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Research on Safety Risk Grading and Hidden Trouble Identification and Management Strategy of Dual Prevention Mechanism Based on Multi-Level Analysis Approach

Fang Yan[1, ✉]

[1] Training and Education Department, Hunan Vocational Institute of Safety Technology, Changsha, Hunan, 410151, China

ABSTRACT

The construction of dual prevention mechanism is a necessary way to solve the problem of "not recognizing, not thinking, not managing well" in the field of enterprise safety production. This paper combines the elements involved in the theoretical framework of the dual prevention mechanism, constructs two evaluation index systems of safety risk classification and the operation effect of the dual prevention mechanism, and then establishes an evaluation model based on the multi-level analysis method and the fuzzy comprehensive evaluation method, to explore the operation effect of the dual prevention mechanism in the enterprise. The evaluation results show that after the dual prevention mechanism of safety risk classification and hidden danger investigation and management strategy is operated in S enterprises with higher safety risk level (1.50 points), the awareness of safety production and the level of intrinsic safety of the enterprises have been significantly improved, and the average value of the evaluation of the operation effect of the dual prevention mechanism in enterprises is 3.91 points, which reaches a good level. The research results of this paper not only have strong guiding significance and practical help for the optimization of risk management of production safety in enterprises, but also can be used by the same type of enterprises and even other enterprises in optimizing the risk management of production safety and the management of hidden danger investigation.

Keywords: multilevel analysis, fuzzy comprehensive evaluation, indicator empowerment, dual prevention mechanism, safety risks

1. Introduction

The essence of the dual prevention mechanism is to control the risk before the hidden danger arises through the safety risk classification and control, and to eliminate the hidden danger before the

✉ Corresponding author.
E-mail address: yanfang20242024@163.com (F. Yan).
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accident occurs through the hidden danger investigation and management [1]. Building a dual prevention mechanism is a fundamental way for enterprises, institutions, construction sites, indoor, equipment, etc. to establish and improve the long-term mechanism of safety control, is to realize the important measures of source management, moving the gate forward and preventing in advance, is an important means of effectively curbing the occurrence of accidents, and is an effective measure for self-restriction, self-improvement, precise prevention and control, saving for a rainy day, and preventing accidents from occurring in the first place [2-5]. Taking enterprises as an example, at present, the production safety management of most enterprises still stays in the "rule of man" stage, mainly relying on the personal experience of managers to carry out safety management. Due to the varying cultural and business levels of the managers, it may lead to the occurrence of insufficient identification of hidden dangers, unreasonable risk grading, and inadequate control measures. By vigorously promoting the construction of dual prevention mechanism, the enterprise can further strengthen the safety risk awareness of all employees, firmly establish the safety development concept of "people first, life first", effectively solve the safety management problems such as unclear understanding of risks, inadequate safety risk management and control, inappropriate hidden danger investigation, untimely and incomplete management of hidden dangers, and eventually Form a double line of defense back with risk management and control in the front and hidden danger inspection and management in the back, create a safety management pattern in which all staff are responsible, all staff are in control, all staff are in inspection, all staff are in duty, and form a safety management system that is full-process, all-encompassing, full-coverage, constantly improving, and continually improving [6-8].

In addition, according to Heinrich's law of safety, behind every major accident, there must be 29 minor accidents and 300 potential risks and hazards, if you can't do a good job of identifying the hidden dangers and take reasonable measures to effectively eliminate the hidden dangers of accidents, it is inevitable to cause production and safety accidents, which will cause incalculable losses to the enterprise. Due to the hidden nature of hidden accidents, it is difficult to thoroughly investigate all the hidden dangers in place by relying on personal management. Therefore, in the case of long-term safety hazards in the enterprise, it is necessary to rely on a good internal management system and organizational system to establish a scientific, systematic and comprehensive accident prevention system to ensure the long-term mechanism of production safety [9-11]. Through the construction of the dual prevention mechanism, it will help enterprises to realize all-round control without dead angle, improve the ability of safety production organization and management, hidden danger investigation and management, emergency response capability, etc., realize the implementation of risk control measures in place, and ultimately help enterprises to achieve intrinsic safety [12-13]. Therefore, to carry out the construction of dual prevention mechanism is fundamental to the development of enterprises.

