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Regional Infectious Disease Risk Assessment Method

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Abstract

In the post-pandemic era, people are increasingly aware of the dangers of malignant infectious diseases and the important role of regional healthcare security. At present, the research on the pathology of malignant infectious diseases has become one of the hot spots in the field of medical care. However, research on the assessment of infectious disease risk in regions that are equally important appears to be very scarce. Faced with the risk of sporadic outbreaks of infectious diseases, regional infectious disease risk assessment has important theoretical and practical significance. Especially in the early stages of infectious disease outbreaks, the assessment results play an important role in helping to develop reasonable prevention and control strategies and suppressing further losses caused by infectious diseases. This study proposes a regional infectious disease risk assessment method based on D-S (Dempster Shafer) evidence theory. Firstly, based on existing research results, construct an infectious disease risk model. Then, map the regional risks and the actual situation of infectious diseases into the risk model to obtain the necessary data for risk assessment. Next, the fusion assessment results of regional infectious disease risk are calculated using the D-S theory. The assessment results can demonstrate the level of infectious disease risk in the region and the weaknesses when the region faces different types of infectious diseases. Finally, the study verifies the effectiveness, rationality, and feasibility of the proposed method through case design and analysis.

Keywords: Healthcare; Regional infectious disease risk; Risk assessment; Risk fusion; D-S theory

Introduction

The outbreak of Corona Virus Disease 2019 (COVID-19) at the end of 2019 swept the world in a very short period [1,2], bringing huge disasters to countries and people all over the world. People are increasingly aware of the dangers of malignant infectious diseases and the importance of regional healthcare security. Irregular outbreaks of malignant infectious diseases, such as avian influenza [3], west nile virus [4], *streptococcus suis* [5], global A/H1N1 influenza [6], dengue fever [7], COVID-19, have become a world recognized fact. The risk of infectious diseases refers to the potential harm and losses that may be caused during the emergence, transmission, occurrence, and disappearance of various infectious diseases. The current level of human technology is not yet able to fully predict the risk of such sporadic outbreaks of malignant infectious diseases. Compared with waiting to die, actively understanding and mastering the risk level of infectious diseases in the region, and improving the ability to prevent and respond to sudden malignant infectious diseases in the area of medical care will save more lives to a large extent and effectively reduce the losses caused by malignant infectious diseases.

After the emergence of the epidemic, various regions have understood the shortage and importance of medical resources. More and more medical resources and research related to infectious diseases are constantly emerging. These have obvious positive effects on the prevention and control of malignant infectious diseases, and can effectively reduce casualties and losses in all aspects after the outbreak of the epidemic. However, these are insufficient to predict the outbreak of malignant infectious diseases and control the spread of infectious diseases. As a result, when new malignant infectious diseases appear, it is difficult for regional governments and medical institutions to fully understand the risks to regional healthcare security and quickly formulate reasonable and effective prevention and control strategies relying on existing research results. Therefore, how identifying key elements from numerous infectious diseases influencing factors, and assessing and determining regional infectious disease risks, has become an effective solution to solve the above problems.

In response to the above issues, this study proposes a regional infectious disease risk assessment method based on the Dempster–Shafer (D-S) evidence theory. Based on the factors influencing infectious disease risk proposed by predecessors, a risk assessment model for infectious diseases is constructed. Based on the model, the fusion rules of D-S theory are used to integrate the regional infectious disease risk situation with the actual risk situation of various infectious diseases. Through the fusion results, on the one hand, the level of resistance to various infectious diseases in the region can be evaluated; on the other hand, the fusion results can be used to identify the shortcomings of the region in preventing and controlling infectious diseases, to make up for the shortcomings in dealing with different types of infectious diseases, thereby reducing unnecessary redundant construction and resource waste. The research in this study is the extension and application of D-S evidence theory in the field of healthcare. It has important theoretical significance and practical value for reducing regional healthcare risks, monitoring the status of regional healthcare risks, formulating reasonable strategies in the event of an epidemic, and thus suppressing further losses caused by infectious diseases.

The remainder of this study is organized as follows: In section two, we introduce the current research status in healthcare, infectious diseases, and risk assessment methods. In section three, we introduce the relevant concepts and models needed for the research. In section four, a detailed introduction to the infectious disease risk assessment method based on D-S theory is provided. In section five, a specific case is proposed and the effectiveness and feasibility of the proposed method are demonstrated through case analysis. Finally, the conclusion and future research are given in section six.

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Literature Review

Healthcare

In addition to research in pathology and pharmacology, the main content of research in the field of infectious diseases is: firstly, technological innovation, that is, the use of artificial intelligence, machine learning and other technologies to improve the level and ability of prevention and control; the second is research on content and models, which analyzes influencing factors and evaluates models based on existing infectious disease safety.

In terms of technology, Eze et al., explored the potential of unsupervised anomaly detection machine learning technology to discover epidemiological signals of interest, and pointed out that anomaly detection is a potentially valuable approach to discovering patterns of epidemiological importance [8]. Literature looks forward to three possibilities for the development of artificial intelligence in the healthcare field: Firstly, AI will diagnose all patients [9].A second possibility is that more patients can be analyzed with AI, with doctors examining fewer patient cases, thus reducing the number of people treated by doctors and decreasing healthcare system spending. A final possibility is that AI will aid clinicians by helping doctors make better clinical choices, improving patient outcomes and cost efficiencies. Literature have pointed out that artificial intelligence in healthcare can help strengthen patient diagnosis, improve prevention and treatment, increase cost efficiency, and provide fair access and treatment for all [10,11]. From the above research, it can be seen that, AI innovation is crucial within healthcare to create new methods for facilitating and tackling healthcare challenges and discovering new opportunities [9].

