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The role of management in preventing occupational accidents in the mining sector

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Abstract
The mining sector comprises metal ore mining, quarrying, coal mining, and support service activities. Although the coal mining sub-sector accounts for 25% of the number of employees in the mining sector, one in every two occupational accidents occurs in this sector. In this respect, this study aims to determine the perspectives of employees in underground units regarding the process of preventing occupational accidents in the coal mining sub-sector. For this purpose, the study used the grounded theory design of qualitative research designs. This study was conducted on a study group consisting of 20 underground unit employees selected according to the purposeful and theoretical sampling strategy in a coal enterprise with the lowest accident rate in Turkey. Qualitative data in the study were collected through semi-structured interviews. The data were analyzed using the thematic analysis technique in the MAXQDA 2024 program. The research findings show that the prominent factors in preventing occupational accidents in coal mines are the management's commitment to safety, rules, risk awareness and safety focus, inspection, and incentive practices. Among these factors, it is seen that the management's commitment to safety stands out. Prioritizing safety and risk awareness and maintaining this commitment with rules, incentives, and monitoring mechanisms are essential in reducing work accidents.

Keywords
coal mining, preventing work accidents, commitment to security, risk awareness

Introduction

The mining sector plays a significant role in the economies of many countries (Kurowska-Pysz et al., 2022). The mining sector provides a significant source of raw materials and energy for many industries (Vintró et al., 2014; Nyahuna & Swanepoel, 2022; Obagbuwa & Munzhelele, 2024; Cornellissen & Mukwarami, 2024). Mining enterprises in Turkey operate 365 days a year, and the annual number of days off is determined by mandatory circumstances, legal irregularities, and large-scale accidents (Yıldız, 2022). Although the sector has a critical role, it also has occupational health and safety risks and environmental and social problems specific to the sector (Tubis et al., 2020; Bouhlal & Sedra, 2022; Pangestuti et al., 2024). Approximately 1,700 workplaces employ approximately 120 thousand employees in the mining sector in Turkey (TÜİK, 2023). In addition, the employment rate in the mining sector in Turkey is 0.9% of all employment (TÜİK, 2023; ÇSGB, 2023). Despite this, 8% of fatal occupational accidents are seen in the mining sector (Durdu, 2014; Tetzlaff et al., 2021). In particular, the mining sector's accident frequency and accident probability rates are well above the Turkish average. The probability of having an accident in the mining sector is six times higher than that of employees in other sectors in Turkey, and the probability of death as a result of an accident is seven times higher (Iphar & Cukurluoz, 2020; Sekmen & Zengin, 2023). Deaths in mining accidents are massive when compared to accidental deaths in other sectors. In 1992, 263 workers lost their lives as a result of a firedamp disaster in a coal mine in Zonguldak (TMMOB, 1992). In 2014, 350 miners lost their lives as a result of accidents such as firedamp explosions, flooding, and fire in three different mines (Karadere, 2018; Derin et al., 2017). In 2022, 41 workers lost their lives as a result of an explosion in a coal mine in Bartın (Eşidir & Bak, 2022). These losses of life deeply affected the whole of Turkey and increased social sensitivity in the mining sector (Karadere, 2018; Derin et al., 2017; Yaşar et al., 2015; Eşidir & Bak, 2022).

Accidents occurring in mines should be discussed with economic, social, and political factors (Küçük & Ilgaz, 2015). First, it is noteworthy that occupational accidents are observed as the scale of the mining enterprise decreases (Bilim et al., 2018; SGK, 2022). The number of micro and small-scale enterprises (SMEs) in the mining sector in Turkey accounts for approximately 94% of the total number of enterprises in the sector (Bayraktar et al., 2023; SGK, 2022). Human and financial resource constraints (He et al., 2012), lack of managerial awareness in the field of safety (Ghahramani & Amirbahmani, 2022), and difficulties in accessing training (Ajmal et al., 2022; ILO, 2021) cause SMEs to experience higher rates of occupational accidents.