This paper takes the theoretical framework of the dual prevention mechanism as the basis, and constructs the evaluation index system of safety risk grading and the evaluation index system of the operation effect of the dual prevention mechanism according to the close connection between the safety risk management, the management of potential hazards and the safety accidents in the dual prevention mechanism. Multi-level analysis method is used to empower the indicators, judgment matrix is constructed based on the evaluation index system, evaluation matrix is established by combining the scoring results of experts, and average random consistency index test is conducted, and then the weight value of each evaluation index is calculated based on the evaluation matrix of experts. Subsequently, the fuzzy mathematical model is used to calculate the degree of affiliation of the indexes, and the fuzzy comprehensive evaluation is carried out on the indexes in the evaluation system of the operation effect of safety risk classification and dual prevention mechanism by combining the weights. Finally, the operational effect of dual prevention mechanism in enterprise safety risk management and hidden danger investigation and management is explored through empirical application.

2. Theoretical framework for dual preventive mechanisms

Dual prevention mechanism [14] refers to the hierarchical management of safety risks and the comprehensive investigation and management of potential risks. In the traditional safety management approach, risk control and potential risk remediation are considered to be two completely independent steps. However, in this dual prevention mechanism, risk management and potential risk remediation form an interconnected and proven safety barrier. In the dual prevention mechanism, the close connection between risks, potential hazards and accidents is shown in Figure 1. Efforts should be made to identify potential latent risks in the project and take early warning and preventive means to reduce or control these risks. In addition, potential safety problems due to negligence in risk management should be identified through continuous troubleshooting, and improvements and fixes should be made to the parts with poor risk management. In addition, it is important to be prepared for emergency response to accidents in order to minimize injuries or damages caused by incidents or accidents involving the safety of persons and property.

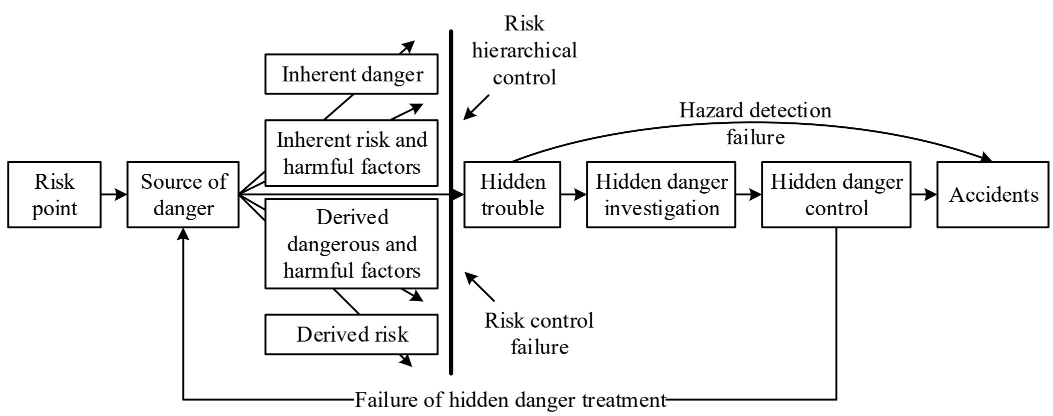


Fig. 1. Relationship between risks, hazards and accidents

The process based on the design of the dual prevention mechanism can be divided into two major parts, one is the construction of the safety risk classification and management mechanism. The second is the construction of the hidden risk investigation and management mechanism, and the specific design process is shown in Figure 2. In the process of constructing the safety risk grading management mechanism, in order to establish such a mechanism, it is necessary to design a suitable control process from the three key aspects of safety risk identification, evaluation and grading management. In the process of constructing the hidden danger investigation and management mechanism, the following strategies can be considered: first, clarify the management process of the three key links of hidden danger investigation, evaluation and closed-loop management, so as to form a perfect hidden danger management system. Next, it is necessary to combine the hidden danger investigation and management mechanism with the safety risk classification management mechanism to play a driving role, and the ultimate development goal of the prevention strategy should be formulated in the process of implementing the mechanism. Finally, the information management system is built, and the hidden danger inspection is carried out at the same time as the safety risk grading management, so as to improve the development results of risk management and better realize the development goal of risk management.