In terms of the influencing factors of infectious diseases, Li et al., pointed out that the factors affecting epidemic risk include biological factors of the pathogen itself, natural factors related to climate, and social factors [12]. McConnon PJ pointed out that public health and related policies are important factors in infectious disease control [13-15]. Hu et al., introduced the concept of population density into the epidemic transmission model, studied the epidemic transmission mechanisms of different population densities, and pointed out that population density is a key factor affecting the spread of infectious diseases [16]. Liu et al., pointed out that there is an important correlation between population Health literacy and epidemic infection [17]. Zhaoying T pointed out that factors affecting the risk of the epidemic include geographical factors, climate factors, and customs [18]. Smith R pointed out that geographical location is an important factor affecting the spread of epidemics [19,20].

Assessment of epidemic risk

At present, there is little research on healthcare risk assessment. The assessments that have been conducted are all focused on specific disease risk studies, and the relevant prevention and control measures are only targeted at certain epidemics [21,22]. As a disaster, epidemic risk can also refer to some common risk assessment methods, such as modelling and assessment based on risk probability [23]. In addition, with the outbreak of the COVID-19 epidemic, some scholars have begun to propose a general model for epidemic risk assessment. Gong et al., proposed a comprehensive risk assessment model based on probability, severity, and vulnerability [24]. Chen et al., proposed a quantitative assessment method for the control effect of COVID-19. Tao et al., defined epidemic risk as a combination of likelihood, severity, and sensitivity, and evaluated the risk of school opening. Seuc proposed a framework called Comparative Disease Assessment (CDA) to assess the impact of the incidence rate of exposure to certain diseases on health outcomes [25-27].

Akhtar et al., proposed a deep residual network based on dragonfly rider competitive group optimization for IoT big data classification [28]. Katib et al., designed a new heap-based deep quantum neural network optimization model for decision-making in intelligent medical applications [29].

Overall, there is little research on the overall risk assessment and prediction of regional infectious diseases. Existing research either innovates the original medical treatment level from a technical perspective or analyzes the risk factors of infectious diseases. These can indeed improve some of the local prevention and control levels. However, the assessment of the overall risk of infectious diseases in the region can lead to more effective prediction and prevention and control of future outbreaks and control of infectious diseases. In addition, these studies have failed to integrate and screen these risk factors, and have not established a comprehensive risk assessment model. Most studies only discuss the relationship between risk factors and epidemics, without quantitative assessment. Although some scholars have proposed relevant assessment models, these assessment models usually only evaluate the risk state at a certain moment and cannot perform dynamic assessment, resulting in little impact of assessment results on decision-making.

Definitions and models

Literature points out that risk is a combination of the harmfulness and likelihood of a hazardous event that has not yet occurred. Literature suggests that conventional risks generally include three aspects: The expected loss caused by the occurrence of the risk, the probability of the risk occurring, and the detectability of the risk [30,31]. Regional infectious disease risk is a specific manifestation of risk in the field of healthcare and belongs to the scope of risk analysis, management, and research. Based on the concept of risk, combined with the characteristics and attributes of infectious diseases, this study clarifies the content of regional infectious disease risk as the expected loss L of risk occurrence, the steady-state probability Q of risk occurrence, and the uncertainty U of risk.

Explanation (Regional Infectious Disease Risk, (RIDR))

Regional Infectious Disease Risk (RIDR) is a quadruple, RIDR= {Q, L, U, F}, where,

1. Q is the steady-state probability and probability of the occurrence of infectious disease risk, corresponding to the probability of risk occurrence in traditional risk definitions. Steady-state probability is the probability of the outbreak of epidemic Sexually transmitted infection calculated according to regional medical, education, transportation, environment and other factors. The higher the Q value, the greater the probability or frequency of risk occurrence.

2. L is the potential loss and degree of harm caused by an outbreak of infectious disease risk. Assessing the degree of loss can effectively assist regional management departments in making reasonable choices to reduce the degree of loss and harm. The higher the L value, the greater the loss it brings when the risk occurs.

3. U is the uncertainty of infectious disease risk, corresponding to the degree of risk detectability in traditional risk definitions. Uncertainty can be understood as the difficulty of detection or control, referring to the difficulty of predicting, detecting, mitigating, or controlling the risk of such infectious diseases. The more single the influencing factors are for a specific risk, the easier it is to predict and detect. The larger the U value, the higher the uncertainty of the risk, and

the more difficult it is to predict, detect, and control.

4. F is the set of main influencing factors and assessment indicators of infectious disease risk, F= {f1, f2, …, fn}. This study summarizes 12 factors that affect healthcare risks based on the characteristics of the healthcare field, using methods such as survey research and literature review.

According to the definition and description of infectious disease risk, we have summarized the main indicators of infectious disease risk in the affected areas [32] (Table 1) and built a hierarchical model for regional infectious disease risk assessment (Figure 1) according to the definition and description of three aspects of risk content.

