Research on Influencing Factors of Coal Mine Accident Emergency Management Based on Grounded Theory

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Abstract. In order to deeply analyze the influencing factors of coal mine accident emergency management, the program-based theory method and Nvivo20 qualitative analysis software were used to code and analyze 35 especially major coal mine accident investigation reports, and the influencing factors model of emergency management from the dual Angle of "government-enterprise" and "hidden danger - prevention" was constructed. According to the constructed model, the hidden danger conditions and prevention conditions of coal mine accidents are systematically analyzed. It is pointed out that emergency management should not only remedy after the event, but also pay attention to prevention before the event. This study provides a visual analysis framework for understanding the influencing factors of coal mine accident emergency management, and has theoretical and practical significance for improving China's coal mine accident emergency management ability.

Keywords: Coal mine accidents, Emergency management, Grounded theory, Qualitative analysis, Accident investigation.

1 INTRODUCTION

In recent years, with the rapid development of China’s economy and society, the coal mining industry has grown rapidly, with an increasing number of manpower and equipment, leading to increasingly complex mechanisms behind accidents. Consequently, occupational safety has been increasingly emphasized by all sectors of society. However, it is evident that there are still many unresolved issues in China’s occupational safety situation. Existing safety science and technology as well as safety management measures have yet to achieve complete prediction and prevention of accidents[1]. Therefore, enhancing the emergency management capability of coal mine accidents is an indispensable aspect of safety management in coal mining enterprises.

In recent years, both domestic and international scholars have conducted extensive research on emergency management. Fu Gui et al.[2] utilized the 24 Modelel to analyze gas accidents and proposed preventive measures from both "gas" and "human" perspectives. Wang Yuxi and Fu Gui et al.[3] analyzed the reform measures and ex-

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periential effects of Chinese government in coal mine safety management from three aspects: government supervision, technical equipment, and miner training system. Hu Xu et al.[4] determined various capacities of on-site public health responders in emergency situations using grounded theory analysis. Wang Liukai et al.[5] focused on connotation of coal mine safety risk management; identified risk factors through factor analysis/hierarchical cluster analysis; built CA-SEM model providing decision-making basis for achieving essential coal mine safety. Wen Hong et al.[6] used programmatic grounding theory method to build analytical model "enhancing paradigm awareness (knowing prevention) - improving prevention ability (being able to prevent) - improving prevention system (knowing prevention)", further summarizing crisis learning process mechanism promoting risk prevention as "three mechanisms/two modes". To sum up, according to China's national conditions, we should conduct multi-faceted research from different perspectives to continuously improve the emergency management capabilities of local governments and enterprises.

This paper selects the investigation report of major sudden accidents in the coal mine industry as the research material, uses the program-based grounded theory method to code the investigation report of coal mine industry accidents from 2003 to 2023 from the two aspects of enterprises and the government, constructs the influential factor model of coal mine accident emergency management, and analyzes the influential factors through the model. In order to provide reference for the prevention of coal mine industry accidents, scientific development of coal mine industry accident prevention measures and improve the ability of emergency management of coal mine industry accidents.

2 RESEARCH DESIGN

2.1 Research Methods and Processes

The research method of grounded theory is a qualitative research method that uses systematic procedures to develop and inductively guide the grounded theory for a certain phenomenon[7]. The important steps of its research include three kinds of coding: open coding, spindle coding and selective coding. By mining the core concepts and categories in the three types of coding data of the initial data, the nature of the categories and the intricate relationship between them are finally determined[8]. According to grounded theory, not only observation and interview data can be used as research data - it follows the principle of "all is data", and policy texts with strong authority, availability and representation can also be used as data sources[6]. This paper adopts the method of programmatic grounded theory to extract, model and analyze the key influencing factors in the emergency management of coal mine industry.

2.2 Data Collection

The major sudden accidents in the coal mine industry collected in this paper include gas combustion, coal dust explosion and water leakage accidents, etc. In order to ensure the authenticity of the data, the data comes from the accident and disaster inves-

tigation report issued by the Ministry of Emergency Management, PRC. Excluding the accident investigation report of non-coal mining industry, a total of 35 investigation report text data from 2003 to the beginning of September 2023 were obtained.