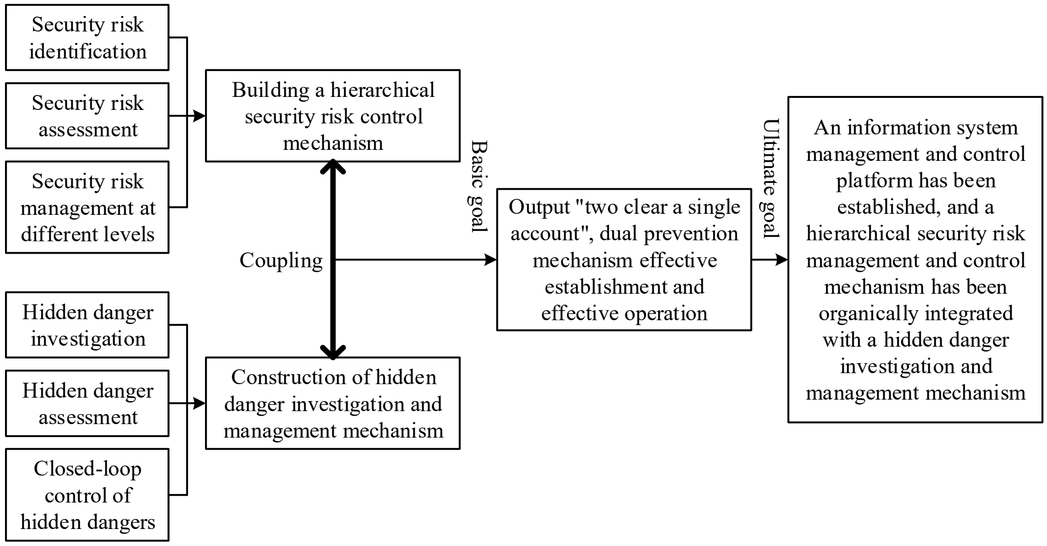


Fig. 2. Theoretical analysis framework of dual prevention mechanism

3. Evaluation methodology based on multilevel analysis

3.1. Construction of evaluation index system

3.1.1. Evaluation indicators for security risk classification. After collecting and analyzing relevant research data [15], this paper determines the safety risk grading evaluation index system of the production project, and the specific evaluation index system is shown in Table 1. The first-level indicators include physical factors, factual factors, and human factors, and the second-level indicators include material factors, equipment factors, natural environment, site environment, operator factors, and managerial personnel factors. In addition, 19 third-level indicators are included.

Table 1. Safety risk evaluation index system

Primary indicator	Secondary indicator	Tertiary index	Numbering
Physics (P)	Material safety risk factor (P1)	Material performance	P11
		Material transfer	P12
		Material storage and use	P13
	Equipment safety risk factor (P2)	Equipment quality inspection	P21
		Equipment safety usage	P22
		Equipment maintenance and maintenance	P23
Reason (R)	Natural environment (R1)	Extreme weather conditions	R11
		Geologic hydrological condition	R12
	Field environment (R2)	Safety protection facilities	R21
		Safety warning sign setting	R22
		Construction environment maintenance condition	R23
Hermit (H)	Safety risk factors for workers (H1)	The degree of use of safe protective goods	H11
		The frequency of the risk of violation	H12
		Job experience	H13
		Proficiency in special skills	H14
	Manager safety risk factor (H2)	Lack of safety education training	H21
		Manager's experience	H22
		The on-site safety inspection is formalized	H23

3.1.2. Indicators for evaluating the effectiveness of the functioning of the dual prevention mechanism. The operational effectiveness evaluation index system of the dual prevention mechanism's safety risk grading and hidden danger investigation and management strategy is shown in Table 2. The former focuses on ex ante prevention by comprehensively and meticulously identifying, evaluating and controlling risks, and seeks to minimize the likelihood of safety accidents. The latter focuses on the investigation and management of hidden dangers that already exist, and strengthens process monitoring to ensure the timely elimination of potential safety hazards and prevent them from evolving into actual accidents. The close linkage between the two has formed an integrated management model from risk control to hidden danger management, which jointly guarantees the effective operation of the dual prevention mechanism for production safety.

Table 2. Security risk rating system

Primary indicator	Numbering	Secondary indicator	Numbering
Safety risk classification	A	Safety risk database management efficiency	A1
		Security risk identification	A2
		Safety risk assessment	A3
		Safety risk control scheme	A4
		Safety risk control	A5
		Safety risk information dissemination and dynamic monitoring efficiency	A6
Hidden danger	B	Risk database management efficiency	B1
		Risk classification and classification	B2
		List of pitfalls	B3
		Trouble finding and reporting rectification efficiency	B4
		Hidden management	B5
		Risk adjustment rate	B6
		Hidden acceptance	B7

3.2. AHP-simulation integrated evaluation model

3.2.1. Methodology for the assignment of indicators. In the process of judging the two-by-two comparison of safety production risk evaluation indexes 1-9 is used as a scale, and a judgment matrix is constructed for risk analysis calculation [16]. According to the above method, each element is scored by m experts to build an evaluation matrix, and according to the scoring of an expert, there is an evaluation matrix as follows:

$$A^{(k)} = (a_{ij}), k = 1, 2, 3, \ldots, m \tag{1}$$

$$A(x) = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \tag{2}$$

$$w_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}} \tag{3}$$

$$w_i^k = \frac{w_i}{\Sigma_i w_i} \tag{4}$$

$$\lambda_{\max} \approx \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \tag{5}$$