Regional healthcare risk assessment method based on D-S theory

D-S theory: The evidence theory was first established by renowned scholars Dempster-Shafer; hence it is also known as the D-S evidence theory. It is viewed and analyzed by transforming propositions into mathematical sets. The most important things in D-S theory are to determine the scope of the answer to the question (identification framework), allocate the probability of the evidence set (basic trust allocation function), and synthesize the evidence probability data (dempster synthesis rule). Advantages of D-S evidence theory: Due to the need for prior data in evidence theory being more intuitive and easily obtainable than in probability reasoning theory, and the Dempster synthesis formula being able to integrate data or knowledge from different experts, evidence theory has been widely applied in fields such as pattern recognition, data mining, artificial intelligence, decision support, expert systems and information fusion [33-36].

The D-S evidence theory also has some limitations. The limitations are mainly reflected in: Firstly, the theory requires that evidence must be independent; secondly, as the types of evidence increase, the identification framework may face potential exponential explosion issues.

In this study, the influencing factors of various infectious diseases are the evidence in the D-S theory. When analyzing and organizing the influencing factors, we have carefully analyzed and classified them to ensure the independence between the influencing factors. On the other hand, in response to the potential exponential explosion problem of identification frameworks, the root cause of exponential explosion lies in the exponential growth of the number of combinations between different evidence as the evidence increases, mainly reflecting the non-independence and uncertainty between the evidence. The research in this article shows that different influencing factors are independent of each other, and the influencing factors included in the three aspects of risk are relatively stable. Although there are 12 influencing factors, the number of theoretical recognition frameworks has reached 212. However, based on the risk content to be identified, the number of recognition frameworks is only 12. Therefore, the research here can effectively avoid the limitations of the D-S theory, and the research method has a solid theoretical foundation.

The three most important contents in D-S theory are recognition framework, basic probability assignment and Dempster synthesis rule.

Recognition framework

Θ= {θ_1,θ_2,…,θ_n }, Among, θ_1,θ_2,…,θ_n represents a set of mutually exclusive basic assumptions that can form a complete belief, namely: θ_i∩ θ_j=∅, i≠j; i,j=1,2,…,n. The set composed of all subsets of Θ is called its power set, denoted as 2^Θ.

Basic Probability Assignment (BPA)

BPA (Basic Probability Assignment) refers to the process of calculating the basic probability of each piece of evidence in the identification framework, using the basic probability allocation function, also known as the m function. The m function reflects the reliability of a proposition, denoted as m (x), and satisfies:

$$m: 2^{\Theta} \rightarrow [0,1]$$

$$m(\emptyset) = 0, \sum_{A \subseteq \Theta} m(A) = 1$$

m (A) reflects the support of evidence for proposition A, and its value is the basic trust allocation value of the proposition.

D-S synthesis formula

For ∀A⊆Θ, identify a finite number of m functions on the framework m_1,m_2,m_3,…,m_n. Their synthesis formula is as follows:

$$m(A) = [m_1 \oplus m_2 \oplus m_3 \oplus \ldots \oplus m_n](A)$$

$$= \begin{cases} 0, & A = \emptyset \\ \frac{1}{K}\sum_{A_1 \cap A_2 \cap \ldots \cap A_n = A} m_1(A_1)m_2(A_2)\ldots m_n(A_n), & A \neq \emptyset \end{cases} \quad (1)$$

Among them, K is named as the normalization factor, also known as the conflict factor, which reflects the level of conflicts between different evidence sources. The larger the K value, the more severe the conflict. In this study, it is indicated that the lower the compatibility between regional risk factors and the inherent factors of infectious diseases, the lower the overall risk of outbreaks of this type of infectious disease in the region.

$$K = \sum_{A_1 \cap A_2 \cap \ldots \cap A_n \neq \emptyset} m_1(A_1)m_2(A_2)\ldots m_n(A_n)$$

$$\sum_{A_1 \cap A_2 \cap \ldots \cap A_n = \emptyset} m_1(A_1)m_2(A_2)\ldots m_n(A_n) \quad (2)$$

Regional infectious disease risk assessment methods and processes

The overall calculation framework for regional infectious disease risk assessment is shown in Figure 2. The input to the calculation process mainly comes from two aspects: Firstly, regional factors related to the occurrence, transmission, and control of infectious diseases. Map the actual situation of these factors into the evaluation model to obtain data on the influencing factors of regional infectious disease risk. On the other hand, the characteristics of infectious diseases. Map the specific characteristics of a certain infectious disease into the evaluation model to obtain data on various influencing factors of the infectious disease. After obtaining regional risk factor data and relevant data on infectious diseases, use the D-S evidence theory to calculate the fusion evaluation results of the two aspects of data. The specific calculation process is shown below.

Input: Regional feature data related to various risk factors. Data related to the characteristics of a certain infectious disease.

Output: Overall situation of a certain infectious disease risk in the region Rd. The steady-state probability Q, loss expectation L, and uncertainty U of the occurrence of this type of infectious disease in the region. Matching results between regional factors and characteristic factors of infectious diseases fi, i=1, 2, …, 12.

Step 1: Construct the risk assessment model based on the content of regional infectious disease risks.

Step 2: Receive and obtain data on regional infectious disease influencing data and the characteristics of infectious diseases to be assessed.

Step 3: Map the regional feature data and infectious disease feature data onto the assessment model respectively to obtain the regional infectious disease risk factor data Rf= { r(f1), r(f2), …, r(f12) } and infectious disease risk data Df= { d(f1), d(f2), …, d(f12) }.

