

Risk Factors Analysis of Criminals Escape from Prison Based on Interpretative Structural Modelling

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Abstract

Urban public facilities play essential roles during the operating process of cities. How to prevent and mitigate emergencies which affect the urban public facilities is the focus of urban emergency management. However, the risk factors of emergencies in urban public facilities are obscure and numerous. Besides, one risk factor influences or interacts with one another. That presents challenges to mitigate these emergencies which need to eliminate the risk factors in order to achieve the goals of risk prevention and controlling. In this research, a prison in Guangdong Province in China is investigated as an empirical research. The main research problem is how to prevent the criminals' escape emergency in the urban public facilities which is through analysing the interactive risk factors. First, all of the risk factors that may affect the criminals' escape emergency were identified from four dimensions, such as human behavior, equipment and facilities, environment, security management. Second, the interactive and influence relationships among all the risk factors were evaluated by a group of experts. Third, according to the Interpretative Structural Modelling (ISM), all the risk factors and influence relationships among them are represented and analyzed. The results show that the multi-level hierarchical Interpretative Structural Modelling is a powerful way to reveal and understand how these risk factors lead to criminals' escape in this prison. This research is of great significance to tackle with complex emergencies in urban public facilities effectively by analyzing risk factors. Moreover, it provides a novel way to design managerial suggestions of risk mitigation in urban public facilities emergency management.

Keywords

Urban Public Facilities, Risk Mitigation, Risk Factors, Interpretative Structural Modelling (ISM)

1. Introduction

The two functions of urban public facilities are to provide services for residents to maintain the quality of urban living environment (Tsou et al., 2005). Urban public facilities are interdependent, including functional and spatial interdependence (Rinalidi et al., 2001). The managers of urban public facilities also attach great importance to their interdependent activities, thus promoting the realization of network utility of public facilities (Zimmerman, 2001). Urban public facilities are defined as industries, public institutions and media which could continue to provide products or services for national defense, economic security and national health and welfare undertakings (Liu & Zhang, 2009). Urban public facility complex system includes energy, water supply and drainage, road traffic, post and telecommunications, environmental protection, disaster prevention and so on; six systems interact with each other, coordinating in the development of prison security.

To provide material basis for the city's production and living activities, the safe operation of urban public facilities is the prerequisite to ensure normal urban function. The relationship between risk factors is inseparable, interdependent and coupling for the urban public facilities system. Once risk factors suddenly break out, it will lead to emergencies and even chain reactions. The prison, as an important component of urban public facilities, undertakes an important mission for protecting social and public safety, implements the national penalties and corrects criminals' behaviors. Therefore, how to prevent and control the possible emergencies in the operating process of prison facilities, is an integral content of urban safety management. The prison faces the threat of emergencies at any time that seriously affect and violate the normal order (for example, living, laboring, studying, resting), which has special groups in this special place and special circumstance. Emergencies may cause serious damage to the prison facilities, even threaten the prison security and public security directly (Zhou, 2008).

The sudden occurrence of prison facilities emergencies is caused by the interactive relationship of all kinds of risk factors with strong concealing and mutual coupling character. This feature gives rise to taking strict precautions against criminals' escape in prison facilities which is extremely complex. The security situation of prison facilities is very serious, besides prison facilities emergencies have occurred frequently in recent years; especially the criminals' escape has drawn great attention from the government and society. In this paper, the researchers choose the event of criminals escaped from prison facilities as a case study through identifying risk factors comprehensively and analyzing the relationship between the various factors from prison facilities, which will provide theoretical guidance for the design of emergency risk controlling strategies.

In view of this research problem, it was based on the theory of Accident Causation Theory and Fault Tree Analysis, established the fault tree model of drilling lost circulation and analyzed the risk source by using the fault tree to find out the factors that have the greatest influence on the lost circulation (Yuan et