The main factors affecting the high rate of occupational accidents in the mining sector in the world are the lack of awareness and experience of employees (Du, Sun, 2012), lack of machinery and equipment (Abukhashabah et al., 2020), lack of appropriate protective equipment (Zhang et al., 2020), lack of training (Ivascu et al., 2021), lack of qualified labour, unfavourable environment and geological structure in mining sites (Song & Zhang, 2022). In addition to these factors, in traditional societies such as Turkey, inability to fully establish OSH awareness and culture (Yaşar et al., 2015), belief in fatalism (Akdeniz et al., 2018), weaknesses in work policies (Yilmaz & Kirlot, 2019), deficiencies in practices and audits (Eşidir & Bak, 2022; Sekmen & Zengin, 2023) can be included. On the other hand, the causes of accidents vary according to the development levels of countries. In developed countries, the causes of occupational accidents in mines are generally shown as unsafe behaviours caused by employees (Arıtan & Ataman, 2017; Sanmiquel et al., 2010; Di et al., 2021; Ghahramani & Amirbahmani, 2022). According to the study conducted by Sanmiquel et al. (2010), unsafe behaviours are the leading cause of occupational accidents in mines in Spain. On the other hand, the leading cause of occupational accidents in developing countries is unfavourable situations and conditions caused by management (Hämäläinen et al., 2006).

The mining sector, especially coal mining operations, is where the most injuries and deaths occur (Bilim et al., 2018). It has been determined that the most common cause of accidents in coal mines in Turkey is management security weaknesses. Due to these weaknesses, firedamp and dust explosions, landslides, mine fires, and technical malfunctions related to transportation and mechanization are among the causes of accidents (Küçük & Ilgaz, 2015). Again, in the study conducted by Öney et al. (2018) to determine the leading causes of occupational accidents in coal mines in Turkey, collapses, inadequate ventilation controls, wagon overturns, incorrect use of work equipment, falling materials, and electric shocks were prominent. The striking situation here is that the leading causes of occupational accidents in mines in Turkey are administrative weaknesses and gaps, lack of education, lack of supervision, safety violations and negligence, and lack of information.

The mining sector has broad boundaries, including many sectors and sub-sectors such as exploration, preparation, production, and logistics. This sector inherently contains many risks. It is impossible to eliminate these risks. However, thanks to improvements at both sectoral and workplace levels, risks can be minimized, and at least fatal accidents can be significantly reduced. The study conducted by Bayraktar et al. (2023) determined that increasing the scale of mining enterprises and increasing safety awareness will support the prevention of occupational accidents in the mining sector in Turkey, and sectoral inspections should be increased together with sector-specific measures. The study by Öney et al. (2018) emphasized that OHS inspections should be increased and should be tightened by legislation to prevent occupational accidents. The study conducted by Dündar et al. (2018) concluded that complete mechanization of production, especially in underground mining, prevents

occupational accidents. The study by Önder and Önder (2010) determined that examining the occupational accidents occurring in mines is essential in preventing similar accidents and revealing faulty points. According to Amponsah-Tawiah and Mensah (2016), it is possible to ensure sustainability in reducing occupational accidents in mines, especially for workplaces at the SME level, with the support of governments and regional organizations.

Research findings in the field suggest that emphasizing managerial issues and themes related to preventing occupational accidents is effective in reducing occupational accidents. However, this approach provides a narrow vision of reducing occupational accidents only from a managerial perspective, thus overlooking the focus on employees directly exposed to occupational accidents. Despite these insights, there is a lack of information on the causes of occupational accidents in the mining sector, how these themes affect employees and organizations, and themes that can prevent accidents. Although such information requires a qualitative approach to understand how these themes can prevent occupational accidents, most previous studies have been conducted quantitatively. The activity branch with the highest accident frequency in the mining sector is the coal mining sub-sectors (Öney et al., 2018; Dündar et al., 2023; Zhang et al., 2020). In addition to the significant lack of qualitative research in this area, the function of such themes in preventing occupational accidents in the mining sector has revealed the need to be examined, especially in coal mines. Addressing this gap will reveal the latent factors that lead to an occupational accident rate of approximately 55% (SGK, 2022) in the coal sub-sector, which accounts for 25% of the number of employees in the sector, compared to other sub-sectors (metal ore mining, quarrying and supporting service activities), and will provide a new perspective on the research problem.

As a result, this article aims to investigate the perspectives of mine workers to reveal how occupational accidents can be prevented, especially in underground units in the coal sub-sector. Therefore, this article seeks to answer the research question "How can occupational accidents in underground units of coal mines be prevented?" to provide a detailed understanding of occupational accidents in the mining sector. Such an understanding, which is a potential impact of this study, can be used to prevent possible problems and damages by determining the primary factors that effectively prevent occupational accidents in the focus of the state, enterprise, and employee.

