table 2. Urban Road Traffic Safety Risk Classification

| Risk level | Risk level | risk interval |
|------------|------------|---------------|
| I | high risk | 0.8000 |
| II | Higher risk | 0.6000-0.8000 |
| III | Medium risk | 0.4000-0.6000 |
| IV | Lower risk | 0.2000-0.4000 |
| V | low risk | <0.2000 |

5. Conclusion.
According to the main ideas of the regional disaster system theory, a disaster risk assessment idea based on the regional disaster system is proposed. At the same time, based on the analysis of urban road traffic safety risk index factors, a framework of urban road traffic safety risk influencing factors is proposed. And through the example verification, the risk index framework of urban road traffic safety is applied, and it is concluded that the risk evaluation ideas and risk index framework have certain scientific rationality.

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