Coherence indicators:

$$C.I. = \frac{\lambda_{\max} - n}{n - 1} \tag{6}$$

Calculate the consistency ratio $CR. = \frac{C.I}{R.I}$ ($R.I.$ is the average random consistency index) $C.I.$ value is inversely proportional to the degree of consistency, i.e., a low value of $C.I.$ results in a high degree of consistency, and vice versa for a high value of $C.I.$ results in a low degree of consistency. Consistency is passable only if $CR < 0.1$, otherwise this evaluation matrix needs to be corrected. The accuracy of the multilevel analysis method of calculating weights depends on the judgment matrix constructed by experts, for the questionnaire type of decision-making when calculating the weights of the problem, this paper adopts the construction of a judgment matrix by each safety project manager to synthesize a judgment matrix from multiple judgment matrices to calculate the weights, the synthesis method is a weighted geometric mean synthesis method, and finally the consistency test with standard deviation method, such as if there are m project managers participate in the survey, the weight of the kth person is $\lambda_k (k = 1, 2, 3, \ldots, m)$, when it is difficult to obtain direct information on the results of the survey or not easy to make comparisons, usually the weight of the experts as the same treatment.

When the weights of experts are consistent, the synthesized formula:

$$W_{ij} = \sqrt[m]{W_{ij,1} \cdot W_{ij,n} \cdots\cdots W_{ij,m}} (i, j = 1, 2, \cdots, n) \tag{7}$$

The standard deviation can be used to determine the feasibility of the evaluation matrix with standard deviation:

$$\sigma^k = \sqrt{\frac{\Sigma_{j=1}^{m}(w_j^k - w_j)^2}{x-1}}(k = 1,2,\ldots\ldots,m) \tag{8}$$

When $\sigma^k < \varepsilon, \varepsilon \in [0.5,1]$, the evaluation matrix for the kth person is feasible.
Calculate the overall standard deviation:

$$\sigma = \sqrt{\frac{\sum_{k=1}^{m}(w_k - \overline{w})^2}{m-1}}(k = 1,2,\ldots\ldots,m) \tag{9}$$

When $\sigma^k < \varepsilon$, the determination of this cluster is plausible.

In this paper, we used the method of surveying and scoring by 10 practicing project managers to obtain information on the importance of each safety risk factor. The invited personnel included roles such as senior management of the contractor as well as the project product manager and the head of research and development. Afterwards, the results of the survey were processed using the multilevel analysis method, and finally, the weighted values of each indicator can be obtained.

3.2.2. Evaluation models.The evaluation study in this paper may affect the comprehensiveness of the evaluation results if it relies only on expert judgment and questionnaires, using some of the subject's opinion expression. It is difficult to draw accurate conclusions about the impact of evaluation elements and indicators on production safety risk grading. Because the evaluation indicators are fuzzy, the fuzzy comprehensive evaluation method is selected on the basis of multi-level analysis method, and then the attribute model is used to quantify the fuzzy problems and draw the evaluation conclusion. According to the evaluation index system constructed in the previous section and the determined weights of the indexes, the affiliation matrix of the index layer is constructed, and the fuzzy evaluation method is used to calculate the evaluation results.

1) Determination of the affiliation matrix R of the indicator layer. This paper determines the degree of affiliation (also known as the frequency of affiliation) by evaluating the maturity level scoring given by the evaluators to the security risk-related indicators through the fuzzy mathematical modeling calculation method [17]. The formula is:

$$\text{Membership of } v_0 \text{ to } A = \frac{\text{Degree of } v_0 \in A}{\text{Total number of trials } n} \tag{10}$$

where v_0 represents a deterministic element located on the thesis U and A represents a changeable clear set on the thesis U . Therefore, the steps for calculating the affiliation degree of the indicator layer are as follows.

r_{ij} is determined by the fuzzy statistical method, v_{ij} represents the number of people whose i th indicator is rated at the j th rating level, and $\sum_{i=1}^{j} v_{ij}$ represents the total number of experts who conducted the evaluation, then r_{ij}:

$$r_{ij} = \frac{v_{ij}}{\sum_{i=1}^{j} v_{ij}} \tag{11}$$

where $i = 1,2,\cdots,k;\ j = 1,2,3,4,5.$

Construct the indicator layer affiliation matrix R_i:

$$R_i = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & r_{21} & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{k1} & r_{k2} & \cdots & r_{k5} \end{bmatrix} \tag{12}$$

where R_i represents the affiliation matrix of the indicator layer under the i nd element.

