



Research on public security risk assessment of emergencies based on scene coupling driven

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Abstract The security risk in the process of emergency occurrence and development is composed of the interaction of various risk elements, which have many distinct characteristics different from the normal. This paper constructs a public security risk prediction model adapted to scene coupling drive by combining with the risk interaction coupling characteristics of HHM-RFRM theory. The qualitative, quantitative filtering, rating and risk assessment of public security risk scenarios are carried out by using Bayesian theorem and model. Combined with the actual data of multidimensional risk scenario, the coupling relationship is effectively analyzed to realize the transition from single risk to coupling risk early warning. It is found that the method has strong consistency with the actual data, the evaluation accuracy is further improved, and it has stronger adaptability to the security risk of emergencies evolution.

Keywords Multidimensional risk · Risk assessment · Emergencies · HHM-RFRM theory · Scene coupling

1 Introduction

In recent years, mass events, natural disasters, public health events, public security events and other emergencies occur frequently. Due to the characteristics of burstiness,

variability, stage, disposition urgency, hazard severity and public nature of Emergencies, the security of public has present many distinct characteristics different from the normal. Due to the lack of early warning evaluation and dynamic changes characteristics of emergencies, all kinds of crimes affecting security of public and stability are concentrated, which resulting in public chaos and affecting the progress of the government in handling emergencies. As an important part of the whole public crisis management system, security of public risk assessment has become an important part of modern public governance. In the face of new emergencies, how to effectively evaluate the security of public environment, and to build an effective security risk coupling early warning evaluation mechanism by combined with the dynamic data information, which have attracted more and more attention of the public security police personnel and scholars (Nurse and Creese 2017; Vlasselaer et al. 2017; Schmitz and Pape 2020; MansourAlali and MehediHassan 2018; Smith and Brooks 2013).

Tong Li (2017) has attributed security risk factors to four parts: event, person, object and environment by combined with the principle and flow mechanism characteristics of emergencies. Nayu Wang (2017) puts forward the key population risk control model in dynamic public environment based on risk assessment theory, intelligence-led policing theory and process reengineering theory. Yu Liu (2018) has proposed the scenario information model by the analysis of the emergency and its situational characteristics based on the characteristics of event knowledge base, multiple scenario knowledge base, resource knowledge base and associated knowledge base. Fortune (2018) the method of neural network and expert reasoning is put forward to quantitatively analyze the risk factors affecting

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the security prevention system and improve the accuracy of the evaluation model. Trond (2018) has analyzed the effectiveness of security system and optimize the index weight ratio by fuzzy theory, mathematical model and expert system. Klara Svalin (2018) has given the effectiveness of risk assessment and early warning of police force use in sudden police cases from the point of view of risk prediction system construction, 'model construction and data acquisition.

The above research analyzes the source and formation mechanism of emergency security risk from different angles, but it is often limited to a single risk factor, and the multi-source coupling risk factor is often lack of effective evaluation. However, many risk scenarios are often coupled output problems due to interreaction, and the risk scenarios have great uncertainty in the process of different types of emergencies, which involves many factors, such as the event itself, public impact, information change and government response. The failure of multi-factor interaction and early warning mechanism often leads to the further deterioration security of public. Experts in this kind of risk related fields put forward the scenario-response risk management model, but there is still a lack of specific governance methods and strategies.

Combined with the experience of experts in various related fields (Scheitle and Halligan 2017; Nalan Ergün and Bülbül 2019; Chainey and Monteiro 2019) and the research results (Jiaguo et al. 2019; Aleksandrovskaia et al. 2019; Qing et al. 2017) by Liu Jiaguo and others, this paper proposes a multidimensional security risk early warning degree model based on holographic modeling from the perspective of risk filtering, rating and governance. We use Bayesian theorem and model to carry out the coupling evaluation of different risk scenarios around the dimensions of event content, influence degree, propagation law, risk scenario, diffusion range and countermeasure utility. And combine the multi-type security risk factors caused by multi-type events into one, which is beneficial to the transformation of risk elaboration and evaluation to accurate and quantitative.

2 HHM-RFRM dynamic modeling

The severity, risk and influence range of emergencies are the most important external environmental drivers to determine the stability of public security. In the identification model analysis, the static factors affecting public order should be fully considered as the fixed index and the variable factors as the process parameters.

