Research on Risk Assessment in Typical Industries and Fields

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Abstract. To achieve scientific, effective and accurate prevention and control of major emergency, this paper summarizes and summarizes the research status of risk assessment at home and abroad. The paper summarizes and analyzes the current status and existing deficiencies of existing risk assessment studies from the types of events, time characteristics and event chains. The results of the thesis suggest that the primary problem of the current research is that the risk assessment is mostly based on the subjectively strong indicator system method, and the evaluation results cannot directly reflect the physical relationship between the risk level and the impact of the event. The consideration of risk dynamic characteristics is the focus and difficulty of the future risk assessment and evaluation process. Based on the theory of complex systems, the disaster chain has become the key to scientifically characterizing the level of risk.

1. Introduction

With the continuous optimization and improvement of the emergency response system, the emergency response has undergone a strategic transformation, which is characterized by a gradual shift from focusing on post-disaster relief to focusing on pre-disaster prevention and from responding to a single disaster to comprehensive disaster reduction. Furthermore, risk assessment research has become an important component of emergency response and prevention and control.

At present, many scholars have proposed concepts and assessment methods for risk assessment in their respective fields for scientific, effective, and precise prevention and control of various emergencies\textsuperscript{[1-4]}. This paper systematically summarizes the research progress of risk assessment at home and abroad, and summarizes and analyzes the current progress and shortcomings of existing risk assessment applications from the types of events, time characteristics and event chains. Moreover, the paper puts forward the problems that need to be solved in risk assessment and the future research priorities.

2. Risk Assessment Based on Event Type

2.1 Natural disaster risk assessment
2.1.1 System Theory and Disaster Risk Assessment
System theory is an important theoretical basis for research in natural disasters. From the perspective of system theory, the natural disaster risk is formed by the interaction of three sources: risk source, risk carrier and human society's disaster prevention measures. It is a kind of uncertainty that people cannot accurately grasp and are unwilling to accept. From a situational perspective, the risk of natural disasters is "a scenario in which future adverse events may be caused by natural events". Natural disaster risk assessment is the core of disaster emergency management and disaster prevention and mitigation.

![Diagram of Correspondence between Natural Disaster System and Natural Disaster Risk System]

Figure 1. Correspondence between natural disaster system and natural disaster risk system.

2.1.2 Natural disaster risk assessment Methods
At present, there are many methods for natural disaster risk assessment at home and abroad. From the method characteristics, it can be divided into qualitative methods, quantitative methods and semi-quantitative methods. From the model implementation of the method, it can be divided into extreme value method, probability method and fuzzy method. From the driving factors of the method, the assessment method of natural disaster risk can be divided into indicator-driven and pure data-driven methods.

2.2 Accident disaster risk assessment
2.2.1 Coupling in accident disaster risk assessment
Among the four types of emergencies, accident disasters have the highest degree of coupling with human production and life. Technical research on risk analysis, prediction simulation and emergency rescue for accident disasters is the core to promote urban safety development.

Compared with the natural disaster risk assessment, the risk assessment of accident and disaster events is quite different. The risk sources of natural disasters are relatively clear and clear, and the controllability is not strong. The risk assessment focuses on reducing the resilience of disaster-tolerant bodies. The danger sources of accident disasters generally exist in the production, use and operation of enterprises, and can be avoided or mitigated through better measures such as investigation and prevention. At the same time, the existence of such controllability increases the instability of the source of danger, especially in the field of safe production, the proportion of accidents caused by external factors is extremely large. This kind of coupling has become an important factor in the occurrence of accident disasters, and it is also a difficult point in related risk assessment research.

2.2.2 Risk assessment of accident disaster
In addition to the non-compliant operations in the production, use and operation of accidents, some accidents occur due to many external factors, such as floods, earthquakes, landslides, and lightning. Therefore, the risk assessment research of accident disasters can be roughly divided into two categories, one is the risk assessment for accidents caused by the failure of single safety production control measures, and the other is the risk assessment of accidents induced by external factors. Therefore, the accident disaster risk assessment can be summarized into three key links: external driver analysis, safety production failure mode analysis, and impact analysis.