3 DATA ANALYSIS AND CODING

Firstly, the text content was sorted out, and after repeated screening and eliminating invalid content, 202,000 words of text data were finally formed. 20% of the accident investigation reports (7 reports) in the database were randomly selected as the material for theoretical saturation test. Secondly, according to the process of programmatic grounded theory, NVivo20 software is used to carry out open coding, main-axis coding and selective coding for the text content, and complete the extraction, clustering and comparative analysis of the initial concept, category and main category. Finally, the reserved 7 accident investigation reports were coded and analyzed again for theoretical saturation test.

3.1 Open Coding Categorization

The main work of open coding is to decompose and compare the original text data, encode the same or similar sentences uniformly, so as to conceptualize and categorize the text content. This process mainly plays a preliminary role in condensing and defining the concept[9]. With the help of NVivo20 software, the remaining 80% survey reports (28 reports) were imported into the software to establish a database, forming 71 initial categories; The results of open coding from a macro perspective (part) are shown in Table 1. Due to space constraints, the conceptualized coding statements and source data in the table are presented as examples only.

Table 1. Examples of open coding categorization

Serial number	Original statement coding	Initial concept	Initial category
1	When the operator was dealing with the fall of the roof, the illegal open gun caused the gas explosion, and the coal dust participated in the explosion	Illegal firing of open fire	Illegal operation
2	The mine ignored government supervision and organized illegal production for a long time	Disregard government regulation	Illegal organized production
3	Fu Mining Group Company and Sunjiawan Coal mine focus on production, light safety, one-sided pursuit of efficiency, neglect of safety management	One-sided pursuit of benefits	Neglect of safety management
…	…	…	…

3.2 Spindle Coding

Spindle coding is the process of clustering and integrating categories extracted from open coding in order to discover and establish relationships between different catego-

ries[10]. In order to further refine the category, the correlation between 71 initial categories was compared and analyzed, the logical relationship between categories was further clarified, the logical sequence and interaction between categories were summarized, and categories with similar or similar themes were grouped together, a total of 16 main category concepts were obtained, such as insufficient safety training, strengthening safety emergency response capability and inadequate government supervision. Due to limited space, only part of the main categories are shown. The connection between the initial categories and the main categories is shown in Table 2.

Table 2. Spindle coding example

Principal category	Initial category	Categorical connotation
Inadequate safety training	Safety training is inadequate No emergency drills were conducted	The problem of safety training reflects that employees do not understand and pay little attention to their own or others' safety behaviors, and lack of emergency handling ability after accidents.
Strengthen security emergency response capacity	Strengthen safety training Emergency plan drill	Formulate and implement perfect emergency plans, regularly conduct safety emergency training and exercises, improve the ability and skills of relevant personnel in emergency handling of security incidents, and ensure that they can respond and handle security incidents quickly and accurately.
Weak government supervision	Technical underwork Regulatory enforcement is a formality The site was not verified	There are problems such as inadequate inspection, inadequate supervision, inadequate grasp of the situation, inadequate work guidance, failure at all levels of administrative approval, mere formality of supervision and law enforcement, and lack of professional and technical personnel.
…	…	…

3.3 Selective Coding

Selective coding is mainly a systematic analysis of all categories and major categories that are found to have conceptual class associations, and the selection of core categories[11]. At the same time, the logical relationship between the core category and the main category is analyzed in detail to build a new theoretical structure[12]. This paper takes "Influencing factors of emergency management of major safety accidents in coal mine industry" as the core issue, and summarizes all open coding and spindle coding into four core categories on the basis of comprehensive systematic analysis and integration. They are respectively management defects, ideological imbalance, capacity building and system building, as shown in Table 3.