Step 4: As per Formula (2), calculate the conflict coefficient Kf using Rf and Df as inputs.

Step 5: Substitute Rf, Df and Kf into formula (1) to calculate the fusion assessment result fi for each risk factor.

Step 6: Based on the correlation between risk content Q, L and U in the assessment model and risk factors, calculate the regional risk contents Rc= { rr (Q), rr (L), rr (U)} and the infectious disease risk contents Dc= { dr (Q), dr (L), dr (U)}, respectively.

Step 7: Using Rc as the regional risk weight information and Dc as the infectious disease risk information to be evaluated, the risk content fusion evaluation results Q, L and U can be calculated by multiplying the two.

Step 8: The overall risk of infectious diseases in a region can be calculated by the following formula:

$R_d = \sum_{i=1}^{3}(\omega_i \times A_i), A_i \in \{ Q, L, U \}$. ω_i can be set according to the actual situation in the region.

Case analysis

Case study: To verify the effectiveness and feasibility of the risk analysis model and method proposed in this article, this article selects the city where the authors are located as an example and calculates the current infectious disease risk situation of the city based on its actual situation in various aspects. The specific situation of the city in 2021, as shown in Table 2.

Factors	Descriptions
Cultural and educational level f1	People with higher levels of education and stronger health awareness are more likely to pay attention to their own health issues and can make more reasonable and scientific response measures in a timely manner during the outbreak of the epidemic. At the same time, there is also a higher demand and attention to the risk of infectious diseases.
Population density f2	The size of population density has a significant impact on disease transmission and control, as well as the allocation of medical resources. The larger the population density, the stronger the possibility of infectious disease transmission, and the greater the losses and uncertainties it brings.
Medical management f3	This includes information construction, medical quality management, safety management, risk management, and talent team building, which play an important role in disease management and control. The higher the level of medical management, the higher the level of resource scheduling analysis, which can more effectively reduce losses.
Sociodemographic characteristics f4	The age structure, ethnic composition and underlying diseases of the population in different regions can all affect the demand and quality of medical services. For example, the increase in the elderly population has led to an increase in demand for chronic diseases and long-term care services.
Medical service level f5	Evaluate the service quality of medical institutions, professional quality of medical staff, doctor–patient relationships, medical technology innovation, etc. The higher the level of medical service, the more effective it is to reduce the losses caused by infectious diseases.
Medical resource level f6	The geographical distribution and utilization of medical resources have a direct impact on the level of regional healthcare services. For example, the quantity, quality, and distribution of medical institutions such as hospitals, beds, and doctors can all affect the quality of medical services. The level of medical resources directly determines the outbreak, loss, and uncertainty of infectious disease risks.
Geographic environment f7	The outbreak and spread of infectious diseases vary in different regions due to factors such as geographical terrain, terrain, altitude, and climate factors such as season, humidity, temperature, and wind power. The geographical environment often determines whether infectious diseases can occur in a certain area, and different infectious diseases can selectively occur in certain areas.
Social customs f8	Social customs such as work, dietary habits, and festive celebrations have a significant impact on the outbreak and spread of diseases. Different social customs and habits can directly affect the occurrence and spread of certain infectious diseases.
Traffic f9	Traffic conditions have a significant impact on the spread and control of infectious diseases.
Socio economic development Level f10	The higher the income level, the higher people's attention to their respective health aspects, and their ability and willingness to access healthcare services will also increase.
Regional scale f11	The size of the region will have an impact on the controllability and detectability of infectious diseases.
Policies and regulations f12	The completeness and implementation of medical policies and regulations formulated by the government, as well as the reform of the doctor's professional environment, will have a significant impact on the prevention and control of infectious diseases.