al., 2010). Given the causes of fire in the school dormitory with the fault tree design model, it mainly discussed and assessed the accident probability, the impact of these factors on the probability of the accident, the probability of the occurrence of fire, and the importance of the basic events for the relevant departments of the school to provide a scientific basis for management (Wu et al., 2005). On the basis of analyzing the occurrence of fire and causing casualties, it presented the main causes of human casualties caused by building fire from three directions: the minimum cut set, the minimum caliber assemblages and the importance of structure (Zhu & Shi, 2009). And the critical way of accident prevention is discovered by assaying and comparing the sequence of factors with the emphasis on basic events gradation. In summary, Fault Tree Analysis is to show that the factors can cause disaster events but ignore the relationship between the risk factors, which can't make a far-reaching description of the logical relationship between the risk factors. Although the Interpretative Structural Modelling can describe the ties between the constituent elements of the system in detail, so it can provide a practical and reliable reference for the system security management of the prison. The existing research methods can't deal with the complex relationship between the risk factors of each emergency. Nevertheless, the hierarchies and relationships among the risk factors leading to the vulnerability of emergencies can be analyzed, and the most direct and fundamental factors of the vulnerability of emergencies can be determined by explaining the results of the hierarchical model of the structural model.

Interpretative structural modelling (ISM) as a tool for system analysis (Thakkar et al., 2007), it represents that the elements of the system are essentially interdependent, mutually constrained and interrelated models. The structural model is a complex model that could be decomposed into several subsystems, use people's practical experience and knowledge, and find out the interrelationships among the elements to form a multi-level hierarchical structural modelling (Ravi & Shankar, 2005, Mandal & Deshmukh, 1994, Attri et al., 2013).

The core content of the Interpretative Structural Modelling is based on the reachable matrix processing about the multi-level hierarchical structural modelling. The main advantage lies in the low dependency on the mathematical knowledge, the hierarchical structure can visually display the relationship between the system elements, which can help to improve the system problem. This paper introduces the research method of system analysis of interpretative structural modelling, which is used to explain the relationship between a mass of factors of the criminals' escape, the set of system elements composed of risk factors, and the influence of factors in the collection. According to the layered results of the structural modelling, the analysis of the risk factors that leads to the emergencies of the prison criminals' escape, there must be a hierarchical relationship between the risk factors. In the end, the researchers put forward the theoretical basis for effectively prevention measures against these interdependent risk factors and give suggestions to mitigate the risk of emergencies.

2. Case Description and Data Collection

2.1. Description

The prison is one of public facilities that carries out penalties for the state, and its safety management plays an important role in the security management of urban public facilities. In recent years, the situation of prison security management has become increasingly serious, and has threatened the normal operation of the prison facilities, especially when the occurrence of criminals escape event which has caused a high degree of government attention and social concern. The premeditated activities before criminals' escape is seriously subtle, and the planning is more detailed which shows that its characteristics are intelligent and violent. The means of choosing escape presents its diversity, which presumes not just the prison security management in the face of the key emergencies, but also has great difficulty in prevention and response.

This paper chooses H prison in Guangdong Province in China as an empirical research object. Because the prison is the new prison, prison facilities management procedures, the external environment and other risk factors need to be identified. How to prevent criminals from escaping is the pivotal task of prison security management departments. This study was conducted on-site participatory observation several times in the prison. The researchers comprehensively identified the risk factors that affected the escape of the prisoners and analyzed the relationship between the risk factors. On this basis, the risk management plan is designing to deal with the escaping events of the prison facilities.

2.2. Data Collection

Text analysis. It is a kind of research method to convert texts and image contents in the documents from the fragmented and qualitative form into the systematic and quantitative form. The key part of the conversion process is the variable extraction and its attribute classification (Li, 2004). The researchers collected and analyzed the prison plans which wrote various measures to prevent prison risks and extracted the risk factors of the criminals' escape from the prison plans. According to the safety science and engineering "Man, Machine, Environment, Management" model of criminals escape from prison, the researchers ultimately divided into five categories of factors.

Interview. In the process of security supervision of the prison system, the identification of the risk factor can't fully explain the problem. Researchers interviewed major prison leaders, grass-roots guards and armed police officers, and had a substantive understanding of the emergency management of prisons. As people who worked in the prison will be personally described, it is conducive to the researchers perceived the relationship between the risk factors, and further to ensure the authenticity and reliability of the data.

Delphi method. Based on the particularity of the prison, the experts who have the direct experience and professional knowledge apply the method of judgment and prediction to study the problem. In accordance with the previous historical

cases, the grass-roots prison guards, the armed police officers and the risk assessment experts in the field analyze, so they determine the relationship between risk factors of the prison escape which are interdependent and mutual restraints and establish the adjacency matrix.