Material and Methods

In this study, which aims to determine how occupational accidents in coal mines can be prevented, the grounded theory (GT) qualitative approach was adopted. This section comprises four subsections: the rationale for GT selection, sampling strategy, data collection, and data analysis.

Selection of grounded theory approach in this study

GT is an inductive approach that aims to develop a theory or explanation by comprehensively investigating a series of cases through a constant comparative process (Mészáros & Kelemen-Erdős, 2023; Fu et al., 2023). According to Charmaz (2014), GT consists of systematic but flexible guidelines for collecting and analyzing qualitative data to create theories from the data itself. GT starts with inductive data, involving iterative strategies of going back and forth between data. The analysis phase begins at the same time as data collection, not just after data collection, as in other methods. Insights obtained through the stepwise analysis of data guide further data collection, then further analysis, and if necessary, further data collection and analysis cycles. Constant comparison helps the researcher move away from pure description and think analytically and conceptually about the data to detect consistencies and differences in concepts and categories (Tie et al., 2019).

Given that this study aimed to determine how occupational accidents can be prevented, the strategies provided by GT allowed for the development of a set of interrelated concepts that led to the production of a fundamental theory. The paucity of empirical studies on the prevention of occupational accidents in underground mines also highlighted the utility of the GT approach. The chosen method provided in-depth information on preventing occupational accidents in underground mines, mainly based on the data and findings that emerged. The researchers prioritized developing new knowledge from the collected data rather than existing frameworks to avoid limiting researcher sensitivity to emerging themes and influencing data interpretation.

Sampling strategy

Two types of sampling strategies were adopted in this study. First, purposive sampling was used to select participants and data sources (Chapagain et al., 2024; Zaman et al., 2024) suitable for answering the research questions. An initial purposive sampling was conducted simultaneously, guiding the data generation and analysis of the study. This simultaneous data generation and analysis is an essential aspect of GT research, as it allows the initial data to be collected, coded, and analyzed before further data collection and analysis. Second, a theoretical sampling strategy was used in a grounded theory study, which allows the researcher to follow clues in the data by sampling new participants or materials that provide relevant information (Birks & Mills, 2015). Theoretical sampling is a strategy for developing a theoretical category instead of sampling for population representation. This strategy allows the sampling of new participants who provide information about the categories that emerge from the initial data obtained through purposive sampling.

The purposive selection of underground mine operators guided this study's simultaneous data collection and analysis process. However, open-ended questions were asked to participants to gain insight into how they interpret occupational accidents without imposing any prejudiced information on the prevention of occupational accidents. This approach prevented the researchers from limiting their sensitivity to the emerging themes (Robson, 2005). Despite this approach, codes emerged due to analyzing the data obtained from the purposeful sample regarding how organizational and managerial factors effectively prevent occupational accidents. Codes related to the perception of discipline in the organization, the reflection of possible occupational accidents results in the rules in the sector, and management's priority of safety and rewards emerged from this initial data. Based on the initially created codes, managers with decision-making roles and occupational safety experts with field expertise were included in the theoretical sampling process to saturate the developed categories and reach a rich data source.

According to Charmaz (2014), the sample size is based on theoretical saturation, which is the point at which collecting more data on a theoretical category does not reveal new features or provide more theoretical insight. Theoretical saturation occurs when further data no longer contribute to developing categories, inter-category relationships, or the emerging theory. In addition, factors such as the nature of the research purpose and problem, the context under investigation (Guetterman, 2015), the sensitivity of the phenomenon (Thomson, 2010; Anasweh, 2021; Hebdzyński, 2024), and the length of the interviews (Blaikie, 2018) determine the sample size. The sample size of this study is consistent with other GT studies where similar sizes have been used and reported. For example, Thomson (2010) found the average sample size to be twenty-five in his study, where he conducted a content analysis of one hundred articles using grounded theory and interviews as a data collection method. Morse (1994) recommended 30-50 interviews for grounded theory, while Creswell and Poth (2016) recommended 20-30 interviews. Mason (2010) analyzed 560 qualitative doctoral studies and determined that an average of 20 participants were used for GT studies.