Table 1: Risk inluencing factors

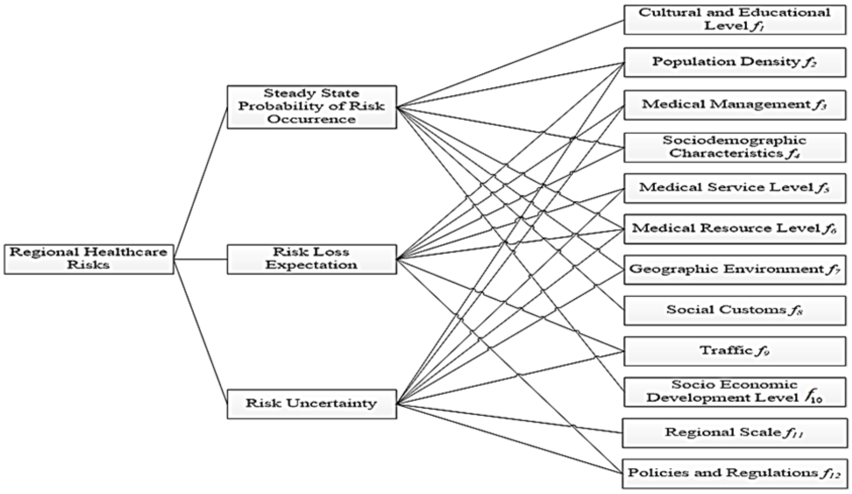

Figure 1: Assessment model

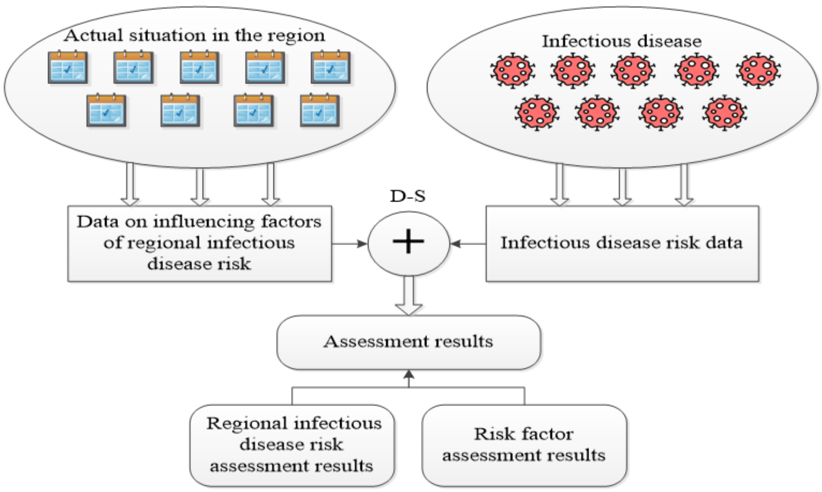

Figure 2: Assessment process

Factors	Descriptions
Cultural and educational level f1	The proportion of people with a bachelor's degree or above is about 10%, and the proportion of people with a high school degree or above is about 45%.
Population density f2	The permanent population is 8.6 million, with an area of 21000 km^2 and the density is between300 500 persons/km^2.
Medical management f3	The medical management level in the urban area is average, and there are certain management problems.
Sociodemographic characteristics f4	The aging population in urban areas is relatively severe. The proportion of people aged 60 and above among urban permanent residents exceeds 15%, while the proportion of people aged 65 and above exceeds 10%.
medical service level f5	More than 40% of medical staff have a bachelor's degree or above.
Medical resource level f6	The average number of doctors per capita in the urban area is 0.25 0.3; The average number of beds per person is approximately 0.3 to 0.4 beds; There are a total of 2000 3000 pharmacies in the urban area.
Geographic environment f7	The Height above the mean sea level of the city is about 1891m, which belongs to the subtropical plateau mountain monsoon climate in the low latitude of northern latitude. Due to the influence of the warm and humid airflow in the southwest of the Indian cean, the perennial temperature is between 0 (and 29 (the sunshine is long, the frost period is short, the annual average temperature is 15 ℃, the annual average sunshine is about 2200 hours, the frost free period is more than 240 days, and the annual precipitation is 1035 mm.

Social customs f8	Due to relatively underdeveloped economy and a large number of ethnic minorities, there are some unhealthy customs and habits in terms of living habits.
Traffic f9	The region has diverse terrain, complex transportation, and a well developed transportation industry. There are multiple subways in the urban area. Land, railway, and air transportation are developed. The number of private cars owned exceeds 1 million.
Socio economic development level f10	The region's GDP is $700 billion $800 billion, with an average annual growth of 3.0% and a per capita GDP of $1000 $2000.
Regional scale f11	The city has jurisdiction over 7 districts, 3 counties, 1 County level city and 3 autonomous counties, 81 streets, 42 towns and 16 townships, covering an area of 21000 $km.^2$
Policies and regulations f12	There is no specific policy or disease.

Table 2: Characteristics of the city

According to the internationally recognized concepts of Class I, II, and III infectious diseases, we choose one of each type as a typical representative for case analysis. Next, we will use the evaluation method proposed in this article to calculate the risk profiles of three types of infectious diseases in the region, to verify the effectiveness and feasibility of the method. The selected representatives of infectious diseases are shown in Table 3.

Data acquisition method for risk influencing factors: To simplify the research process, in terms of regional risk factor data, we use the AHP scoring method to score the local regional risk factors and all aspects of the three typical infectious diseases, and obtain the original data for subsequent fusion assessment. The specific operation is as follows, hired fifteen local experts, scholars and healthcare professionals in the field of infectious diseases and score the local influencing factors and the influencing factors of the three types of infectious diseases according to the AHP scoring rules.

After obtaining the average of the raw data, normalize the average using the standardized formula, and the results are shown in Table 4 and Figure 3. Substitute the values from Table 4 into Formula 2. Calculate the conflict coefficient Kf (Table 5) for each type of infectious disease and the risk factors of the region.

According to the fusion rules of D-S theory, the data in Tables 4 and 5 are substituted into formula (1) to calculate the fusion evaluation results of risk factors (Figure 4) (Table 6).

According to the relationship between risk content and risk factors in Figure 1, the risk factor data included in the risk content is sum is taken to obtain the relevant data of the risk content (Table 7).

According to the risk content fusion calculation method in step 7, the risk content fusion assessment result can be calculated (Figure 5) (Table 8).

Assuming that the current probability of risk occurrence Q, risk loss expectation L and risk uncertainty U in the region have the same weight (to simplify the calculation process, 1 is used as the weight value for each content), the values in Table 8 are substituted into formula $R_d = \sum_{i=1}^{3}(\omega_i \times A_i)$. Calculate the overall risk results of three types of infectious diseases in the region (Table 9).

Discussion

This section will conduct a specific analysis and discussion of the case results. We analyze and discuss the results from two aspects: Influencing factor risk and overall risk.