3. Influencing Factors and Relational Identification of Criminals Escape

3.1. Identifying the Influencing Factors of Criminals' Escape from Prison Facilities

Social experience, intellectual conditions, criminal experience and personality characteristics of individual criminal are different, so the motivations to implement escape are different; at the same time, the difference between deterrent measures and management control conditions of the prison facilities is huge. Besides, the geographical environment and the road conditions around the prisons are also different. The time and places of the criminals are different from each other. Therefore, the events of criminals' escape from prison facilities show that their characters are premeditated, diverse and hidden.

Through the statistical analysis of the escaping events over the past years, grass-roots guards, armed police officers and risk assessment experts of this field have identified the prison risks. Based on the model of "Man, Machine, Environment, Management", the impact factors of prison system security are divided into five categories: human behavior factors, equipment and facilities factors (Chen, 2015), prison safety regulatory factors, external environmental factors, prison environmental factors (Xin, 2014). What's more, these five types of prison system security factors are interrelated (see Figure 1).

The impact factors are finally divided into five aspects of the 19 prison criminals escape factors, as shown in Table 1.

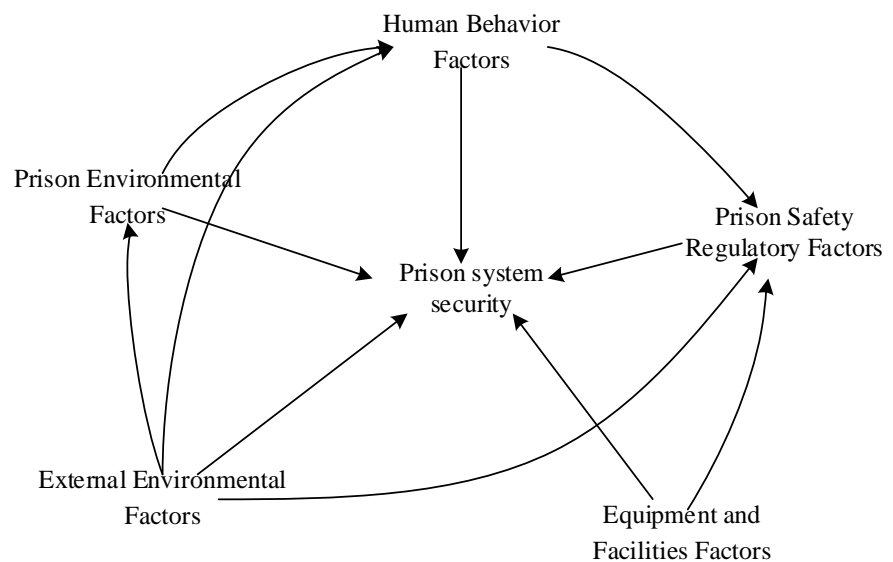


Figure 1. The relationship between five types factors that affect the prison system security.

Table 1. The risk factors of criminals escape from the prison.

	Code	Risk Factors
Human Behavior Factors	F1	The request of the sick criminals isn't met by the prison
	F2	The demands of criminals who have suffered from family misfortune have not been met
	F3	Criminals are in conflict with the disciplines of individual guard
Equipment and Facilities Factors	F4	Hiding in vehicles outside the surveillance zone
	F5	Using the vehicle collision to destroy the prison wall
	F6	Using the prison sewage, flood pipes or digging holes and tunnels
	F7	Using the insulation equipment, ropes, ladders and other climbing tools, and using the prison terrain over the wall
	F8	Criminals are freed on medical parole
Prison Safety Regulatory Factors	F9	Criminals deliberately set fire, destroy faculties, make chaos
	F10	Criminals forge documents and steal clothing, so they can mix out of the regulatory area or meeting room
	F11	Criminals force to escape from the supervision area, the meeting room or the labor site
	F12	Hijacking the police, armed police, outsourcing staff
	F13	A major production safety accident occurred
External Environmental Factors	F14	Illegal organization planning
	F15	Occurrence of natural disasters (such as earthquakes, fog)
	F16	A major public health situation
Prison Environmental Factors	F17	Large-scale deployment of criminals
	F18	Unfair treatment in prison
	F19	Life conditions in prison are extremely deteriorating

Dates from “Reaction and Management on Prison Emergency”