2.3 Public health risk assessment
2.3.1 Infectious characteristics and public health risk assessment

(1) National public health emergency classification and risk assessment framework

At present, the risk assessment of public health emergencies at home and abroad mainly includes major infectious diseases, food poisoning, exposure to acute chemicals and risk assessment of large-scale activities[12]. Since April 2011, the China Center for Disease Control and Prevention (CDC) has started the monthly risk assessment. The assessment work is mainly carried out by means of expert consultations, and assesses the public health emergencies at home and abroad and the risks of key infectious diseases.

Figure 2. Public health safety incident risk assessment process

(2) Risk assessment of public health events with contagious features

The evaluation and consideration of contagiousness is the core of the risk assessment of public health emergencies, and it is also a distinguishing feature which is different from the other three types of emergencies[13].

Due to the existence of this contagiousness, time and space elements need to be included in the risk assessment process for public health emergencies. Time dimension mainly refers to the evaluation and analysis of the survival and transmission timelines of pathogens, and the corresponding risk control for time-effect analysis; spatial dimension mainly refers to the fact that the public health event risk source can be moved in space due to contagiousness, and the event impact The spatial extent of the expansion is scalable, which requires the identification of risk sources in the public health event risk assessment to be accurate and comprehensive, and to the source of the risk.

Figure 3. Infectious theroy in public health risk assessment

2.3.2 Main methods of risk assessment for public health events

(1) Risk assessment of major infectious diseases based on kinetic modeling

In view of the research needs of the transmission mechanism and damage mechanism in the risk assessment of major infectious diseases, the indicator system method cannot meet the risk assessment of major infectious diseases. Using dynamic modeling method to study the interaction between pathogens and social systems and to elucidate the development law of infectious diseases situation is an important research field of public health events of major infectious diseases. This is also one of the methods to characterize the quantitative relationship between risk source and disaster bearing body in risk assessment.
In current academic research, Compartment models, Network models, Agent-Based models (ABM), and Metapopulation models are used\[^{[14-15]}\].

(2) Risk assessment of food poisoning based on quantitative microorganisms

The risk assessment of food poisoning collects sufficient information through epidemiological studies, toxicological studies, in vitro experiments, etc., and establishes models of exposure dose and adverse reactions to estimate the possible adverse effects of people exposed to a particular risk source\[^{[16]}\]. Risk response strategy. The primary method of risk assessment for food poisoning is to quantify microbiological risk assessments, to determine the likely response to the food chain by simulating the likelihood of pathogenic infections in the food chain due to food consumption, and to assess the effectiveness of various measures.

(3) Risk assessment of exposure to acute chemical substances based on the indicator system method

Risk assessment of exposure to acute chemical substances is often based on a combination of qualitative and quantitative analysis, and the indicator system method is used more. Specifically, the indicator system used mainly includes the types of hazardous materials, physical and chemical properties and their forms, exposure time and exposure concentration, morbidity, mortality, and preventive control measures\[^{[17-18]}\].

(4) Risk assessment of public health events in large-scale activities based on matrix method

Large-scale activities have the characteristics of cross-regional, large number of participants or followers, high concentration of people, long duration, and great social influence. The flow and concentration of large populations in a short period of time tends to increase the risk of occurrence and spread of sudden infectious diseases. The risk assessment of large-scale activities is mainly to identify all the risks and characteristics that may exist in a certain period and in a certain area. The risk matrix method is often used in such research\[^{[19]}\].

3. Time-based Risk Assessment

3.1 Long-term static risk assessment for zoning

From the perspective of service targets, most of the current risk assessment research work is used to guide the spatial and temporal distribution of regional cognitive risks, and to carry out risk prevention and control through long-term measures such as disaster relief material bank construction and industrial structure adjustment. This type of risk assessment can be summarized into three characteristics, namely, zoning, long-term, and static.

3.1.1 Research mostly use statistics

From the perspective of risk assessment data sources, the long-term and static risk assessment for zoning mainly uses statistical data such as accident frequency data, hazard body attribute data, and disaster data as data sources. The statistical data can truly reflect the long-term disaster/accident situation in the area, including the occurrence and impact.

3.1.2 Research mainly based on indicator system

Risk assessment by constructing an indicator system is a common method used in conducting risk assessment work in various fields. Taking natural disasters as an example, in the drought risk assessment, Liu Hang et al.\[^{[20]}\] based on the natural disaster risk theory, from the hazard factor risk, the exposure to the disaster environment, the vulnerability of the disaster-bearing body, and the ability to prevent and mitigate disasters. The drought disaster risk index system was established. In the geological disaster risk assessment, Wang Yanlin et al. constructed a total of nine indicators including geological hazard and geological hazard economic and social vulnerability, and carried out research on geological hazard risk zoning in Shaanxi Province\[^{[21]}\].