Table 3. Selective coding

Core category	Principal category
Management defect	Enterprise management problem Equipment problem Safety training problem
Ideological imbalance	Illegal subcontracting Illegal production problem Lack of ideas Weak government supervision The intermediary is deceptive
Capacity building	Strengthen professional skills Strengthen management ability Strengthen security emergency response capacity Control risk in advance
Institutional construction	Strengthen coordination and interaction Rapid emergency response Strengthen the sense of responsibility Improve institutional construction

The reference points of each initial category, main category and core category were counted, and a total of 614 reference points were obtained. The four categories with a high proportion of reference points were selected for display. The code of "weak government supervision" accounted for 15.31%, and the code of "rapid emergency response" accounted for 7.17%. The code of "enterprise management problems" accounted for 24.42% and the code of "strengthening management ability" accounted for 8.31%. As shown in Figure 1, the total node coding hierarchy diagram of influencing factors of coal mine accident emergency management can be clearly and intuitively seen that weak government supervision and enterprise management problems are important factors affecting coal mine accident emergency management.

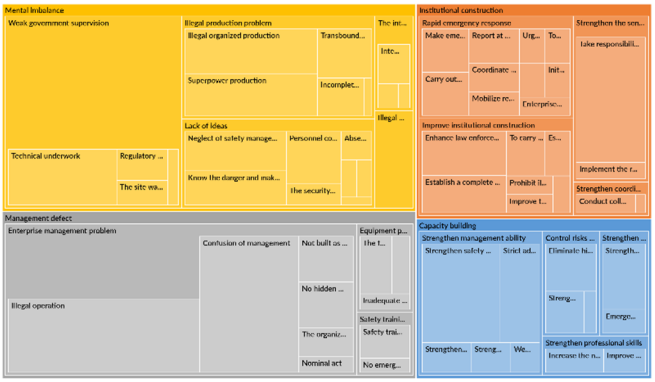

Fig. 1. Coding hierarchy diagram

3.4 Theoretical Saturation Test

Theoretical saturation testing is the process of determining criteria when no new genera or related topics emerge to decide to stop sampling when there is no more data to further develop a category feature[13]. The 7 investigation reports without coding analysis were re-coded according to the above coding method to compare whether new concepts and categories were generated. As shown in Table 4, the total number of emerging categories in the 1-28 investigation reports increased to 71; in the 29-35 accident investigation reports, the number of new emerging categories was 0, and the total number of emerging categories was stable at 71. The results show that there are no new concepts and categories, which means that this study passes the theoretical saturation test.

Table 4. Examples of topic saturation tables

Accident investigation report	Reference point	Category	Common category number with the previous case	Number of emerging categories	Total number of categories that have emerged
1	85	27	-	-	27
2	26	17	15	2	29
……	……	……	……	……	……
28	27	18	17	1	71
29	34	22	22	0	71
……	……	……	……	……	……
35	39	33	33	0	71

4 MODEL DESCRIPTION AND ANALYSIS OF INFLUENCING FACTORS

According to the condensation and extraction of the investigation report, the initial category, main category and core category are obtained, and the model of "Influencing factors of emergency management of major safety accidents in coal mine industry" is further constructed, as shown in Figure 2. The logical relationship between the causes of accidents is summarized by the grounded theory, which lays a foundation for further analysis of the influencing factors of coal mine accident emergency management. Therefore, from the dual perspective of "government-enterprise" and the two conditions of "hidden danger - prevention", this paper will explain the logical relationship with the factors affecting the occurrence of accidents, and take "ideological imbalance" and "management defect" as the negative influencing factors of coal mine accident emergency management, and "capacity building" and "system construction" as the positive influencing factors. This paper hopes to provide some suggestions and inspiration for improving the emergency management ability of coal mine accidents.