In this study, 10 participants were first deliberately sampled to reach theoretical saturation, and initial codes were created. Then, ten more participants were theoretically sampled to develop the codes and categories created from the initial purposeful sampling. After continuous comparison between the developed theory and the raw data of 20 participants, theoretical saturation was reached where no new findings emerged from any of the concepts or categories. The 20 participants who participated in the interviews were underground unit operators, managers, and occupational safety experts with different experience periods and fields in an enterprise with the lowest accident rate in coal mining in Turkey. The reason for selecting this group was that the operators actively worked with the technicians, occupational safety experts, and managers in the mine, at the mine entrance, and underground. The long-term interaction of the participants increased the possibility of providing in-depth insights in the interviews. Due to the concern for anonymity, only basic information such as occupation, field of expertise, and years of work were collected from the participants (Tab. 1).

Tab. 1 Participant information

Participant	Age	Level of education	Position and status	Work experience in the mine (years)
P1	29	Primary Education	Operator (loader)	7
P2	29	Secondary Education	Operator (subcontractor)	5
P3	32	Secondary Education	Mill öğütme operatörü	5
P4	30	Primary Education	Operator (subcontractor)	3
P5	30	Secondary Education	Operator	5
P6	27	Secondary Education	Technical staff (subcontractor)	5
P7	29	Primary Education	Operator (subcontractor)	8
P8	25	Secondary Education	Operator (subcontractor)	2
P9	40	Secondary Education	Operator (subcontractor)	9
P10	33	Primary Education	Operator	11
P11	48	Undergraduate	Manager	12
P12	34	Undergraduate	Occupational safety specialist	4
P13	41	Master's Degree	Manager	8
P14	34	Undergraduate	Occupational safety specialist	6
P15	30	Undergraduate	Manager	3
P16	27	Master's Degree	Occupational safety specialist	2
P17	51	Master's Degree	Manager	14
P18	32	Undergraduate	Occupational safety specialist	7
P19	46	Master's Degree	Manager	9
P20	34	Undergraduate	Manager	4

Data collection

Interviews

Semi-structured interviews were used to collect qualitative data. The use of semi-structured interviews in the study allowed for a broader exploration of participants' perspectives, experiences, and perceptions beyond predetermined questions and for unexpected data to be reached (Mackey & Gass, 2005). Interviews were conducted face-to-face between February and April 2023. Each interview lasted approximately one hour. Participant approval was obtained with an informed consent form before the beginning of each interview. Interviews were divided into two groups representing the groups sampled purposively and theoretically to comply with the GT approach. Both interview sets began with an information phase that included general information about the study. Participants were informed about the purpose of the study and were assured of the confidentiality of the research process.

There are differences in the structure of both interview groups. Open-ended questions were asked to reveal how participants interpreted safe work without imposing any biased information on the participants of the first group sampled purposively. This approach is consistent with the suggestion of grounded theory, which assumes that the researcher's sensitivity to emerging themes is limited and thus helps to avoid a situation that affects data interpretation. For example, the first group interviews started with an open and general question in which participants evaluated their professional experiences of being a miner. For example, "Can you tell me about the challenges you have encountered in your job?" was asked. As the participants described their experiences, additional questions were asked to obtain more information about the first question. For example, "Do you trust your current level of competence and skill to overcome the challenges?" "How do you feel about your competence or incompetence?" "Do you receive institutional support to improve your competence and skill level?" were used.

The interview organization followed Charmaz's (2014) GT interview technique, which is designed to be open-ended. In this process, intervening questions were used to explore the participants' experiences in ensuring occupational safety and to create an in-depth explanation. The following questions asked about the participants' roles and positions in the occupational safety process. For example, what should be done individually and institutionally to prevent occupational accidents in the mining sector? Should individual efforts or institutional activities be prioritized to prevent occupational accidents in the mining sector? This approach helped create a series of themes that emerged from the data rather than imposed by a predetermined theoretical framework.

The second set of interviews began after the iterative and simultaneous data generation and analysis of the first set of interviews. Questions were structured at this stage to develop themes from the first interviews. This structuring is significant in saturating the developed categories, identifying gaps in the existing data, and providing insight into the unknown.