3.1.3 The assessment results are mostly presented in the form of risk zones
Risk zoning is one of the main outcomes of a series of risk assessment studies currently under way. The risk zoning can visualize the spatial distribution of the risks of various types and levels at medium and long-term scales. Through risk zoning, relevant responsible entities can conduct forecasting and warning, disaster prevention and mitigation, and disaster management in a more scientific and targeted manner.

3.2 Event-oriented real-time dynamic risk assessment
In addition to the above-mentioned static risk assessment work serving risk zoning, the practical guiding significance of the real-time risk assessment work for the emergency response and rescue and emergency risk trends of an emergency or pre-occurrence phase more prominent. This type of risk assessment can be summarized into three characteristics, namely event-oriented, real-time, and dynamic.

3.2.1 Data sources are often combined with real-time data and statistical data.
From the perspective of risk assessment data sources, the real-time and dynamic risk assessment of events is mainly based on event real-time attribute data and disaster-bearing body data. The real-time data acquisition methods are mostly sensor monitoring and forecasting data, and have real-time performance. Real-time data can truly reflect the event situation, loss situation, etc. at the current moment.

3.2.2 The evaluation method is mainly based on model simulation.
Constructing mathematical models for event situation and loss pre-assessment is an important method for conducting event-oriented rapid risk assessment. The US HAZUS disaster assessment software system estimates the socio-economic losses and risks caused by disasters. Zhou Hongjian[22] portrayed the relationship between extreme heavy rainfall, house vulnerability and damage by constructing a damage house evaluation model.

4. Event Chain and Risk Assessment
Chain and coupling characteristics have gradually become an important feature of public safety events, which makes the harm and impact caused by an event far greater than the single disaster event. Therefore, risk assessment from the perspective of the event chain can better reduce the losses caused by the disaster chain effect.

In the field of disaster research, some scholars have carried out specific research on the characteristics of disaster chain network structure, disaster chain construction of typical disasters, and cumulative effect evaluation methods of disaster chains[23]. Among them, the empirical disaster statistical model, probability model, complex network model, disaster chain simulation and disaster conceptual model under multi-domain knowledge are commonly used evaluation models[24]. The research of complex network structure is the basis and entry point of event chain research. Liu Aihua et al. proposed a disaster chain risk assessment model based on complex network structure[25], which provides a good reference and reference for disaster chain risk assessment research.
Table 1. Risk calculation model for chained events\[^{25}\]

\[
R = \sum_{i=1}^{n} P_i L_i
\]

Consider only node risk, \(P\): probabilities, \(L\): losses

\[
R = \sum_{i=1}^{n} P_i L_i + \sum_{t=1}^{T} P_{et} L_{et}
\]

Consider node and edge risk, \(P\): probabilities, \(L\): losses

5. Conclusions and discussion

This paper systematically summarizes the research progress and shortcoming of risk assessment at home and abroad, from the dimensions of events, time characteristics and event chains, and puts forward the urgent problems needed to be solved and the future research emphasis in risk assessment.

(1) The physical significance of the risk assessment results needs to be emphasized. The primary problem of the current research is that the risk assessment is mostly based on the subjectively strong indicator system method, and the evaluation results are mostly presented in the form of risk levels based on the matrix method or a certain level of division criteria. This risk assessment result is applicable to characterizing the risk level between different time zones in the same area or different regions at the same time, but it cannot directly reflect the physical relationship between the risk level and the impact of the event.

(2) The assessment process should consider the dynamics of the risk. With the continuation of the incident time, in addition to grasping the current event situation, emergency personnel should also assess the risk change trend in the future from the perspective of risk, and achieve effective disposal and prevention before the event occurs.

(3) Risk assessment should integrate disaster chain information. Based on the theory of complex systems, the disaster chain has become the key to scientifically characterizing the level of risk. Therefore, the risk assessment should be based on the formalized description results of the disaster chain to study the trigger factors and trigger threshold of the chain structure. The above trigger factors and thresholds should be fully integrated into the assessment process to improve the rationality and comprehensiveness of risk assessment.

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