Through qualitative and quantitative analysis, the key influencing factors are clearly distinguished to establish the input–output relationship between emergency and security

environment. The static data is effectively fused with the dynamic data, and the multiple risk scenarios are coupled and integrated. The evaluation model can be compared and analyzed by historical and scoring data. The set of dynamic change data effectively reduces the influence on randomness and nonlinear expression in the evaluation process. The historical measured data are added to the evaluation model, and the actual results are compared to correct the model and improve the accuracy. This paper analyzes the effects of various risk factors one by one combined with the HHM-RFRM risk index system, and analyzes the interaction and coupling between various risk factors, which mainly in three aspects:

2.1 Scenario recognition perspective

The concept of multidimensional risk coupling is put forward. Suppose C_i^e means that category i emergencies consist of e risk scenarios, b_i represents a risk scenario of emergency C_i^e , B_n^m indicates that the n risk scenario consists of m risk elements, N_i represent risk elements B_n^m risk scenarios. Definition:

$$C_i^e = B_1 \Theta B_2 \Theta B_3 \Theta B_m \quad (1)$$

For symbols Θ , their algorithms satisfy the commutative law.

2.2 Risk qualitative assessment perspective

From the view point of the influence degree of each risk factor on the stability of public security, the qualitative analysis of the characteristics of each risk factor is helpful for decision makers to quantitatively evaluate the risk factors and the overall risk by combined the complex characteristics of the risk of public security prevention and control in emergencies. According to the relevant analysis, the ability of public security risk prevention and control is distinguished, and the characteristics of each risk factor are comprehensively evaluated to provide a reference for quantitative evaluation. This paper refers to relevant literature and lists 10 criteria for public security risk evaluation, as shown in Table 1:

2.3 Risk quantitative evaluation

Combined with Bayesian theorem and quantitative calculation is carried out from two dimensions of probability and consequence by using multi-dimensional risk measurement model, and the definition is as follows:

$$D_{\text{risk}} = C_{\text{risk}} \times P_{\text{risk}} \quad (2)$$

The D_{risk} as the risk degree of the subfactor, C_{risk} as the possible consequences of the risk factor, as shown in

Table 1 Multiple criteria for security risk assessment

Number	Criteria	Remark
I	Invisible	The existence pattern of initial event in a scenario can not be found before event occurs
II	Uncontrollability	There is no control method to adjust and prevent or reduce the impact of events
III	Multiple risk approaches	One factor has many ways of influencing public order
IV	Irreversibility	When a certain factor occurs, it affects the stability of public order
V	Event impact time	Impact of event duration on risk triggering
VI	Coupling effects	Influence and interaction of one sub-risk factor on other sub-risk factors
VII	Risk scenario	Risk sensitivity of unknown social stability scenarios
VIII	Severity	Impact extent on public security stability
IX	Complexity	The behavioral potential of a factor to the factors of the system
X	Transmissibility	Event risk affects the speed and extent of transmission

Table 2 Indicators of risk factors

Item C_{risk}	Indicators	Remark
Very Severity	1	Public security has been seriously affected and spread to a wide range
Severity	0.8	Public security has been great changes and many problems
Commonly	0.5	Public security haS been general changes and fewer problems
Small Extent	0.3	Public security haS been small changes, and the simple governance can be restored
Negligible	0	Public security has been no change and no special treatment

Table 2. P_{risk} as the occurrence probability of the risk coupling scenario.

The hypothesis H and E are two random variables, the $H = h$ is a hypothetical risk factor, and the $E = e$ is the related risk caused by the hypothetical influencing factor. The analysis shows that $P(H = h)$ is a single probability and $P(H = h \cap E = e)$ is a coupling probability without considering the related risks. The Bayesian theorem formula is:

$$P(H = h|E = e) = \frac{P(H = h)P(E = e|H = h)}{P(E = e)} \tag{3}$$

Combined with Table 2, the probability of each risk coupling scenario can be calculated by using the coupling relationship between historical data, statistical analysis and risk factors, and the risk degree of the risk scenario can be calculated by combining formula (1) and (2).

3 Risk identification

3.1 Risk factor construction

It is the key of public security risk prevention and control to analyze the influence factors of emergency public

security effectively. The research shows that the public security risk is easy caused by emergency. According to the literature analysis, the risk consists of three parts: risk factor, threat target and trigger mechanism. For security risk threat target such as public security and stability, it is an important basis for risk identification to effectively clarify the trigger mechanism of risk factors and its constituent elements. In view of the complexity and diversity of public security risks in the course of emergencies, this paper adopts the method of combining objective analysis with subjective judgment, the elements of public security risks are analyzed by combining historical documents, public security statistics and expert opinions.