Based on the analysis of the influencing factors of the criminals' escape emergency event, this paper identifies the relationship between these incentives through explaining the structural model of the mutual influence from the criminals' escape. This paper uses the interpretative structural modelling to explain the hierarchical relationship between the factors that lead to the escape of the criminal and identify the underlying causes of the criminals' escape. The adjacency matrix abstractly describes the interrelationship between the causes of the offense of escape. Based on the basic requirements of the interpretive structural modelling, for system $S(F_1, F_2, \dots, F_n)$ with n elements, we can define the adjacency matrix as a direct relationship between system elements, so

$$A_{ij} = \begin{cases} 1 & \text{when the factor } F_i \text{ has a direct effect on } F_j \\ 0 & \text{when the factor } F_i \text{ has no direct effect on } F_j \end{cases}$$

3.2. Determining the Relationship between the Risk Factors

Researchers interviewed experts, someone who is professional in this field, such

as prison leaders and grass-roots guards. On the basis of experts' opinions, the nodes are used to indicate risk factors of the prison criminals escape event after identifying the influencing factors of prison criminals. The connection between the two nodes indicates a relationship, and the connection represents the interdependence among the risk factors of the prison criminals' escape event. Therefore, the construction of the interactional relationship network which displays the ties among risk factors of the escape, as shown below **Figure 2**.

4. An Analysis of Risk Factors of the Prison Criminals Escape Event Based on Interpretative Structural Modelling

4.1. Building the Interpretative Structural Modelling of the Prison Criminals Escape Event

4.1.1. Generating a Reachable Matrix

The reachable matrix is used to describe the degree of arrival which a factor passes through a certain length of the path in the form of a matrix (**Table 2**). It implies a hierarchical relationship between the different factors. Based on the Boolean algorithms, the sum of the adjacency matrix A and the unit matrix I is scaled, then the reachable matrix M of the system element can be obtained. The formula is

$$M = [A + I]^{R+1} = [A + R]^R \neq [A + R]^{R-1} \neq \dots \neq [A + I]^2 \neq [A + I]$$

Table 2. Generating a reachable matrix.

F	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
F1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F3	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F8	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F9	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F10	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0
F11	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F12	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F13	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F14	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1
F15	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1
F16	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F17	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1
F18	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
F19	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1