2) Fuzzy comprehensive evaluation of indicator layer and element layer:

(1) Fuzzy comprehensive evaluation of indicator layer. U_i fuzzy comprehensive evaluation, notation $U_i = \{U_{i1}, U_{i2}, \cdots, U_{ik}\}$, corresponds to a weight of $W = (w_{i1}, w_{i2}, ..., w_{ik})$, and the comprehensive evaluation of U_i is:

$$\begin{aligned} B_i &= W_i \cdot R_i \\ &= \{w_{i1}, w_{i2}, \cdots, w_{ik}\} \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & r_{21} & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{k1} & r_{k2} & \cdots & r_{k5} \end{bmatrix} \\ &= \{b_{i1}, b_{i2}, b_{i3}, b_{i4}, b_{i5}\} \end{aligned} \tag{13}$$

(2) Fuzzy comprehensive evaluation at the element level. The fuzzy comprehensive evaluation of the element layer is noted as $U = \{U_1, U_2, U_3, U_4, U_5\}$, the corresponding weight is $W = (W_1,\ W_2,\ W_3,\ W_4,\ W_5)$, and its comprehensive judgment matrix is R. The comprehensive evaluation of the target layer is B:

$$\begin{aligned} B &= W \cdot R \\ &= (W_1, W_2, W_3, W_4, W_5) \cdot [B_1, B_2, B_3, B_4, B_5]^T \\ &= (b_1, b_2, b_3, b_4, b_5) \end{aligned} \tag{14}$$

(3) Calculation of assessed value:

$$U = B \times C^T \tag{15}$$

where U represents the evaluation value, reflecting the level of safety risk grading, B is the comprehensive evaluation vector, and C^T represents the transpose matrix. $C = (1, 2, 3, 4, 5)$, is the row vector matrix of safety risk grading evaluation level, corresponding to the five level scores of safety risk grading evaluation. The safety risk level is categorized into out-of-control level, basic level, standard level, excellent level and strategic level, and the corresponding scores are [0, 1], (1, 2], (2, 3], (3, 4] and (4, 5], respectively. The evaluation of the effectiveness of the functioning of the dual prevention mechanism was graded as poor, poor, moderate, good and excellent, with the same scoring criteria corresponding to [0, 1], (1, 2], (2, 3], (3, 4] and (4, 5].

4. Analysis of the effectiveness of the operation of the dual prevention mechanism for work safety

4.1. Analysis of the risk profile of security in enterprise S

4.1.1. Overview of S Enterprises. S enterprise's main project for automobile precision forging gears and other bearing precision forgings, is a collection of precision forging gears research and development, production, sales as one of the leading enterprises in China, is the world's first-class level of precision forging gears supplier, car precision forging gear production and sales for many years in the domestic counterparts in the first place.S enterprise was founded in 1995, covers an area of 54,600 square meters, building area of 29,500 square meters. The registered capital is RMB 512,632,540,000, and the bank credit rating is AAA. As of December 2023, according to the statistics, S enterprise has the following types and quantities of equipments, 18 sets of cranes and elevators, 12 motor vehicles (forklifts), 58 sets of forging equipments, 460 sets of machining equipments, 18 heat treatment furnaces, 14 sets of shot blasting machines, 16 sets of cleaning machines, and 72 sets of mold workshop equipments. Therefore, the common accidents in S enterprises are mechanical injuries, object strikes, burns, electrocution, vehicle injuries and so on.

4.1.2. Statistics on production safety accidents. The compilation and statistics of the safety ledger data of Enterprise S. The regional statistics of the occurrence of safety incidents within the period of January 2010-December 2022 are shown in Figure 3, and the values corresponding to the stacked graphs are the total number of safety incidents occurring in the year.A total of 470 safety incidents occurred in Enterprise S during the period of 2010-2022. Despite the decrease in the number of security incidents in 2022 (33) compared to 2020 (45) and 2021 (49), the overall trend of security incidents in Enterprise S is increasing between 2017 and 2021. In particular, the number of security incidents increased by 8.89% in 2021 compared to 45 incidents in 2020. It is also noteworthy that the number of security incidents in Enterprise S remained above 40 for all four years from 2018 to 2021. This indicates that enterprises still face certain challenges in terms of security and need to further strengthen their management and preventive measures.