The iterative analysis of risk data index is carried out by combined with holographic modeling and risk factor composition theory. The iterative process is mainly carried out by two groups of experts, the first group is to search for risk factors by 10 experts from the public security and security departments. Each expert has more than 10 years working experience and research foundation to the emergency occurrence and the handling influence to the public security question. This group of experts conduct a questionnaire, which is divided into two parts. The first part includes the 35 risk factors extracted from the literature and public security data. The second part sets up the open type problem, so the experts can list the emergency security risk

factors according to their own experience, and then expand the risk source framework. The preliminary analysis results are obtained. The second group is to demonstrate the risk factors by 10 experts from public security colleges and government departments. The experts group review the preliminary analysis results of risk sources to test their scientific, comprehensive and operational. If the audit is approved, the HHM framework can be constructed according to the analysis results, otherwise, the above operation can be repeated on the basis of the opinions of the second group experts. Combine with the risk action and coupling mechanism, the perfect risk elements system is constructed by iterative analysis, and the security risk factors are classified according to the results of expert audit and case verification, as shown in Table 3. Reflect the source of security risk and its influence relationship.

The sources of emergency security risk factors are broader, how to effectively manage and analyze is a large-scale and complex system engineering. Combined with the related expert analysis and comprehensive index, the source composition of emergency risk is divided into five aspects: people(P), emergency(E), equipment and data(H), management(M), information(I), and these five aspects are classified as static and dynamic risk of public security.

(1) Static risk is mainly the daily defense means of public security risk management, which mainly refers to the improvement of the control and management ability of the internal risk elements of the public security system in order to enhance risk resistance and response ability.

People factors (P) mainly include the police quality, psychological state, physiological state, training situation, the masses state and so on. In the course of public security operation, people is the main body of public security operation and maintenance, and human factor is an extremely active factor. Many public security problems are caused by the ways and means of handling problems for public security personnel or government personnel. For example, the police station is too busy to failure to send police to deal with the problem, which lead to and the neighborhood conflict turned into a serious violent crime in 2017, which the information comes from news reports of the year. Eventually leading to casualties and serious public impact.

Equipment factors (H) mainly include common monitoring equipment performance, monitoring equipment distribution, information transmission and detection, intelligent identification equipment, common police equipment and so on. Among them, the uneven distribution of equipment, damage and transmission obstacles will cause delays in the resolution of security problems. For example: a shop in Tianjin was stolen in 2018, because the monitoring equipment was not opened lead to the lack of effective video evidence, which delayed the time of solving

the case. Eventually caused some items to be lost, which the information comes from news reports of the year.

Organizational management (M) mainly includes supervision and control of public security system, communication command, emergency management plan, government response ability, control strategy, information management and so on. Public security and government departments regulate and effectively manage public activities and personnel is an important factor to resist risks. The key to organizational management is to manage dangerous personnel and regions from the source. If the control is improper, it will cause major problems. For example, in 2019, a probation officer has fought with others in other cities in Guangzhou, Guangdong Province due to the street and police station did not carry out effective monitoring and management which resulting in the personnel out of management scope. The information comes from news reports of the year.

(2) Dynamic risk mainly refers to the control and effective handling of emergency information in the process of public personnel activities. Dynamic risk mainly includes information (I) and emergency factor (E) two factors.

Information and environment (I) mainly includes information composition and dissemination speed, public opinion response, government public opinion control, public overall environment and so on. In the process of public security governance, information and environmental factors have become an important uncertain factor. Only by accurately mastering information and environmental changes can ensure the safety and stability of public security. For example, a chemical plant in Sichuan suspected gas leakage in 2020 which the information comes from news reports, the government did not effectively predict and control, which lead to public chaos and some public security problems due to nearby residents in unknown circumstances panic evacuation. In the risk management of public security, the dangerous environment and information should be understood in advance to avoid adverse communication and influence.

Emergency factors (E) mainly include emergency type, emergency impact, emergency time, emergency place and so on. Determining the dynamic change and predicting the influence of the emergency is helpful to grasp the guidance of the whole event. Only by mastering the risk factors of the event in time and accurately can ensure the effective control event. For example, there is a fight and brawl incident in a middle school in a certain part of Shaanxi in 2019, which resulting in the expansion of the subsequent brawl incident scope due to the school and the public security department to estimate the incident insufficient. Eventually causing casualties and adverse public effects, which the information comes from news reports of the