Risk factor fusion assessment analysis

Analysis of regional infectious disease risk factors: The data on regional infectious disease risk factors and three types of infectious disease factors are shown in Figure 3. The fusion evaluation results of regional infectious disease risk factors and three types of infectious disease risk factors are shown in Figure 4. Regional risk factors represent the degree to which they have an impact on the occurrence, development, and control of infectious diseases. The higher the score of the factor, the greater the risk. The risk factors of infectious diseases indicate the correlation between the occurrence and development of infectious diseases and this factor. The higher the correlation, the stronger the impact of this aspect.

According to Table 4 and Figure 3, the ranking results of the influencing factors of infectious disease risk in the region are: f5>f6>f4 >f3>f12>f8>f10>f7>f11>f9>f2>f1.

The three influencing factors f3, f5 and f6, are all related to medical aspects. At present, regardless of which region and city, facing a large number of disease patients, if these aspects are insufficient, they will be the main influencing factor in terms of infectious disease risk. This area belongs to a relatively remote area, and the level of medical resources, management, and services are not high, so the factor score in this area is relatively high.

The three influencing factors f4, f8 and f12, have a significant impact on the risk of infectious diseases in the region. These three factors directly reflect regional characteristics. For f4, the population ageing in the region is relatively severe, and the health quality and level of the population are not high, with a certain number of people suffering from basic diseases. In the face of such malignant infectious diseases as COVID-19, these people are greatly conflicted. At the same time, these groups also indirectly increase the risk level of other groups, thus having a larger weight value. For f12, the formulation of policies and regulations in the region is not perfect enough, and the overall level is not high. Under normal conditions, it did not show a significant impact. However, after the emergence of the COVID-19 epidemic, the role of policies and regulations has been highlighted and society has also begun to establish relevant rules and regulations and response mechanisms. For f8, this area belongs to a minority gathering area, with a large proportion of the minority population and various customs and habits. Some bad customs and habits have a significant negative impact on regional healthcare risks. In addition, the region is also a hot tourist city, and the population aggregation caused by various festivals is not conducive to the prevention and control of infectious diseases. Therefore, f8 has become a unique risk influencing factor in the region, with a higher weight value.

For the three influencing factors f1, f2 and f9, their weight values are the smallest. When constructing an infectious disease risk assessment model, factors are intentionally retained to verify the rationality of the model. The three-factor stages of f7, f10 and f11 are conventional factors. These three factors have a direct impact on healthcare risks, but due to their relative stability, they are difficult to change in the short term and are easily overlooked as routine factors.

Types	Descriptions	Selected
I	It refers to infectious diseases with high virulence, strong infectivity, high mortality rate or critical condition of pathogens, difficulty in prevention and control, and easy to cause social and public health events. Examples include pestis, cholera, rabies, smallpox, ebola, COVID-19, etc.	COVID-19
II	It refers to infectious diseases with moderate virulence, strong infectivity, easy transmission among people, and a certain risk of epidemic spread. Examples include hepatitis, tuberculosis, dysentery, anthrax, dengue fever, etc.	Pulmonary tuberculosis
III	Refers to infectious diseases with low virulence, weak infectivity, mild pathogenicity, and high cure rate of pathogens, but still require prevention and control. Examples include malaria, influenza B, hand foot mouth disease, influenza, etc.	Common flu

Table 3: Selections of epidemic infectious diseases

	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11	f12
Rf	0.0445	0.0649	0.089	0.0897	0.1401	0.0945	0.0761	0.0834	0.0661	0.077	0.0678	0.0865
D_(f_I)	0.0659	0.0989	0.0879	0.1099	0.0879	0.0989	0.0769	0.033	0.0769	0.0879	0.0769	0.0989
D_(f_II)	0.0952	0.0833	0.1071	0.0595	0.0714	0.0833	0.0833	0.0833	0.0714	0.0952	0.0595	0.1071
D_(f_III)	0.0656	0.1475	0.0984	0.0492	0.0492	0.0656	0.0328	0.082	0.1148	0.1311	0.0656	0.0984