Transcription of interviews

With the consent of the participants, the recorded audio recordings were transcribed before starting the data analysis. Maxqda 24 Transcription software, which has automatic speaker detection and timestamps, was used to transcribe the audio recordings. MAXQDA 24 Transcription allowed for individual voices and opinions to be analyzed individually or collectively by tagging each speaker's contribution with their name. Timestamps provided a clear and organized transcript by linking text sections to corresponding audio sections. The resulting texts were compared by repeatedly listening to the audio recordings, and possible data loss was prevented.

Data analysis

MAXQDA 2024 software was used to manage, sort, classify, and transcribe the audio data while analyzing the data obtained from the purposive and theoretical sample groups. The data were analyzed using the GT approach, which starts with a sequential sampling strategy and involves an iterative process. This process was followed by an iterative data collection and analysis involving different coding stages, accompanied by note-taking and constant comparative analysis. Additional details of the GT procedure adopted in this study are detailed in the following subsections.

Development of codes and themes through initial, focused and theoretical coding

Charmaz's (2014) initial coding, focused coding, and theoretical coding strategy were used in the study's coding and theme development process. As a result of the researchers' deep dive into the data, some themes were discovered even while the interviews were transcribed before the data was coded. The first step after the GT procedure adopted in this study was the initial coding, which was the beginning of any idea conceptualization and assigning similar labels to the data. The initial coding began with the line-by-line coding of the first set of transcripts, which included questions about the participants' general perspectives on occupational safety and to gain insight into how they interpreted the effects of occupational safety in the institutional context without imposing any prior knowledge. In this initial coding stage, the theme of the rules, such as preventing neglect, regularization of experiences, and the management's commitment to safety, such as the management's priority of

safety, speed of response to problems, and training approach, were determined. Then, focus coding was performed to continuously advance the development of categories, increase the level of abstraction in the analysis, and select which of the previous codings were more analytical. At this stage, the data obtained from the sampled participants revealed patterns regarding how risky situations and conditions in underground mines affect occupational safety processes, how to solve the difficulties encountered in the institutional context, and what to pay attention to. It was discovered that the additional data obtained from the theoretically sampled interviewees were compatible with these existing codes.

Although new codes or themes were not provided with the data obtained from some theoretically sampled participants, new relationships were determined between codes and themes. Although no new theme emerged after coding transcription 12, the relationship between education and occupational safety awareness in establishing a safe work environment in underground units emerged here. Finally, the codes were organized into five abstract and high-level themes emerging from the data: management's commitment to safety, rules, risk awareness and safety focus, audits and encouragement, and thematic/theoretical coding. This process and narrowing of the codes, aimed at comparing the codes within and between different situations, was carried out per GT's constant comparative analysis. In the final theoretical coding stage, thematic categories were organized according to the code-theory model that regulates the related organization of codes in MAXQDA 24.

Keeping notes

Writing notes during the research process is like a part of the coding process since it activates the researcher in analyzing the data and coding them early. Writing notes is a continuous task that starts with the first coding step. If the researcher continues his research only with coding without writing notes, he is not at any stage of GT. Writing notes guides the researcher about the codes in the research and enables the researcher to abstract and form ideas (Guetterman, 2015). The numerous notes written during the grounded theory study serve the purposes of deep thinking, interpretation, and analysis, as well as forming an essential basis for the theory to be formulated (Rädiker, 2023). The researcher's naming and organizing of the codes, decisions regarding the analysis, and thoughts and comments regarding discovering new patterns in the data were carried out with the memo function of MAXQDA (Moreno-Carmona et al., 2022; Tutar et al., 2024). A sample of the researchers' notes created for this study is presented in the following excerpts:

> "During the interviews initiated with operators, the process of obtaining information about occupational accidents occurring in underground mines or measures to be taken to prevent possible risks, the management and occupational safety experts are given too much emphasis by the employees. Due to the roles of decision-makers and decision-implementers in this position, employees should also be included in the interview processes." (February 20, 2023)
>
> "The occupational safety training category shows itself by differentiating under the theme of awareness and management commitment to safety. Therefore, the function of the training differs in both categories." (April 01, 2023)

The primary function of the memo-writing process in the research is to ensure the quality and validity of the study rather than to use the memos as a separate data set. Given the large number of initial codes generated, the memos also served as a logical guide to the analysis process. The entire memo-writing process helped increase the theoretical sensitivity of the researchers.