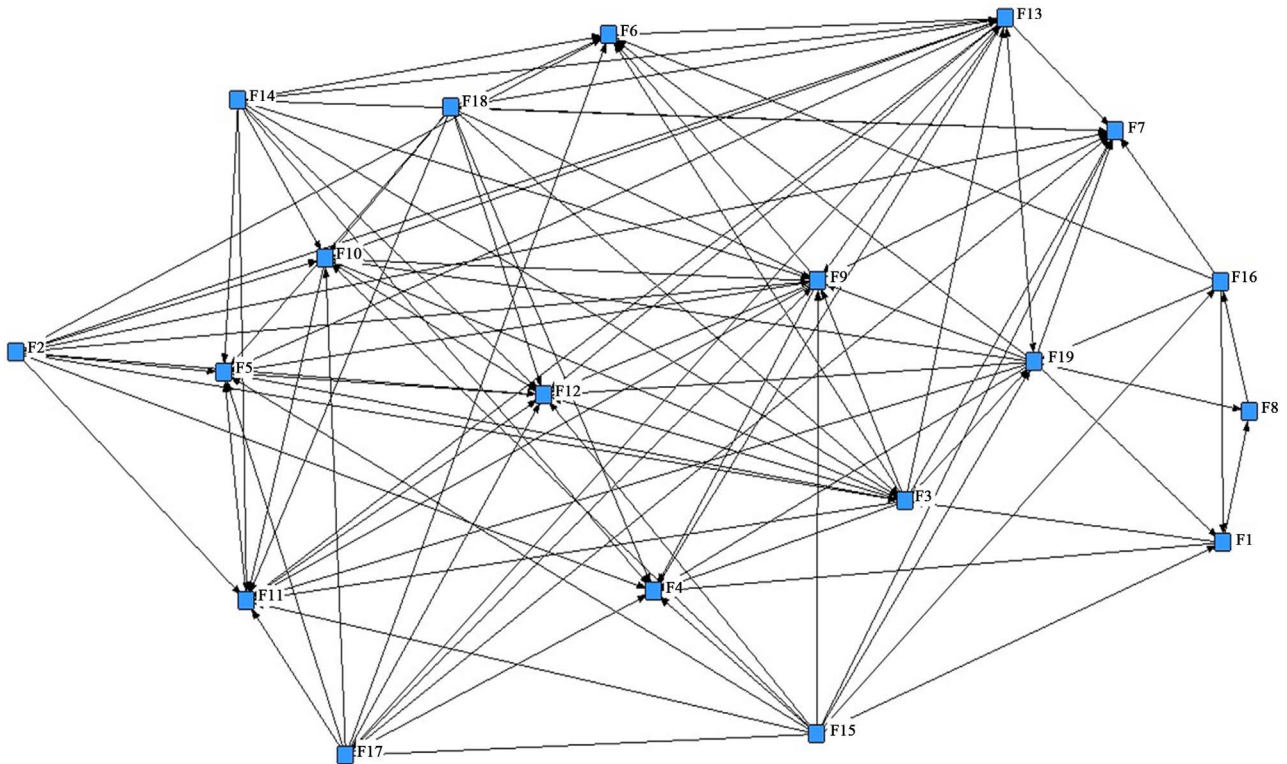


Figure 2. Relationship between the risk factors.

4.1.2. The Hierarchical Processing of the Matrix

After obtaining the matrix, the main step to establish the interpretative structural model is level division. The set of factors that affect F_i is the antecedent set of factors $A(F_i)$ for the factor F_i , that is, all other sets of factors that can achieve S_i . The set of factors affected by the factor F_i is the set of factors that can be reached by the factor $R(F_i)$, that is, the set of all other factors that the factor F_i can reach. In addition to affecting itself, the collection of all factors that can't affect other factors is the most advanced factors. To determine the highest level of multi-level structure, from the reachable matrix to draw the corresponding rows and columns, followed by analogy, so the research can find elements of the highest level included in the collection.

If $R(F_i) = R(F_i) \cap A(F_i)$, then $R(F_i)$ will be the highest factor set.

The result of the analysis is that

$$L1 = \{F4, F5, F6, F7\}$$

$$L2 = \{F11, F12\}$$

$$L3 = \{F10\}$$

$$L4 = \{F1, F3, F8, F9, F16, F17, F19\}$$

$$L5 = \{F2, F15, F14, F18\}$$

As shown in **Table 3**.

4.2. An Analysis of the Interpretative Structural Modelling Risk Factors of Criminals' Escape

The information can be seen from the following figure that the security of the

Table 3. Level 5 reachable set and antecedent set of risk factors.

F_i	$R(F_i)$	$A(F_i)$	$R(F_i) \cap A(F_i)$
F2	2	2	2
F14	14	14	14
F15	15	15	15
F18	18	18	18

prison system is affected by risk factors which is divided into five layers. It is a very complicated system with multi-level hierarchical structure. It can divide the risk factors into five levels which affect the criminals' behaviors, it's shown in **Figure 3**.

1) The top four factors have the most direct impact on risk factors of the prison criminals escape. Hiding in vehicles outside the surveillance zone (F4), Using the vehicle collision to destroy the prison wall (F5), Using the prison sewage, flood pipes or digging holes and tunnels (F6), Using the insulation equipment, ropes, ladders and other climbing tools, and using the prison terrain over the wall (F7), these four factors are included in the Facilities and Equipment of the prison. It can be seen that the Facilities and Equipment of the prison have a great impact on the safety of the prison system and will ultimately affect the security of the prison system.

2) Then analyzing the second and third levels, Criminals force to escape from the supervision area, the meeting room or the labor site (F11), Hijacking the police, armed police or outsourcing staff (F12), Criminals forge documents and steal clothing, so they can mix out of the regulatory area or the meeting room (F10), these three kinds of incentives belong to the Prison Safety Supervision factors. It is necessary to strengthen the inspection of the insecure factors that threaten the supervision of the site, the supervision facilities and the law enforcement work of the guards. Prison law enforcement officers need a comprehensive understanding of the problems and risks in the regulatory process, and establish a preventive management system for preventing prison emergencies.