Table 4: Risk factor scoring

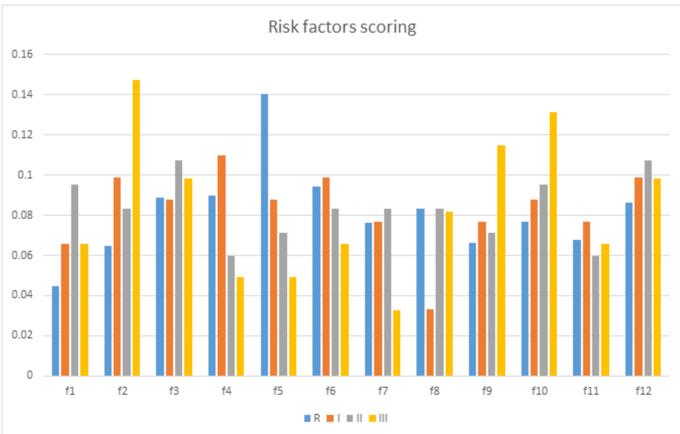

Figure 3: Risk factors scoring

	K_(f_I)	K_(f_II)	K_(f_III)
Rf	0.0829	0.0810	0.0787

Table 5: Conflict coefficient

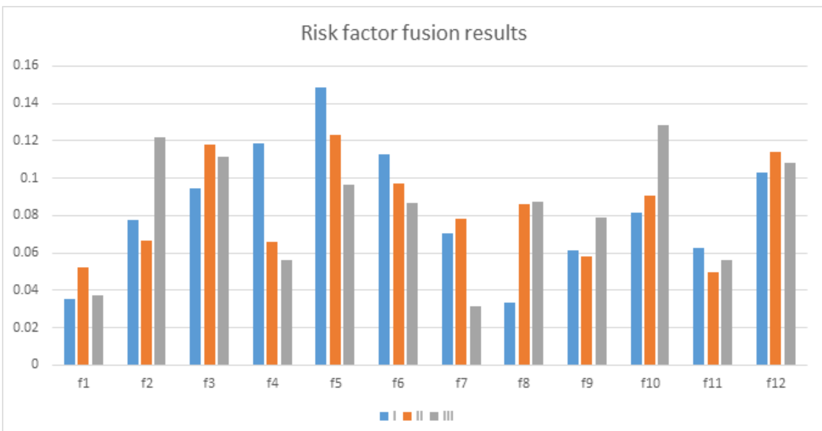

Figure 4: Risk factor fusion results

	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11	f12
I	0.0354	0.0774	0.0944	0.1189	0.1485	0.1127	0.0706	0.0332	0.0613	0.0816	0.0629	0.1032
II	0.0523	0.0667	0.1177	0.0659	0.1235	0.0972	0.0783	0.0858	0.0583	0.0905	0.0498	0.1144
III	0.0371	0.1216	0.1113	0.0561	0.0964	0.0869	0.0317	0.0876	0.0788	0.1283	0.0565	0.1082

Table 6: Risk factor fusion results

	Q	L	U
Rc	0.4467	0.6121	0.685
D_(c_I)	0.4918	0.6373	0.7032
D_(c_II)	0.4998	0.5355	0.6664
D_(c_III)	0.5384	0.5903	0.6723

Table 7: Risk content data

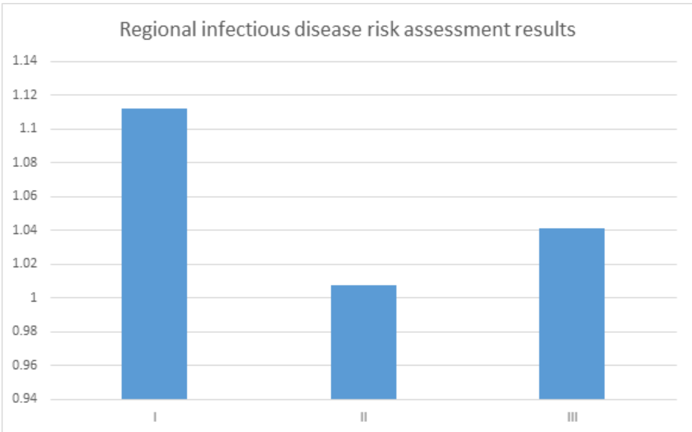

Figure 5: Regional infectious disease risk assessment results

	Q	L	U
I	0.2197	0.3901	0.4817
II	0.2233	0.3278	0.4565
III	0.2405	0.3613	0.4605

Table 8: Risk content fusion results

	I	II	III
R_d	1.1123	1.0076	1.0415

Table 9: Regional infectious disease risk assessment results

Analysis of the fusion results

The fusion results of regional infectious disease risk factors with three types of infectious disease factors are shown in Table 3 and Figure 4.

These results reflect the risk levels of various risk factors in the region when facing these three infectious diseases and are also the advantages and disadvantages of the region when facing this infectious disease. Higher rankings indicate fewer protective factors in specific aspects of the region, thereby increasing the risk in those areas.

For infectious diseases I: f5>f4>f6>f12>f3>f10>f2>f7>f11>f9>f1>f8. For the newly experienced COVID-19, in addition to the three medical factors of f3, f5 and f6, population structure f4 and regional prevention and control policy f12 are also very important for the impact of the epidemic. The region is in a more remote and ethnic minority area. Although the proportion of the elderly population is not large, the health level of the population is not high due to relatively backward living and production habits, and some people have basic diseases caused by bad customs. As a result, the risk level of f4 is relatively high in the region. The impact of regional prevention and control policies and systems on the COVID-19 epidemic is obvious to all. The prevention and control policies in this region often lag the national and advanced regional levels, and the implementation process of policies is often not complete and thorough enough, resulting in a high-risk level of f12 in this region. For f1 and f8, the two low-risk factors, the COVID-19 epidemic is less affected by the level of education and customs, and there is no direct impact on the epidemic situation around the world due to the level of education and national customs. Other factors are conventional, and the risk level is also addressed at a moderate level. Therefore, in response to this type of infectious disease, in addition to various medical factors, the composition of human structure f4, regional policies f12, and regional economic development level f10 are key areas that need to be paid attention to in the region.

For infectious diseases II: f5>f3>f12>f6>f10>f8>f7>f2>f4>f9>f1>f11. For this type of infectious disease with significant harm and certain transmissibility, the three medical factors f3, f5 and f6 also have a high level of risk. Different from the new outbreak of infectious diseases like COVID-19, the medical resources for type II infectious diseases under normal conditions are often well prepared, so the risk of medical management level for the risk factors of type II infectious diseases f3 is higher than the risk of medical resource level f6. For the two factors of f10 and f12, this type of infectious disease has a high dependence on policies. However, the limitations of management level and policy implementation level, as well as the indirect influence of socio-economic development level factor f10, policy factor f12 and economic development level factor f10 have a significant impact on the risk of type II infectious diseases in the region. Due to the large population of ethnic minorities in the region, some of them have some bad customs and habits, which makes it easy for some type II infectious diseases to break out and spread locally. Therefore, local customs and habits f8 have a high risk. For geographical environmental factors f7, the region is in a humid and hot climate, surrounded by many primitive forests and wildlife. On the one hand, a humid and hot climate is not conducive to the control and elimination of type II infectious diseases; On the other hand, contact with wild animals and plants can also easily lead to the occurrence of Class II infectious diseases. These make environmental factor f7 have a high level of risk in the region. The risk levels of other factors do not differ significantly. Therefore, in response to this type of infectious disease, in addition to various medical factors, policy factors f12, regional economic development level f10, and customs and habits f8 are the key areas that the region needs to pay attention to.