Findings

This section presents the results of the perceptions of underground unit operators, managers, and occupational safety experts regarding preventing occupational accidents in mines. These results show the essential themes/factors explaining preventing occupational accidents. These findings were obtained from 20 mine workers with different experiences and expertise in a private sector coal mine in Turkey, who were sampled purposively and theoretically. The high references made by the participants in the purposive sample group (underground unit operators) to organizational/managerial factors regarding occupational accidents provided rich answers to the research question by including managers and occupational safety experts in the theoretical sample group. The participants explained the process of preventing occupational accidents in mines with five interrelated basic themes. These themes are management's commitment to safety, rules, risk awareness and safety focus, audit, and encouragement. The themes are presented in the subsections.

The theme of management's commitment to safety

18 out of 20 participants in the study referred to the dedication and support factor shown in creating and maintaining a safe working environment in preventing occupational accidents. While P9 and P10 referred to the penalty and warning system in the context of workplace rules regarding the prevention of occupational accidents, all other participants emphasized that management prioritizes the culture of occupational safety rather than production. For example, P1 expressed this situation as *"...safety is prioritized over production. You can refuse*

work when you see the slightest danger…" Similarly, P4's statement, *"…management encourages us to refuse work even if we see a 1% risk and does not see it as a cost…*" shows that the initiative to refuse work despite the disruption in production and possible costs shows that management prioritizes safety.

Another element related to management's safety priority is the management's training approach regarding safety. The frequency of OSH training sessions and the reflection of the causes and consequences of occupational accidents occurring both in their mines and in different mines in the OSH training content were evaluated as an indicator of the management's priority for safety. For example, P4 expressed this situation as follows.

"*… OHS training is not only given to us at certain times. We also have training sessions several times a week. The subject of the training changes every week. Accidents, near-miss incidents, or work accidents in another mine can also be the subject of training. We evaluate what would happen to us if a work accident in another mine had occurred in our mine, what would have happened to us, what could have been done."*

The fact that the personal protective equipment used by the employees is satisfactory in terms of number, quality, and up-to-dateness, as well as that the management constantly inspects this equipment, is another factor cited regarding the management's priority for safety. For example, P8 expressed this situation as follows.

"*… personal protective equipment is provided completely. We use equipment I have never seen in the mine where I worked before. When our masks or helmets wear out, we immediately change them. There is a lot of each piece of equipment in stock. Management does not ask why you are changing it. The worker found it necessary and changed it*."

Manager P16 also expressed sensitivity regarding PPE in the context of management's priority for safety.

"*…the personal protective equipment we provide employees is at world standards. Since our priority is safety, we provide protective equipment by considering the demands of the employees, and we pay attention to ergonomics. In case of damage, we replace it with a new one without question.*"