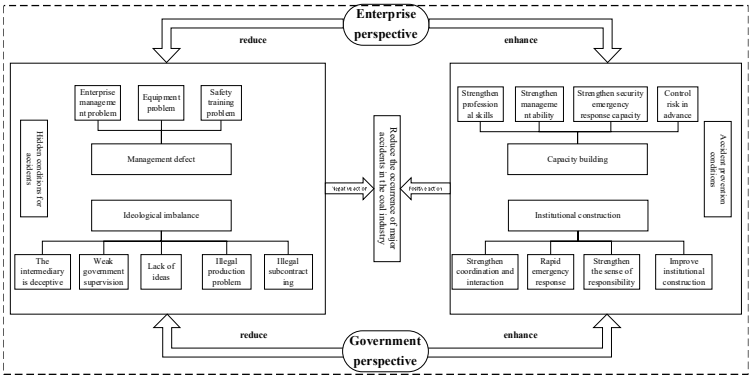

Fig. 2. Influencing factor model of coal mine accident emergency management

4.1 Ideological Imbalance

From the perspective of the government, it should give full play to the role of supervisors to ensure people's safety and social security. However, some government management departments have not really fulfilled their obligations, leaving hidden dangers for the occurrence of many major accidents. The lack of relevant technical work and the lack of professional and technical personnel in accordance with the regulations have led to some obvious major hidden dangers that have been permanently cured and eventually caused irreparable major losses.

From the perspective of enterprises, some enterprise security ideas have not been corrected, and they ignore the instructions issued by government departments and do not implement them. Inside the production situation is not clear, desperate, illegal production; In violation of national laws and regulations, illegal contracting and subcontracting have virtually increased the probability of accidents.

4.2 Management Defects

From the perspective of the government, the government management department failed to effectively manage the enterprise, and the investigation work was not in place. There is no timely supervision and resolution of the nominal behavior of enterprises, and there is a situation of one post and two positions and unclear responsibilities for a long time. The enterprise layer by layer subcontracting, to the package management, risky and reckless behavior did not grasp the situation in time to make a stop.

From the perspective of enterprises, enterprises do not carry out necessary safety training and emergency drills for employees, resulting in the overall low level of safety knowledge and skills of employees, frequent violations of rules and regulations, disregard for labor discipline and other problems, and ultimately lead to production safety accidents still occur. The problem of internal management defects in

enterprises is very serious. If the management of enterprises is not corrected from the root, coal mine accidents will still occur and cannot be cured.

4.3 Capacity Building

From the point of view of the government, the first should enhance the professional skills of cadres, cadres management ability and cadres safety emergency ability. Second, education and training should be strengthened to strengthen the ability of the cadre team to learn new technologies, so that possible security risks can be accurately positioned and prevented in advance.

From the perspective of enterprises, first of all, enterprises should encourage employees to actively participate in safety management and improve safety management capabilities. Secondly, enterprises should focus on improving the professional skills of employees and avoid dangerous behaviors that may lead to accidents through safe and reliable technical operations. Finally, enterprises should regularly carry out safety emergency drills and improve employees' safety emergency response ability through practice.

4.4 System Construction

From the perspective of the government, through the continuous improvement of the system mechanism, it can improve the safety of coal mine security, and maintain the life and property safety of employees. It is necessary to strengthen prevention in advance, establish an emergency framework for major safety accidents, and improve the safety system of coal mines. To complete the reporting system and perfect the reporting mechanism is another key link to perfect the system. We will make comprehensive use of rewarding reports and other forms to improve our capacity for disaster prevention, mitigation, relief and emergency management of major emergencies.

From the perspective of enterprises, we should vigorously promote the people-oriented, life first, safety first thought, adhere to the concept of safe development, and adhere to the red line of safe production. Step up efforts to investigate responsibility for accidents. We will vigorously introduce outstanding personnel, combine advanced science and technology, improve the responsibility system for work safety, improve the work safety management system, and formulate an emergency rescue system for accidents. By constantly looking for the cause of the accident, improve the management system, improve the working mechanism, improve the emergency management ability of the enterprise, and prevent the recurrence of similar accidents.

5 CONCLUSION

(1) The research believes that emergency management is not only a remedial behavior after the accident, but also should be carried out from the perspective of pre-prevention. From the dual perspective of "enterprise-government", it summarizes the four core areas of "ideological imbalance", "management defects", "capacity

building" and "system building", and makes a detailed interpretation of the influencing factors of coal mine accident emergency management. It provides important knowledge and capacity support for improving the emergency management capacity of enterprises and governments.

(2) This paper analyzes the text of the coal mine accident investigation report through the programmed grounded theory, and points out that "ideological imbalance" and "management defects" are the hidden conditions for the occurrence of accidents, which have a negative effect on the emergency management of major accidents in the coal mine industry; "Capacity building" and "system building" are the prevention conditions of accidents, and play a positive role in the emergency management of major accidents in coal mine industry.

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