Table 3 Public security risk HMM evaluation index

Index level	I级	II级	III级	
Public security risk HMM evaluation index	People(P)	People composition (P ₁)	Age culture composition (P ₁₁)	
			Religious belief (P ₁₂)	
			Nationality (P ₁₃)	
			Psychology (P ₁₄)	
			Registration data(P ₁₅)	
	Police(P ₂)	Police(P ₂)	Police stations distribution (P ₂₁)	
			Regional police distribution(P ₂₂)	
			Police professional ability(P ₂₃)	
			Regional security situation(P ₂₄)	
			Governmental ability(P ₃)	
	Management(M)	Plan formulation(M ₁)	Department coordination ability(P ₃₁)	
			Personnel quality and composition(P ₃₂)	
			Personnel evacuation plan(M ₁₁)	
			Emergency disposal plan(M ₁₂)	
			Security prevention plan(M ₁₃)	
	Basic management(M ₂)	Basic management(M ₂)	Public security management system (M ₂₁)	
			Local initial management ability(M ₂₂)	
			Initial police response (M ₂₃)	
Rescue management and quality(M ₂₄)				
Supervision and administration (M ₂₅)				
Equipment(H)	Regional situation(H ₁)	Emergency area(H ₁₁)		
		Food and Health(H ₁₂)		
		Dangerous Goods Distribution(H ₁₃)		
		Finance and gold shop(H ₁₄)		
		Equipment distribution (H ₂)		
Equipment distribution (H ₂)	Equipment distribution (H ₂)	Network information monitoring system(H ₂₁)		
		Camera security system(H ₂₂)		
		Police equipment(H ₂₃)		
		Rescue and medical equipment(H ₂₄)		
		Emergency (E)	Emergency situation(E ₁)	Emergency type(E ₁₁)
Political nature (E ₁₂)				
Sensitivity (E ₁₃)				
Emergency impact(E ₂)	Emergency impact(E ₂)			Impact level(E ₂₁)
				Development speed(E ₂₂)
		Impact scope (E ₂₃)		
		Controllability(E ₂₄)		
		Information and environmental (I)	Information (I ₁)	Speed and range of propagation(I ₁₁)
Information propagation type(I ₁₂)				
Involving wire fraud(I ₁₃)				
Information monitoring(I ₁₄)				
Security Information Detection(I ₁₅)				
Environmental(I ₂)	Environmental(I ₂)		Guidance of information public opinion (I ₁₆)	
			Weather situation(I ₂₁)	
			International and domestic situation(I ₂₂)	
			Geographical location situation(I ₂₃)	

year. Therefore, we should pay attention to the composition and influence of the emergency in time and carry out effective prevention.

If only a certain risk factor can not be considered in the process of risk management to achieve the goal of effective control risk, it is extremely effective to use the HHM to analyze it in all directions and from multiple perspectives. According to the relevant contents of disaster chain theory, in order to capture and reflect its risk sources comprehensively and accurately, this paper analyzes the data index system and its relationship, and establishes a public security risk evaluation index system based on HHM framework. As shown in Table 3.

3.2 Scene identification

Table 3 shows the composition HHM elements of public security risk. In the process of risk management and analysis, it is necessary to couple the relationship between the elements of public security risk to form a HHM risk sub-model. These sub-models are composed of two or more elements, which forming risk scenarios from the perspective of different risk coupling characteristics. So as to carry out research on public security governance based on identifying public security risks by analyzing risk elements in all directions and from multiple angles. Figure 1 shows the coupling relationship between the five first-level index elements of public security. From the diagram, we can see that the five first-level index elements can influence each other, and HHM risk scenarios can be formed between two or any three combinations. Under formula (1), if the human factor-hardware equipment risk scenario is numbered as 1 in the public security risk HHM index model system, the risk scenario can be expressed as $C_{12}=I\&H$. The 10 two-dimensional and 15 three-dimensional risk scenarios can be listed by analogy, as shown in Tables 4 and 5.

When the specific risk scenario is encountered, it is necessary to analyze the interaction of multiple risk scenarios due to each risk factor contains multiple subfactors, so as to effectively determine the risk sources from

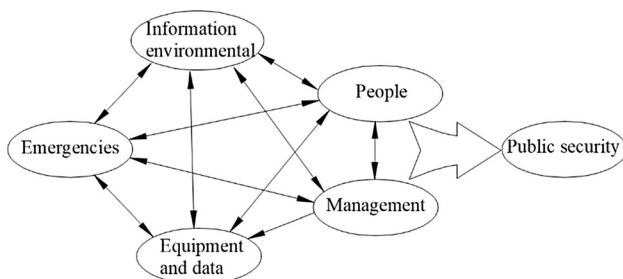


Fig. 1 Coupling relationship of public security riskfactors

Table 4 Two-dimensional risk scenarios of public security

Risk scenarios	Relationship	Risk scenarios	Relationship
C_1^2	I&H	C_2^2	I&P
C_3^2	I&M	C_4^2	I&E
C_5^2	H&P	C_6^2	H&M
C_7^2	H&E	C_8^2	P&M
C_9^2	P&E	C_{10}^2	M&E