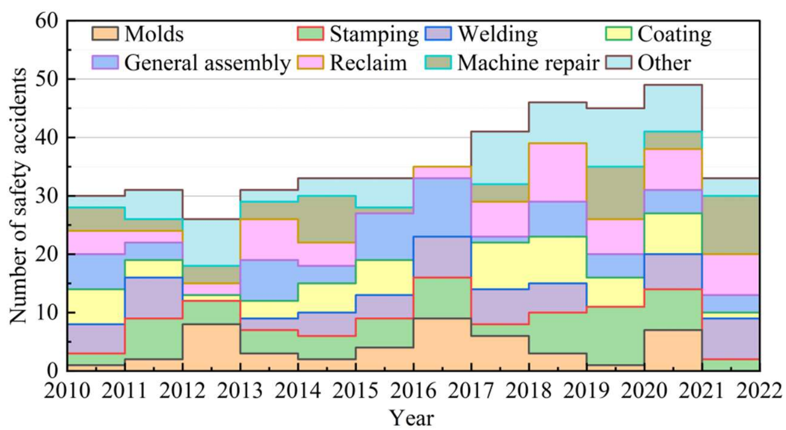


Fig. 3. Regional analysis results of safety accidents

The results of the analysis of the specific accidents of the enterprise's safety production from 2010 to 2022 are shown in Table 3. 264 accidents of mechanical injury, 112 accidents of object striking, 38 accidents of heavy object crushing, 8 accidents of burning, and 48 accidents of other injuries have occurred in Enterprise S in the past 13 years. In terms of the types of accidents, the main types of accidents in Enterprise S are mechanical injury accidents, which accounted for 56.17% of the overall number of accidents in the last 13 years.The causes of accidents in Enterprise S are mainly irregular operation, operation errors, lack of awareness, equipment damage, and illegal command, etc., of which irregular operation and operation errors are common causes for almost all different injuries. This indicates that in terms of training on work safety and supervision of work safety, S enterprises still have a certain degree of shortcomings and weaknesses that need to be emphasized.

Table 3. The result of the frequency analysis of the specific safety accident

Year	Species

	Mechanical injury	Heavy weight accident	Object attack	Burning accident	Other injuries
2010	20	10	4	2	1
2011	15	10	0	0	5
2012	18	9	2	0	2
2013	15	6	3	0	2
2014	18	6	2	1	4
2015	18	9	4	0	2
2016	18	8	4	1	2
2017	21	6	5	0	3
2018	24	7	3	1	6
2019	25	12	3	1	5
2020	22	11	4	0	8
2021	26	13	2	2	6
2022	24	5	2	0	2
Total	264	112	38	8	48
Proportion	56.17%	23.83%	8.09%	1.70%	10.21%

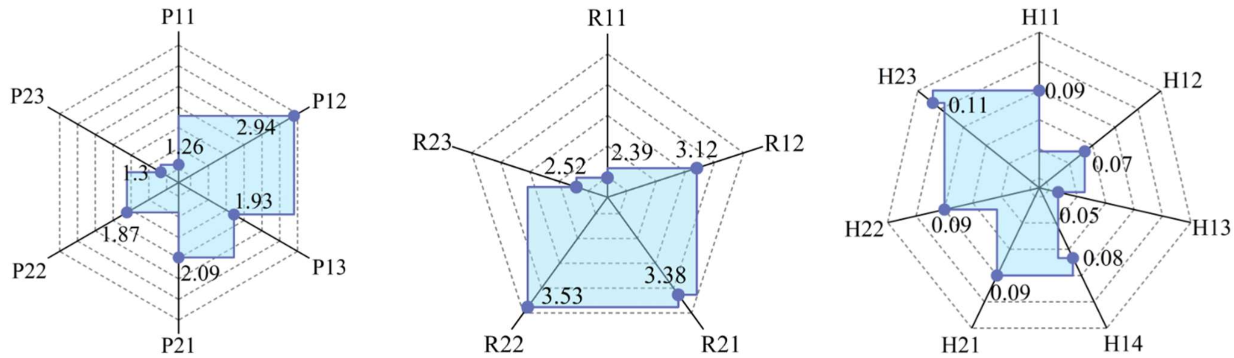
4.2. Results of the evaluation of the risk of production safety at enterprise S

4.2.1. Results of the calculation of indicator weights. Table 4 shows the results obtained by using the multi-level analysis method to calculate the weights of production safety risk evaluation indicators. Among the three first-level indicators, H "Renli" has the largest weight (0.441), followed by P "Physics" (0.314) and R "Shili" (0.245). Under the index of "human management", H12 "use of safety protective equipment" (0.093) and H23 "formalization of on-site safety inspection" (0.092) have the largest weights. According to the results of the overall weight value analysis, the top four risk items exist in the three first-level indicators, so S enterprises should pay attention to the risks of personnel and physical environment when managing safety production risks.

