Review of risk assessment methods for infectious diseases

Xinxing Han*
Institute of Public Safety Research, Department of Engineering Physics, Tsinghua University, Beijing, 100084, China
*Corresponding author’s e-mail: hanxxydy123@126.com

Abstract. At present, the global epidemic situation of infectious diseases is becoming more and more serious and complex, which brings difficulties and challenges to the prevention and control of infectious diseases and poses a serious threat to public health and safety. The premise and basis of the prevention and control of infectious diseases is to carry out scientific risk assessment. Firstly, the common risk assessment methods were introduced, and the limitations of these one-time static assessment methods were analysed. Then the dynamic risk assessment methods for the transmission of infectious diseases were introduced, and expressing the transmission of infectious diseases as scenarios was proposed. Scenarios were deduced to predict the future development trends of infectious diseases. It is of great positive significance to evaluate the risks of infectious diseases according to different development trends, and realize the transition from traditional "prediction-response" to "scenario-response" for improving the emergency management capability of the transmission of infectious diseases.

1. Introduction
In recent years, various kinds of public health incidents occur frequently, especially the risk of infectious diseases, which poses a serious threat to public health security. At present, the global epidemic situation of infectious diseases is becoming more and more complex and severe. Not only are the number of new infectious diseases increasing and the variation of infectious disease pathogens increasing, but also with the further acceleration of China’s opening up and the impact of global economic integration, frequent transnational travel and trade activities have intensified the risk of transnational transmission of infectious diseases[1-4]. It brings new difficulties and challenges to the prevention and control of infectious diseases, and scientific assessment of the risk of infectious diseases is essential to the effective prevention and control of infectious diseases[5].

2. Commonly used risk assessment methods for infectious diseases
Risk assessment is a process of logical judgment of uncertain events or outcomes by scientific methods for decision-making purposes[6]. The process of risk assessment generally consists of three stages: risk identification, risk analysis and risk evaluation (As shown in Figure 1[7]). In the process of risk assessment, there are many kinds of commonly used risk assessment methods, mainly including expert consultation method, Delphi method, analytic hierarchy process, risk matrix method, etc. Among them, expert consultation method[8,9] is the form of collective discussion for experts to evaluate. According to the key content of risk assessment, the organizer prepares a series of questions related to risk assessment in advance, and organizes the experts participating in the consultation for full discussion according to the content of the assessment and relevant evidence, combined with their own knowledge and experience, and puts forward relevant opinions and suggestions on risk...
assessment. The consultation organizers summarize and sort out the risk assessment reports according to the opinions of experts. The core of Delphi Method[10-12] is to conduct several rounds of inquiries for seeking the opinions of experts through anonymous letters. The research group collects and collates each round of opinions, and sends them to each expert for analysis and judgment as reference materials, so as to put forward new argumentation opinions. Repeated like this, opinions gradually tend to be unified, and eventually a more consistent and reliable conclusion or program is obtained. Analytic hierarchy process[13-16] is suitable for multi-objective, multi-level and multi-factor complex systems, especially in the case of complex structure of target factors and lack of necessary data. The basic idea is to divide the levels according to the interrelation of each factor, then compare the importance of each element in the same level with respect to a criterion in the parent level according to the expert opinion, and finally construct the judgment matrix to determine the weight of each evaluation index. Risk matrix method[17-19] usually classifies or quantifies the probability of risk occurrence and consequence according to certain criteria in advance through more intuitive experience of experts, and then conducts multiplication calculation of the possibilities and the seriousness of consequences included in a two-dimensional matrix to obtain the corresponding risk grade according to the criterion of risk importance.

Relevant scholars use these commonly used risk assessment methods to assess the risk of infectious diseases. For example, Tu et al.[20] used expert consultation method and invited experts from provincial (autonomous regions, municipalities directly under the Central Government) Centers for Disease Control and Prevention to participate in the evaluation through video conference based on information on public health emergencies reports and surveillance of key infectious diseases at home and abroad. Qi et al.[21] collected the public health background information of infectious disease-related events in Zhejiang Province, and formulated the risk criteria of public health for emergent infectious disease events and the risk criteria for the impact of public health risks on the G20 Summit in the periphery of Hangzhou City by using literature search, brainstorming and expert consultation methods, and then carried out risk assessment and proposed suggestions on risk management and control. Wang et al.[22] used Delphi method to assess the transmission risk of mosquito-borne infectious diseases in Rizhao City in 2016, providing reference for prevention and control of mosquito vector and mosquito-borne infectious diseases in the next stage. Wang et al.[23] used Delphi method to confirm and determine the risk assessment factors of influenza A (H1N1) and used risk matrix method to confirm the risk level. It was considered that the risk assessment system was suitable for the early assessment of influenza A (H1N1) and could be applied to the respiratory infectious diseases at other ports. Lu et al.[24] used risk factor assessment method, risk matrix method and Delphi method to identify and assess the risk of the epidemic events of infectious diseases on international cruise lines by questionnaire of experts in relevant fields. Yang et al.[25] collected relevant data by means of on-site investigation, literature review and visits to local Center for Disease Prevention and Control, and used risk matrix method to assess the risk of vector-borne diseases in Zhurihe training base. Chen et al.[26] used expert consultation to sort out and establish the risk index system of intestinal infectious diseases after typhoon disaster, and applied analytic hierarchy process to judge the relative importance of indexes and calculate the weight of indexes. Three counties of Wenzhou City were randomly selected to collect or investigate the value of each index, and then the risk score was calculated and the risk value was corrected combined with the weight.