Table 5 Three-dimensional risk scenarios of public security

Risk scenarios	Relationship	Risk scenarios	Relationship
C_1^3	I&H&P	C_2^3	I&H&M
C_3^3	I&H&E	C_4^3	H&P&M
C_5^3	H&M&E	C_6^3	H&P&M
C_7^3	H&P&E	C_8^3	P&M&E

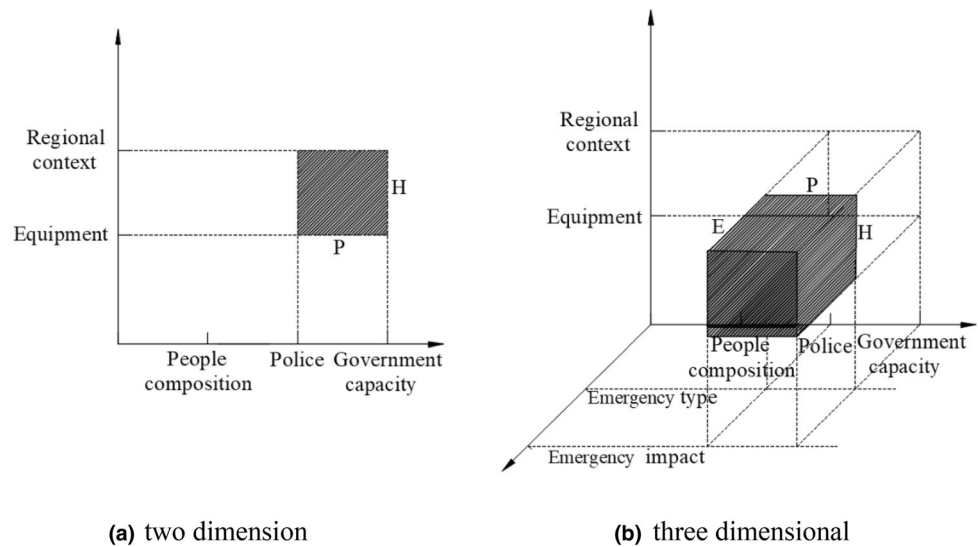
different perspectives. For example, the interaction of information and people two factors creates a new risk perspective for two-dimensional risk scenarios I&P as shown in Fig. 2a. There are different requirements for regional police distribution, police professional ability and police stations distribution in the context of emergencies different propagation speed and scope, propagation type, involving wire fraud and information monitoring. If the two are not matched properly, it is easy to have serious consequences. Similarly, the interaction of information, people and event factors forms a three-dimensional risk perspective for a three-dimensional risk scenarios I&P&E as shown in Fig. 2b. For example, the speed of information dissemination has obvious differences for different types of emergencies, which lead to different personnel requirements have different abilities. If not effective evaluation, it will not be conducive to the effective handling emergencies. According to the method, the interaction risk of multiple subfactor can be identified one by one.

The probability or consequence of risk influence can be determined by using the geometry of the risk coupling relationship between various factors as shown in Fig. 2. Taking the probability measurement as an example by calculating the geometric area and volume to measure the risk degree under the interaction of various factors in a risk scenario. When the dimension of the risk scenario is less than or equal to 3, we can obtain:

$$P_{\text{risk}} = p_x p_y p_z \tag{4}$$

The P_{risk} is defined as the coupling probability risk degree under the interaction of three factors in the C_m^n risk

Fig. 2 Coupling relationship of multiple subfactors. **a** two dimension **b** three dimensional



scenario, p_x, p_y, p_z represents the side length of the geometry generated by the interaction in the risk coordinate system, which the posterior probability of a single risk factor. Specifically, $p_z=1$ when the C_m^n is a two-dimensional risk scenario.

4 Risk evaluation and simulation

4.1 Risk index

With the analysis and identification of the above HHM risk evaluation indexes, 11 II grade risk indexes and 43 III grade indexes were identified. In order to effectively determine the key risk factors, 43 risk factors are qualitatively analyzed, and the two criteria of possibility and consequence are filtered by double standard.

The filtering standard is determined by the analysis of past experience data and expert investigation. According to their own experience and historical data statistics, the experts analyze the inducing factors of public security problems in emergencies, and design statistical analysis

questionnaires. By consulting 30 experienced security staff, the results as shown in Table 6.

The public security risk ranking matrix gives a preliminary rating of each risk factor. The psychology state, regional police force distribution, police professional ability, department coordination ability, security prevention plans, local initial management ability, Initial police response, rescue management and quality, network information monitoring system, camera security system, public security equipment, emergency type, controllability, information public opinion guidance, Information monitoring, international and domestic situation total 16 risk factors were retained as the main risk factors after filtering out the extremely low risk, low risk and general risk. However, the other 27 risk factors are not excluded, they are filtered out only to indicate that the risk is not high relative to the 16 risk factors retained, and the public security risk analysis shall begin with the key risk factors.