3) The fourth layer risk factors are: the request of the sick criminals is not met by the prison (F1), Criminals are in conflict with the regulating pattern of individual guard (F3), Criminals are freed on medical parole (F8), Criminals deliberately set fire, destroy faculties and make chaos (F9), Happening major public health outbreaks (F16), Large-scale redeployment of criminals (F17), Life conditions in prison are extremely deteriorating (F19). This level is an indirect intermediate incentive. Prison law enforcement officers should keep watch on criminal behaviors rigorously, monitor the security vulnerabilities of the prison system in the development of a reasonable prison regulatory system. At the same time, to a certain extent, improving the living environment of is to reduce the risk factors of criminals' escape.

4) The underlying causes are: the demands of criminals (who suffered from family misfortune) don't be satisfied (F2), Illegal organization planning (F14),

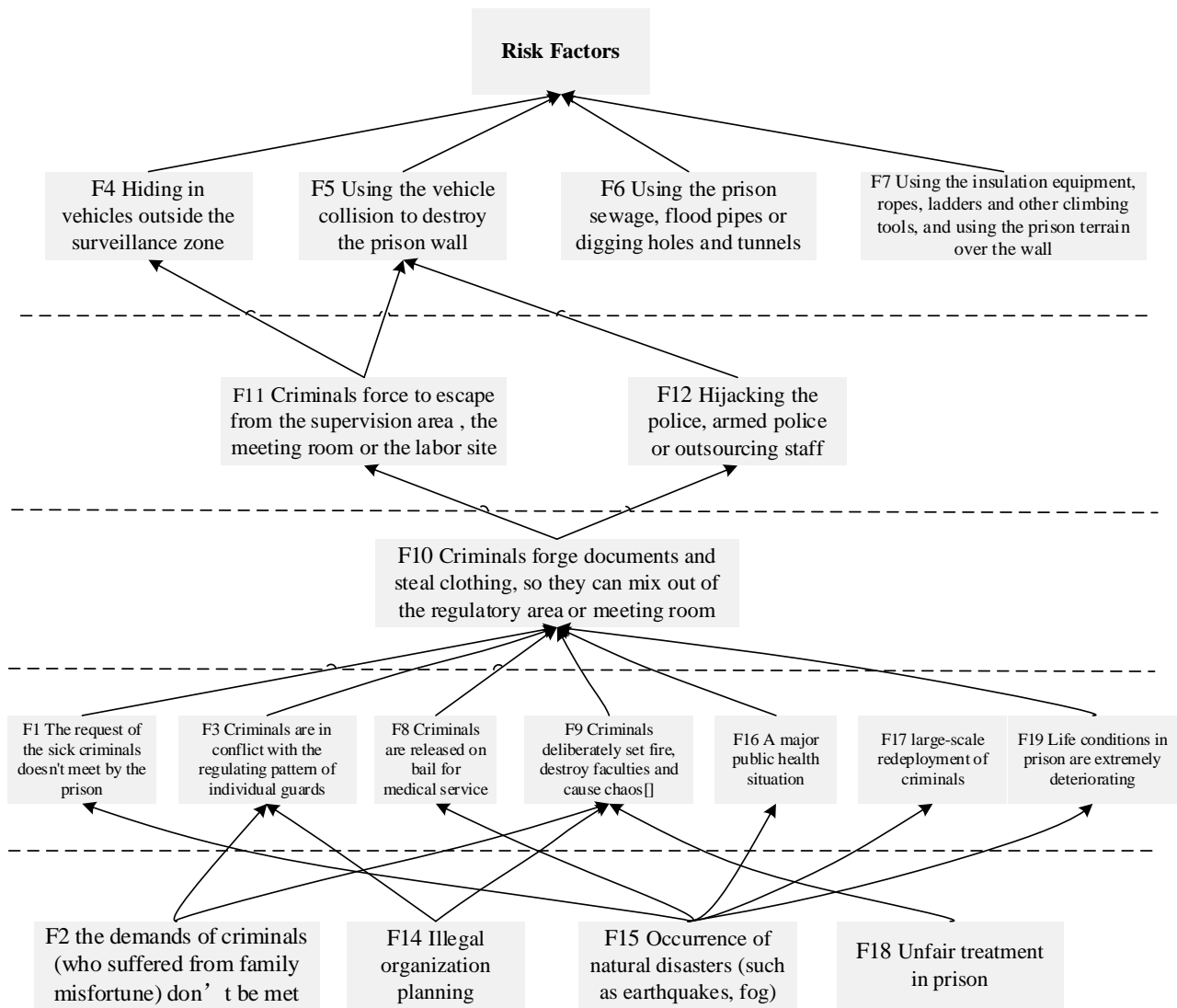


Figure 3. ISM of factors affecting prison system safety.