Table 4. Safety risk classification evaluation index weight

Primary indicator	Secondary indicator	Weighting	Tertiary index	Numbering	Weighting
Physics (P)	Material safety risk factor (P1)	0.179	Material performance	P11	0.087
			Material transfer	P12	0.047
			Material storage and use	P13	0.045
	Equipment safety risk factor (P2)	0.135	Equipment quality inspection	P21	0.034
			Equipment safety usage	P22	0.075
			Equipment maintenance and maintenance	P23	0.026
Reason (R)	Natural environment (R1)	0.056	Extreme weather conditions	R11	0.033
			Geologic hydrological condition	R12	0.023
	Field environment (R2)	0.189	Safety protection facilities	R21	0.094
			Safety warning sign setting	R22	0.019
			Construction environment maintenance condition	R23	0.076
Hermit (H)	Safety risk factors for workers (H1)	0.265	The degree of use of safe protective goods	H11	0.019
			The frequency of the risk of violation	H12	0.093
			Job experience	H13	0.081
			Proficiency in special skills	H14	0.072
	Manager safety risk factor (H2)	0.176	Lack of safety education training	H21	0.016
			Manager's experience	H22	0.068
			The on-site safety inspection is formalized	H23	0.092

4.2.2. Results of risk level evaluation. The safety risk level evaluation scores of Enterprise S before the dual prevention mechanism was implemented are shown in Fig. 4, with (a)-(c) representing the evaluation results of the first-level indicators physical, factual and humanistic, respectively. The total evaluation score of the safety risk of enterprise S is 1.50, which belongs to the basic level (corresponding to the interval (1, 2]). The average evaluation scores of physical, physical and human factors are 1.90, 2.99 and 0.08, which belong to the basic, standard and uncontrolled levels, respectively. A lower level represents a higher and more dangerous risk, and similarly, the closer to 0, the higher the risk, and when infinitely close to 0, infinitely close to high risk. According to the overall scoring results, it can be seen that the overall safety production risk score of enterprise S reaches 1.50, which is a relatively high risk situation, and there is an urgent need for a complete set of efficient and feasible dual-prevention mechanism to control and investigate and manage the safety production risks and hidden dangers. The use of safety protection equipment by operators (0.09 points), the frequency of illegal risky work (0.07 points) and the experience of operators (0.05 points) are all relatively high risks, and further training and optimization is needed to reduce the risks and promote the development of safe production, hazard detection and management, and sustainable operation of the workshops of S enterprise.



(a) Physics (b) Reason (c) Hermit

Fig. 4. Assessment of safety risk rating

4.3. Effectiveness of the operation of the dual prevention mechanism

4.3.1. Analysis of training in work safety. Combined with the evaluation results of the safety risk of S enterprise, in order to optimize the work of hidden danger investigation and management, this paper adopts the principle of PDCA as a management cycle during the implementation of the dual prevention mechanism, which is divided into four main phases, the planning phase (P), the implementation phase (D), the acceptance phase (C), and the enhancement phase (A). This ensures the completeness and consistency of the workflow of the hidden risk investigation of production safety risks in Enterprise S. Finally, safeguard measures are used to ensure the long-term effectiveness of the hidden danger investigation work. This optimization scheme improves the efficiency and quality of the rectification of hidden danger, and through the implementation of this scheme, it can effectively solve the problems of the occurrence of many safety incidents and the recurrence of similar hidden dangers, so as to truly realize the intrinsic safety of production in S enterprises.

Through the development of the plan, efforts have been made to create a universal, applied and standardized training mechanism. It is essential to ensure that employees have an in-depth understanding of the sources of risk and a clear identification of the levels of risk, so as to enhance their awareness of their responsibilities, organizational effectiveness and the quality of the implementation of preventive and control measures in implementing the dual-prevention mechanism. The security risk management training of the personnel of enterprise S is shown in Table 5. In 2023, Enterprise S carried out the formulation of the corresponding personnel training plan according to the dual prevention mechanism, adopted a flexible training mode, completed the training tasks, the frequency of training greatly increased (up 57.14%-450.00%), to a certain extent, to meet the talent needs of production safety management. By strengthening the education and training of risk control, it fundamentally solves the problem that the quality of the employees of S enterprise can not meet the needs of risk control, and also enhances the awareness of safe production and improves the level of intrinsic safety of S enterprise, which achieves a better effect.