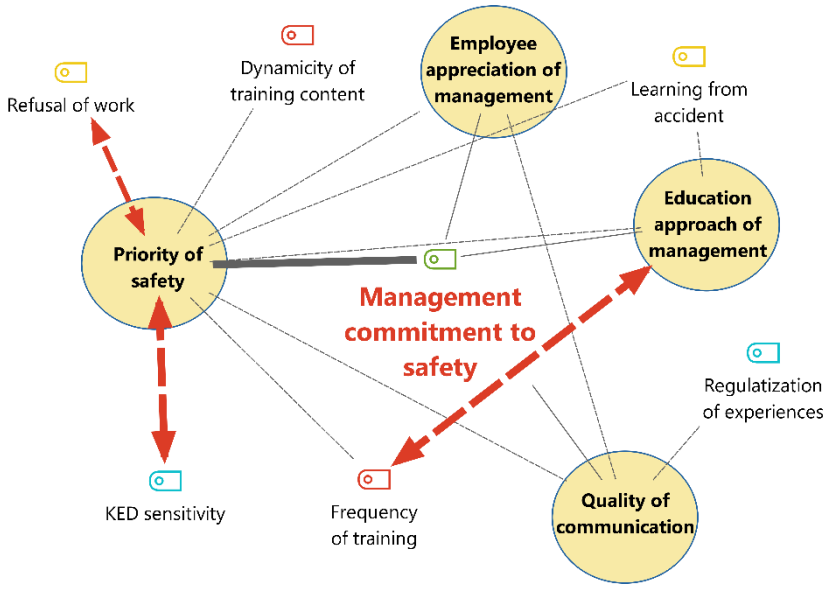

Fig. 1. Management commitment to security theme code relationships

As mentioned before, the participants of this study consist of two groups. The first group comprises the operators who perform the work themselves, and the second group comprises the managers and occupational safety experts who organize and supervise the work process. Although many factors effectively prevent occupational accidents in underground units, the most striking essential factor is that the management positions occupational safety as a priority area for both groups. However, there are some differences between the sources of safety priority for both groups. The basic approach in prioritizing safety for the second group is to protect the company's prestige in the mining sector, as can be seen from the statement of P14, *"... we are the leader in production in the mining sector. We want to maintain the same leadership in the field of occupational safety. The last thing I want is for our company name to be tarnished due to any occupational accident..*."

On the other hand, according to the participants in the first group, the source of safety priority is the perception that the management does not see the employee as a commodity that only adds value. For example, P9 explains this situation as "*... there is no time pressure to complete the work. Everything should proceed slowly but safely. There is an understanding that the most valuable asset is people in the management. They look at us like that…"*

The theme of rules

Determining, implementing, and monitoring rules and procedures in the work environment are critical for both groups. The penalty and warning system in the organization plays a central role in implementing rules. The

role of the penalty and warning system in preventing employees from violating safety policies, procedures, or standards is reflected in the statements of P4 and P16.

"... complying with the rules comes first. If you violate the rules and continue to do so, your contract will be terminated. In other words, not complying with the rules is the same as losing your job. I comply with the rules in order not to lose my job. Nothing has happened to me so far because I follow the rules."

Similarly, the following statement by P16, one of the participants in the second group, can be given as an example of the role of the penalty and warning system in preventing work accidents.

"*... the slightest violation of the rules enters our radar. There are digital surveillance, audit, and hazard notification networks, and it often results in the employee first being warned and then being dismissed. Although this is an undesirable situation, I think it contributes to forming a safety culture among employees*."

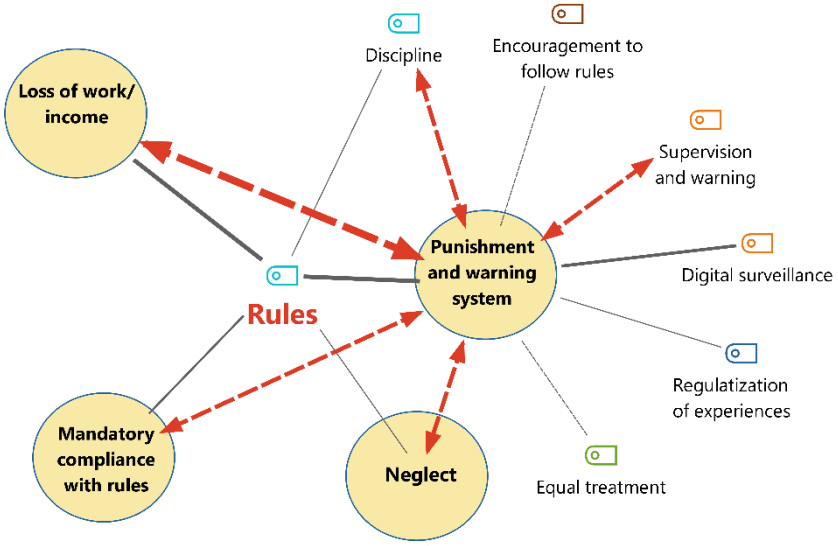

Fig. 2. The theme of rules code relationships

The transformation of information obtained due to dangerous situations and accidents experienced by employees or the organization into procedures and their regularization highlights the function of the penalty and warning system in preventing work accidents. P2 expressed this situation as follows.

"*...some friends are in a hurry. They want the job to be finished as soon as possible. Small accidents caused by this haste attracted the attention of the management. The management warned the employees with a salary deduction and changed some procedures...*"

On the other hand, P6 attributes the obligation to comply with the rules to internal elements rather than external stimuli such as punishment and warning. P6 explained this with the metaphor, *"... rules are written in blood in the mine...*" When the participant was asked why he made this analogy based on this metaphor, he responded: *"... training, warnings, and sanctions are certainly effective, but people learn best by experiencing and evaluating this..."*

Another factor that ensures the functionality of the punishment and warning system in the context of complying with the rules is digital surveillance. Surveillance mechanisms that can monitor and record the entire work area in the underground unit provide data that can be used in the punishment and warning system. Employees are forced to comply with the rules with the idea that any non-compliance will be recorded and punished. For example, P7 expressed this obligation as *"... you can never walk around the field without PPE. Cameras constantly monitor it. It will be a direct warning if you are negligent or lack PPE...*" Similarly, P3 refers to the function of surveillance in forcing employees to behave safely with the following statement.