Table 6 Double standard filtering risk ranking matrix

Consequence	Probability			
	Lower	Low	Middle	High
Seriousness		I ₁₅	P ₂₂ , M ₂₄ , E ₁₁	I ₁₆
Serious	M ₂₁ , H ₁₁ , H ₂₄ , I ₂₂	P ₁₂ , M ₂₅ , E ₁₂ , E ₁₃ , I ₁₁ , I ₁₃	P ₁₄ , M ₁₃ , M ₂₂ , E ₂₄ , I ₁₄	H ₂₃ , P ₂₃ , P ₃₁ , M ₂₃ , H ₂₁ , H ₂₂ ,
Common	M ₁₂ , H ₁₂ , H ₁₄ , I ₂₃	P ₁₃ , M ₁₁ , E ₂₁ , I ₁₂	P ₁₅ , P ₂₄ , P ₃₂ , E ₂₃ , E ₂₂	
Slight		I ₂₁ , H ₁₃		
Negligible		P ₁₁		

4.2 Quantitative rating

According to the risk filtering criteria in Table 1, the expert group further evaluated 16 key risk factors of public security in combination with the investigation, and divided the criteria into three grades: high (H), medium (M) and low (L). The results are shown in Table 7.

In view of the major public health events (Wuhan Covid-19), the frequency of various public security events and the influencing factors leading to public security events are analyzed to determine the priori probability of public security risk factors, through relevant historical data on changes in public security after various emergencies in previous years. For example: security incidents caused by network information monitoring system errors after emergencies. The prior probability is $P(M_{24})=0.5$. According to the emergency design and rescue, the organization coordination ability, the police professional ability and the current external environment, the decision makers and experts make judgments according to the experience and the basic information they have. If the network information monitoring situation is good and the possibility of public security event is small, then the conditional probability is $P(N_1|M_{14})=0.1$, Where N_1 represents the related status of the network information monitoring system of the emergency. So $P(\overline{M}_{14})=0.5$, $P(N_1|\overline{M}_{14})=0.9$, the posteriori probability is calculated according to Eq. (3):

$$P(M_{14}|N_1) = \frac{P(M_{14})P(N_1|M_{14})}{P(M_{14})P(N_1|M_{14}) + P(\overline{M}_{14})P(N_1|\overline{M}_{14})} = 0.1$$

Similarly, the posterior probabilities of other risk factors can be obtained accordingly, and the results are shown in Table 8.

According to the calculated posterior probability, the possibility of 16 key risk factors is divided into four intervals and quantitatively rated, as shown in Table 9. Therefore, this paper filters out the nine key risk elements of public security risk after emergency, that is, police

professional ability, department coordination ability, local initial management ability, rescue management and quality, network information monitoring system, camera security system, police equipment, emergency type, guidance of information public opinion. Therefore, once the emergency evolves the public security problem, we should focus on the above nine risk factors.

4.3 Scene assessment

The interaction of the nine risk factors are analyzed by HHM framework and holographic theory based on the identification and rating of public security risk. So as to further assist managers to make public security risk management decisions in the process of emergency by evaluating the risk scenarios composed of key risk factors. A HHM sub-model of the key public security risk factors of the event is shown in Fig. 3.

According to formula (2) and Table 2, the consequence value of the key risk sub-scenario is calculated. Since all risk factors here are serious and relatively serious factors, C_{risk} is set as 1 or 0.8. That is, the probability is used to measure the danger degree of risk scenario. According to the p_x, p_y, p_z value corresponding to each risk scenario, the risk degree of each two-dimensional risk scenario containing only key risk factors can be obtained by the joint formula (2), as shown in Table 10. In general, we think that risk above 0.01 is high risk for two-dimensional risk scenarios. The three-dimensional risk scenario of public security is not discussed here because its probability is too small.

According to the analysis of the calculation results, there are 7 risk sub-scenarios with risk over 0.01, in the key two-dimensional risk situations of the event, which reflect the risk of information factors-equipment factors and people factors-management factors in the public security risk management of this event.