Occurrence of natural disasters (such as earthquakes, etc.) (F15), Unfair treatment in prison (F18). It can be seen that the deep factors affect the escape of criminals are mainly due to external regulatory factors and natural disaster. Natural disaster is one of the important factors affecting the security of the prison system, mainly caused by the damage of prison Facilities and Equipment (such as high wall and power grid). Its security affects the maintenance of the entire prison system order. In addition, monitoring and easing the psychological status of the criminals is particularly important. The demands of criminals due to family misfortune are not met, resulting in psychological imbalance, and produce a jailbreak motive, which will have a negative impact on its educational reform behaviors.

5. Management Measures and Recommendations

- 1) In order to prevent criminals from escaping from prison, law enforcement

officers need to reinforce the prison system of material resources defense and improve the basic security work. The supervisory facilities for prisons are mainly established by the prison, the armed police forces and the social grass-roots units around the prison area in accordance with the statutory duties. It is commonly called “Three Lines of Defense” system which is a combination of internal management, external guard and the surrounding masses. The prison system reinforces the management of guard facilities such as enclosures, power grids and vehicles. The prison system needs to be well-protected and secure against the criminals’ excavation; the walls should be smooth and free of any climb.

2) Improving early prevention and control mechanism of safety management, law enforcement officers should check the specific regulatory links of the prison system, manage the key parts of the prison and strengthen the management of important facilities such as the meeting room, the guard room, the transformer room, the labor site and its equipment. Moreover, officers should focus on controlling the important period and implementing prison guards’ responsibility system. The prison should be able to keep enough police force, when the important period of defense, major activities or holidays are drawing near. The prison should be able to intensify their vigilance, when criminals reform through labor, dine and sleep, before and after those important moments.

3) Prison guards also need to pay attention to human defense, prison monitoring and prison reconnaissance operations. Prison guards play a leading role in the regulatory security of the prison system, who are the organizers and performers of regulatory security activities. Another major factor influencing prison security is criminals’ uncertain behaviors which play a dangerous role in supervising security activities. Prison People’s Police needs to strictly enforce the individual talk system. The prison guards should talk with criminals in time whose families suffer from major change and conduct their ideological fluctuations. So the guards can warn possible emergencies in advance.

4) The prison guards and the armed police should reinforce the monitoring for the internal and external environment of the prison system. It is necessary to supervise the security of the prisons’ external environment, maintain the stability of the prison order, and prevent the incitement to escape from illegal organizations for the prison system. Thanks to these measures, the prison system could ensure that criminals who are subject to the law of the prison can have a safe and educated environment. From the perspective of the prison guards, they can improve their own law enforcement management ability, familiar with regulatory business and regulate law enforcement management behavior. They need to do the emergency response with the relevant units, when natural disasters cause the possible emergencies and secondary disasters which may lead to unexpected events.

6. Conclusions

The interpretative structural modelling can establish the structure of the risk

factors of the criminals' escape effectively, which intuitively reflects the hierarchical relationship among the risk factors, and provides the basis for the reference to prevent and control of the sudden situation of the criminal escape. Finally, the criminals' escape risk factors are divided into five levels.

Therefore, it is necessary to strengthen the supervision, vehicles management and other facilities and equipment in the course of the operation of the prison system to ensure that there are corresponding contingency plans to dispose of criminals timely to take advantage of such factors. At a special timing node, it is necessary to reinforce the police force and to enhance the emergency response capability of the prison system to deal with sudden supervision of security incidents and public health events. The main purpose of this paper is to clarify the impact level and interrelationship of the main risk factors of prison criminals' escape events, which has great significance to understand the formation, development and evolution mechanism of prison escaping emergencies, and provide the theoretical basis for the prison system to maintain its supervision and security. Different from the assumption of emergency risks in traditional public facilities risk management, this research considers the coexistence of different risks. From the perspective of the relationship between emergencies and risks, the overall risk analysis for all emergencies has laid the foundation on the design of systematic risk control strategies and can provide a reference for the scientific and efficient prevention and management of emergencies in urban public facilities.

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