For infectious diseases III: f10>f2>f3>f12>f5>f8>f6>f9>f11>f4>f1>f7. The typical representative of type III infectious disease is the common influenza. This type of infectious disease is often treated as a common disease. Due to familiarity and expertise of this type of infectious disease, the direct impact of various factors is not significant. Any modern city targeting common flu has a relatively mature medical level and methods, therefore, the three factors f3, f5 and f6 in terms of medical treatment do not have a significant impact on such infectious diseases as the first two. Economic factors f10, policy factors f12, and social customs f8, which indirectly affect the overall quality of people, have become key factors affecting this type of infectious disease. The population density f2 has a direct and obvious effect on any infectious disease. Regional population density is a relatively stable factor in the short term. Due to the harm of type I and type II infectious diseases, cases will be artificially controlled and isolated, thereby suppressing the role of population density factors in the spread of infectious diseases. For type III infectious diseases, cases are no longer artificially controlled and isolated, making population density a key influencing factor for this type of infectious disease. In addition, the region is a famous tourist city, with a low population density but frequent population mobility. The actual population density will be much higher than the data calculated based on the resident population, which also makes population density a major risk factor for this type of infectious disease. Therefore, in response to such infectious diseases, in addition to further improving the level of medical, economic, and policy aspects, the region also needs to focus on the impact of floating population density on infectious diseases and the outbreak and spread of such infectious diseases caused by bad customs and habits.

Overall analysis of regional infectious disease risks

The overall situation of regional infectious disease risk is shown in Figure 3. The overall risk situation shows: RdI>RdIII>RdII. Overall, it is in line with the actual situation in the region. For type I malignant infectious diseases, there is a high dependence on regional medical resources, levels, and management policies and levels. Due to the low economic, social, and medical levels in the region, it is difficult to provide timely and high-level medical and policy support in the face of emerging malignant infectious diseases, making the risk very high. III represents common fluid Although the losses caused by this infectious disease are limited, it is also due to this reason that it often does not receive enough attention, making outbreaks frequent and difficult to control. At the same time, due to the low economic and medical levels in the region, there is still a situation where minor illnesses worsen into major illnesses. Therefore, the risk of this infectious disease is relatively high and higher than that of type II infectious diseases. The representative of II is Pulmonary Tuberculosis. This type of infectious disease is mostly downgraded from type I infectious diseases. In the early stages of the outbreak of this type of infectious disease, it was treated as type I to respond. However, with the familiarity and mastery of disease-related viruses, they are gradually downgraded to type II or even type III, such as COVID-19. This type of infectious disease can bring significant losses and has strong harmfulness, but due to a deep understanding of the disease, high vigilance, and mature prevention and control measures, the risk level of this infectious disease is the lowest. For regions with moderate levels of economic, social, medical, and other aspects, the level of prevention and control for type II is often higher than that for type I and III, and the risk level is often at a lower level. The regions involved in the case are representative of moderately developed regions, therefore, the lower risk level of type II infectious diseases is also in line with the actual situation.

Conclusion

Regional infectious disease risk is one of the most important aspects of healthcare risk, directly related to the safety of residents' lives. After the emergence of COVID-19, people not only pay attention to personal hygiene and healthcare safety but also significantly increase the risk of infectious diseases in the region. Due to different factors such as population, environment, and economy in different regions, the level of risk when facing infectious diseases varies. Simply increasing medical resources and improving medical standards can effectively resist the risk of infectious diseases after they occur. However, in the face of irregular outbreaks of malignant infectious diseases, how to identify the weaknesses in regional prevention and control of infectious diseases, and how to prevent the risk of infectious diseases, can the harm of infectious diseases be fundamentally eliminated and people's life safety be guaranteed. In response to the above issues, this study combined various factors such as regional social, economic, living, and environmental factors with healthcare and infectious disease aspects, and proposed a regional infectious disease risk fusion assessment method based on D-S evidence theory. This method not only calculated the risk level of various infectious diseases faced by the region but also identified the weaknesses of the region when facing infectious disease risks. The assessment results are of great significance for effectively improving the risk prediction and prevention and control level of infectious diseases in the local area. At the same time, it can also help local relevant institutions develop more reasonable prevention and control strategies and optimize and improve the local medical and health level.

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Author Contributions

The authors confirm their contribution to the paper as follows: Material preparation, data collection is done by Rong Jiang and Peng Xu; model construction and assessment method designing was taken over by Tilei Gao and Rong Jiang; analysis and interpretation of results were given by Peng Xu, Tao Zhang and Ming Yang; draft manuscript preparation was performed by Tilei Gao and Peng Xu. All authors reviewed the results and approved the final version of the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the current study.

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