In addition, experts used modeling methods to assess the risk of infectious diseases, such as Sandra et al.[27] assessed the risk of malaria resurgence in the Ebro Delta by combining the modified climate diagrams, the Gradient Model Risk (GMR) index and spatial characterization. Yang et al.[28] produced reliable risk maps reflecting the distribution and intensity of malaria transmission by integrating biology-driven models with statistical regression models.
3. Risk assessment of infectious diseases based on emergency intervention

The common risk assessment methods of infectious diseases are introduced above. Generally, the risk level of infectious diseases is assessed directly by these methods or the risk of infectious diseases is predicted by mathematical modeling. Then, the prevention and control measures are put forward according to the assessment results. These assessment methods are all one-time static risk assessment. However, the actual transmission of infectious diseases is a dynamic process, which is always subject to emergency intervention in the process of large-scale transmission of infectious diseases. A series of measures will be taken, such as quarantine, vaccination and so on. When different emergency interventions are taken, the possibility and consequences of the transmission of infectious disease will also change, and the results will have an impact on the next emergency measures. Therefore, it is particularly important to reevaluate the risk of infectious diseases after emergency intervention. This is a dynamic risk assessment of the transmission of infectious diseases in time and space dimensions. It can adjust the direction of emergency measures in time and allocate emergency resources reasonably according to the results of dynamic risk assessment.

Relevant experts and scholars have also done some research in this area, such as, Ni et al.[29-30] studied the impact of quarantine, contact tracing, antiviral prophylaxis, vaccination, school closure and travel restriction strategies on the transmission risk of infectious diseases. Fan[31] studied three types of infectious diseases with population heterogeneity: hand-foot-mouth disease (HFMD), varicella and AIDS, established a model of infectious diseases with heterogeneous factors, analyzed and simulated the model, and then evaluated the impact of the control strategies of infectious disease on the infected number. Xu[32] established a dynamic model of the transmission of influenza pandemic, and quantitatively assessed the impact of the timing and duration of school closure measures on the transmission behavior of epidemic.

4. Discussion

For the commonly used risk assessment methods for infectious diseases, some scholars refer to the experience of relevant international and domestic risk assessments and develop risk assessment criteria first, then use brainstorming, expert consultation, risk matrix and other methods to directly assess the
probability level, consequence level and risk level of infectious diseases based on the monitoring data of infectious disease. These methods have certain subjectivity and one-sidedness. Sometimes there is a difference between the decision makers, and the evaluation results are not consistent with the actual situation. Some scholars use Delphi method and analytic hierarchy process to establish risk assessment index system for the risk assessment of infectious diseases. However, many factors need to be considered in risk assessment index system, such as the types of infectious disease, etiology, epidemiology, clinical medicine, toxicology, social factors, natural factors, prevention and control capabilities, etc. Therefore, it is very important to establish a scientific and comprehensive risk assessment index system for the accuracy of risk assessment results, but it is difficult to do so in the actual assessment process, which may lead to the overestimation of low-risk infectious diseases and waste of human and material resources, and may also lead to the underestimation of high-risk infectious diseases and insufficient prevention and control, resulting in major economic losses or even serious harm to human and animal health[33].

The commonly used assessment methods mentioned above are all one-time static assessment of the risk of infectious diseases, but the transmission of infectious diseases is a dynamic process, which is always subject to emergency intervention in the process of transmission. Static assessment has gradually failed to meet the decision-making and management needs of the risk of infectious diseases. So some experts conduct a dynamic assessment of the transmission risk of infectious disease after emergency intervention. For the dynamic risk assessment of infectious diseases, we can express the transmission of infectious diseases as a scenario, then deduce the scenario, predict the future development trends of infectious diseases, and evaluate the risk according to different development trends. Different scholars have different understandings of the so-called scenarios, such as Godet[34] believes that scenarios are composed of a series of descriptions of the future and the process from the initial situation to the future situation. Schoemaker[35] argues that scenarios are descriptions of possible future features with script styles and detailed descriptions, with particular attention to causality, internal consistency and specificity. Schwartz[36] argues that scenarios are a tool for perceiving the future with a set of stories. Liu[37] believes that scenarios are totally different from traditional "typical cases". Scenarios are not projections of a specific event, but a collection of innumerable similar events and expected risks. Lou[38] considers scenarios as a hypothesis based on high importance and high uncertainty, and a selective and diversified description of the future through systematic analysis. Therefore, we can extract the key scenario elements of the transmission of infectious disease for scenario combination by means of hypothesis, prediction, simulation and so on. On this basis, we can judge the future development trends of infectious disease under the combined effect of internal and external environmental factors and emergency management factors, and carry out the dynamic risk assessment of each development trend. This can realize the transformation from traditional "prediction-response" to "scenario-response", not only abandoning the traditional method which only focuses on the "past", but also realizing the reasonable transition from "past" to "present" to "future", in addition abandoning the limitations of traditional methods limited to factor statistical analysis and realizing the concept of system analysis[39], which has a very positive significance for assessing the transmission risk of infectious diseases and improving the emergency management of infectious diseases.

5. Conclusion
Firstly, some common risk assessment methods for the transmission of infectious disease were introduced, and the limitations of these common methods for the risk assessment of infectious disease were analyzed and discussed. As a one-time static assessment, these commonly used risk assessment methods have gradually failed to meet the needs of decision-making and management of the risk for infectious disease. In this regard, dynamic risk assessment methods of some scholars for the transmission of infectious diseases were introduced. It is proposed that the transmission of infectious diseases can be expressed as a scenario, and then the scenario is deduced to predict the future development trends of infectious diseases. The risk of infectious diseases is assessed according to
different development trends, so as to realize the transformation from traditional "prediction-response" to "scenario-response", and then improve the emergency management capability of the transmission of infectious disease.

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