Table 5. Training Summary for 2022 and 2023

Serial number	Training category	Training quantity		Gain
		2022	2023	
1	Safety production knowledge training	3	15	400.00%
2	Training in safety law	7	18	157.14%
3	Training in operating skills	3	7	133.33%
4	Risk identification and evaluation training	2	11	450.00%
5	Individual protection training	3	16	433.33%
6	Process training	2	5	150.00%
7	Accident warning education training	5	9	80.00%
8	Accident prevention training	7	11	57.14%
9	Emergency training	5	10	100.00%

4.3.2. Effectiveness evaluation results. In this section, the operation effect of the dual prevention mechanism in enterprise S is evaluated, and the weighting and scoring results of the operation effect evaluation indicators are shown in Table 6. From the perspective of index weight values, the total weight values of the two indicators of security risk classification control and hidden danger investigation and management are 0.393 and 0.607, respectively. The weight of A4 "security risk management and control scheme" in the security risk classification and control is higher, which is 0.091, and the weight of B2 "hidden danger classification and classification" (0.115) and B4 "hidden danger discovery and notification rectification efficiency" (0.122) in the hidden danger investigation and management is larger.

Table 6. The double prevention mechanism evaluates the index weight

Primary indicator	Weighting	Secondary indicator	Numbering	Weighting
Safety risk classification (A)	0.393	Safety risk database management efficiency	A1	0.081
		Security risk identification	A2	0.081
		Safety risk assessment	A3	0.073
		Safety risk control scheme	A4	0.091
		Safety risk control	A5	0.047
		Safety risk information dissemination and dynamic monitoring efficiency	A6	0.02
Hidden danger (B)	0.607	Risk database management efficiency	B1	0.065
		Risk classification and classification	B2	0.115
		List of pitfalls	B3	0.089
		Trouble finding and reporting rectification efficiency	B4	0.122
		Hidden management	B5	0.07
		Risk adjustment rate	B6	0.047
		Hidden acceptance	B7	0.099

A fuzzy comprehensive evaluation of the 13 indicators and 5 rubrics of the operation effect of the dual prevention mechanism is carried out, and the evaluation results of the operation effect of the dual prevention mechanism in S enterprise are shown in Table 7. The total score of the operation effect of the dual prevention mechanism of safety risk classification and hidden danger investigation and management in enterprise S is 3.91, and the comprehensive evaluation result is “good”, which means that the operation effect of the dual prevention mechanism in this enterprise is relatively excellent.

Table 7. Evaluation of the operation effect of the double prevention mechanism

Primary indicator	Weighting	Secondary indicator	Numbering	Weighting
Safety risk classification (A)	3.94	Safety risk database management efficiency	A1	4.11
		Security risk identification	A2	4.67
		Safety risk assessment	A3	3.85
		Safety risk control scheme	A4	4.35
		Safety risk control	A5	3.29
		Safety risk information dissemination and dynamic monitoring efficiency	A6	3.39
Hidden danger (B)	3.88	Risk database management efficiency	B1	3.52
		Risk classification and classification	B2	3.42
		List of pitfalls	B3	4.46
		Trouble finding and reporting rectification efficiency	B4	4.89
		Hidden management	B5	3.33
		Risk adjustment rate	B6	3.32
		Hidden acceptance	B7	4.2

5. Conclusion

This paper utilizes the multilevel analysis method to assign the indicators in the safety risk grading evaluation system and the dual prevention mechanism operation effect evaluation system, and then uses the fuzzy comprehensive evaluation method to design the evaluation model.

1) A total of 470 safety production incidents occurred in Enterprise S during the period of 2010-2022, with the main type of accident being mechanical injury accidents, which accounted for 56.17% of the overall number of accidents. The result of safety risk evaluation found that the total evaluation score of safety production risk of enterprise S is 1.50, which is a high safety production risk, and the experience level of operators (0.05 points) is very high risk, which is out-of-control level.

2) After running the dual prevention mechanism, S enterprise has significantly improved the training frequency of the operating personnel and improved the level of intrinsic safety, while the evaluation of the operating effect of the mechanism found that the total evaluation score of the operating effect of the dual prevention mechanism of safety risk classification and hidden trouble detection and management is 3.91, which achieves a better effect.

After the optimization of risk grading control and hidden danger investigation and management in the dual prevention mechanism, a series of problems currently faced by Enterprise S are fundamentally solved. Here, this study hopes to provide a practice case with great reference value for the safety management of similar enterprises, so as to provide solid support and guidance for the better integration of the dual prevention mechanism system into enterprises.

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