It can be concluded that the risk is very large when the information factors interact with the people factors and the

Table 7 Multiple criteria evaluation matrix of public security risk

Criteria	P ₁₄	P ₂₂	P ₂₃	P ₃₁	M ₁₃	M ₂₂	M ₂₃	M ₂₄	H ₂₁	H ₂₂	H ₂₃	E ₁₁	E ₂₄	I ₁₄	I ₁₆	I ₂₂
I	H	H	H	H	L	M	H	M	L	M	M	H	H	H	H	M
II	H	M	H	H	M	H	M	M	L	M	H	H	H	M	H	H
III	H	L	H	M	M	M	H	L	H	H	M	H	M	H	H	H
IV	L	M	M	M	H	H	H	H	L	M	H	H	H	H	H	M
V	M	H	M	H	H	H	M	H	M	H	H	H	M	M	H	H
VI	H	H	H	H	H	H	H	H	M	H	M	H	H	H	H	H
VII	L	M	H	H	H	H	H	M	H	M	H	H	M	H	H	H
VIII	M	H	H	H	H	M	M	H	H	H	H	H	H	H	H	H
IX	H	H	H	M	H	H	H	H	H	H	M	H	H	M	H	M
X	H	H	H	H	H	H	H	M	L	M	M	H	M	M	H	M

Table 8 Public security risk factor probability

Probability	Factor															
	P ₁₄	P ₂₂	P ₂₃	P ₃₁	M ₁₃	M ₂₂	M ₂₃	M ₂₄	H ₂₁	H ₂₂	H ₂₃	E ₁₁	E ₂₄	I ₁₄	I ₁₆	I ₂₂
Prior Probability	0.4	0.45	0.45	0.3	0.35	0.65	0.2	0.5	0.3	0.4	0.4	0.3	0.4	0.3	0.7	0.3
Conditional Probability	0.05	0.04	0.15	0.1	0.08	0.1	0.05	0.1	0.1	0.08	0.1	0.1	0.06	0.05	0.1	0.06
Posteriori Probability	0.03	0.03	0.12	0.05	0.04	0.17	0.01	0.1	0.05	0.05	0.07	0.05	0.04	0.02	0.2	0.02

Table 9 Public security risk quantitative ranking matrix

Consequence	Probability				
	0 ≤ P < 0.01	0.01 ≤ P < 0.05	0.05 ≤ P < 0.2	0.2 ≤ P < 0.5	0.5 ≤ P < 1
Very Severity		P ₂₂	E ₁₁ , M ₂₄	I ₁₆	
Severity		P ₁₄ , E ₂₄ , I ₁₄ , M ₁₃ , M ₂₃ , I ₂₂	M ₂₂ , P ₂₃ , P ₃₁ , H ₂₁ , H ₂₂ , H ₂₃		
Commonly					
Small Extent					
Negligible					

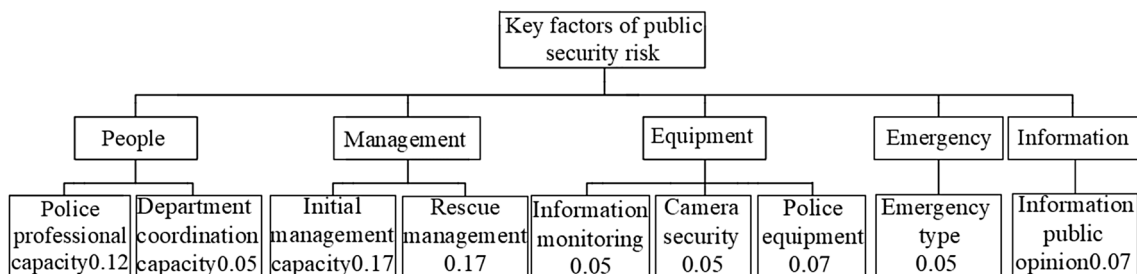


Fig. 3 The sub-model of the key public security risk factors

Table 10 Risk degree of key two-dimensional risk scenarios

Risk scenarios	Sub-scenarios	Risk degree	Risk scenarios	Sub-scenarios	Risk degree
C ₁ ²	I ₁₆ &H ₂₁	0.008	C ₆ ²	H ₂₁ &M ₂₂	0.005
	I ₁₆ &H ₂₂	0.008		H ₂₁ &M ₂₄	0.004
	I ₁₆ &H ₂₃	0.011		H ₂₂ &M ₂₂	0.005
C ₂ ²	I ₁₆ &P ₂₃	0.019	C ₇ ²	H ₂₂ &M ₂₄	0.004
	I ₁₆ &P ₃₁	0.008		H ₂₃ &M ₂₂	0.008
C ₃ ²	I ₁₆ &M ₂₂	0.027	C ₈ ²	H ₂₃ &M ₂₄	0.006
	I ₁₆ &M ₂₄	0.02		H ₂₁ &E ₁₁	0.002
C ₄ ²	I ₁₆ &E ₁₁	0.01	C ₉ ²	H ₂₂ &E ₁₁	0.002
C ₅ ²	H ₂₁ &P ₂₃	0.004		H ₂₃ &E ₁₁	0.003
	H ₂₁ &P ₃₁	0.002	C ₁₀ ²	P ₂₃ &M ₂₂	0.013
	H ₂₂ &P ₂₃	0.004		P ₂₃ &M ₂₄	0.01
	H ₂₂ &P ₃₁	0.002	P ₃₁ &M ₂₂	0.005	
C ₁₀ ²	H ₂₃ &P ₂₃	0.005	P ₃₁ &M ₂₄	0.004	
	H ₂₃ &P ₃₁	0.003	C ₉ ²	P ₂₃ &E ₁₁	0.005
	M ₂₄ &E ₁₁	0.005		P ₃₁ &E ₁₁	0.002

management risk factors. That is, information dissemination and monitoring, police professional ability, rescue ability and so on should be paid more attention to than other risk factors when public security changes after emergencies. Therefore, the security risk management after such emergencies needs to pay priority attention to the ability of information monitoring and equipment application in order to improve the police ability to deal with sudden changes in public security.

5 Conclusion

1. It is found that the HHM-RFRM constructed in this paper has a certain application value in the public security risk assessment of emergency, and the coupling effect of the proposed risk factors will produce a new risk source from a new perspective. The risk assessment method of HHM-RFRM public security can be improved by introducing measurement mode of multi-dimensional risk scenario.
2. Taking public health events (Wuhan Covid-19) as an example, using double standard filtering matrix and multiple standard evaluation matrix, combining Bayesian theorem and risk ranking matrix to quantitatively filter and rate public security risk factors. It is found that this method is helpful to analyze the interaction of risk scenarios, but the public security problems of emergencies are more complex, and decision makers need to further study a variety of risk coupling scenarios.

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Declaration

Conflict of interest There is no conflict of interest in this article.

References

Aleksandrovskaya LN, Ardalionova AE, Papic L (2019) Application of probability distributions mixture of safety indicator in risk assessment problems. *Int J Syst Assur Eng Manag* 10:3–11

- Chainey SP, Monteiro J (2019) The dispersion of crime concentration during a period of crime increase. *Secur J* 32(3):324–341
- FortuneMunodawafa AI (2018) Security risk assessment within hybrid data centers: a case study of delay sensitive applications. *J Inf Secur Appl* 43(3):61–72
- Jiaguo Liu, Jin Cui, Huan Zhou et al (2019) Research on ship navigation risk assessment method based on HHM-RFRM. *Chinese J Manag Sci* 27(5):174–183
- KlaraSvalin CM, TorstenssonLevander M et al (2018) Police employees' violence risk assessments: the predictive validity of the B-SAFER and the significance of protective actions. *Int J Law Psychiatr* 56(3):71–79
- MansourAlali AhmadAlmogren, MehediHassan M (2018) Improving risk assessment model of cyber security using fuzzy logic inference system. *Comput Secur* 74:323–339
- Nalan Ergün K, Bülbül G (2019) An assessment of factors affecting airport security services: an AHP approach and case in Turkey. *Secur J* 32(1):20–44
- Nayu Wang (2017) Research on police mechanism based on risk control of key population. People's Public Security University of China Master thesis
- Nurse JRC, Creese S, De Roure D (2017) Security risk assessment in internet of things systems. *IT Prof* 19(5):20–26
- Qing H, Qingsheng X, Shaobo Li (2017) The model of information security risk assessment based on advanced evidence theory. *Int J Syst Assur Engin Manag* 8:2030–2035
- Scheitle CP, Halligan C (2017) Explaining the adoption of security measures by places of worship: perceived risk of victimization and organizational structure. *Secur J* 30(2):32–43
- Schmitz C, Pape S (2020) LiSRA: lightweight security risk assessment for decision support in information security. *Comput Secur* 90:213–221
- Smith CL, Brooks DJ (2013) Security risk management. *Security Sci* 51–80. <https://doi.org/10.1016/B978-0-12-394436-8.00003-5>
- Tong Li (2017) Fuzzy risk assessment method of large-scale activities and design of corresponding early warning system. China University of Geosciences for Doctoral Degree Thesis
- TrondNordfjærn TorbjørnRundmo (2018) Transport risk evaluations associated with past exposure to adverse security events in public transport. *Transp Res f: Traffic Psychol Behav* 53(2):14–23
- Van Vlasselaer V, Eliassi-Rad T, Akoglu L (2017) Network-based fraud detection for public security fraud. *Manage Sci* 63(9):2773–2781
- Yu Liu (2018) Research on key technologies of scenario information acquisition and analysis for emergency. Wu Han University for Doctoral Degree Thesis

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