"*... We are warned with yellow cards. If we get four yellow cards, we will be fired without question. I have three yellow cards. Two of them were given without my knowledge by following the records. I am more careful now."*

Although many risks in the mining sector are tried to be controlled, sometimes work accidents are inevitable due to the nature of the profession. These explanations reveal the functionality of the penalty and warning systems, such as loss of work or income that prevent negligence and non-compliance with the rules in preventing work accidents in underground units.

Risk awareness and safety focus theme

Another critical factor perceived by some participants regarding the prevention of occupational accidents in underground units is risk awareness and safety focus. Although the codes of risk awareness and management commitment to safety themes show similar connotations in the context of education, the fact that these codes are

not combined under a single umbrella theme is due to the difference in meaning defined in the participants' statements. In management commitment to safety, education covers a formal process where a macro power is dominant over the employee, and participation is required with some sanctions. In contrast, awareness emerges by articulating internal and experiential inferences to the information acquired with the support of formal education processes. For example, P5 expressed awareness in a pessimistic tone of voice as follows: "*... working underground is different from working in other places. The slightest negligence can end the lives of many people, including you. Because you cannot escape from the mine. We have seen and experienced many examples of this in our country. I work with this awareness…*" Similarly, P15 points out the importance of the level of awareness with the following statement.

"*... we can reach a certain point with the training we provide, but it is up to the employee to integrate into the safety culture. Knowing the risk is one thing, internalizing and understanding it is another…*"

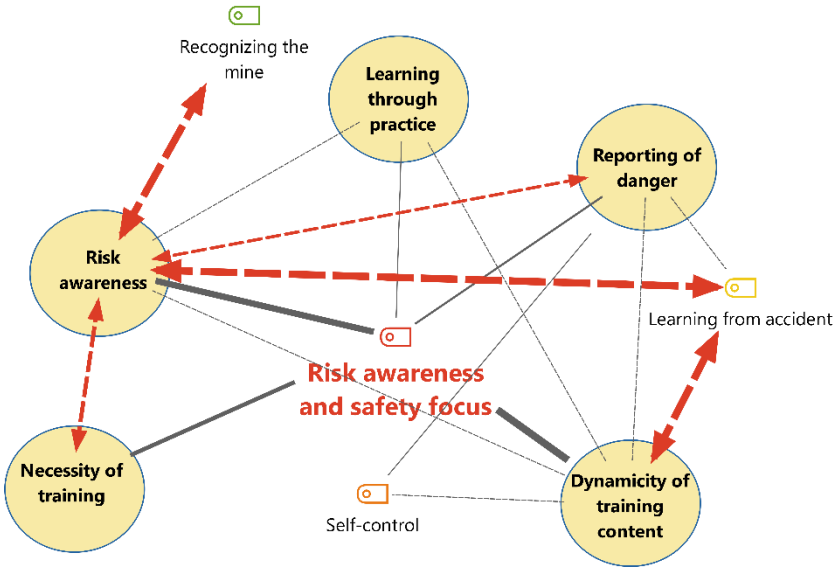

Fig 3. Awareness and security focus theme code relationships

It has been determined that the factor that plays a central role in the theme of risk awareness and safety focus is risk awareness. It has been observed that training practices supported by mandatory and dynamic content provide significant support for knowing what types of risks exist in underground units and how to deal with them, as well as constantly looking at new risks with an open mind. For example, P17 expressed his views on this subject as follows.

"*... we attach special importance to training in underground units. We provide much more than the training required by the legislation. Our priority is not accidents but raising awareness. The rest will come. As you know, there is entry to the underground, but there may not be an exit...*"

While training has significant effects on risk awareness, it has been observed that other more effective factors are getting to know the mine, learning lessons from accidents, and reporting hazards. P11 expressed the effect of working in mines for a long time on awareness " *... a person who has worked in the mine for a long time before and knows the mine already comes to us with that awareness. We do not need to put much on it...*" Similarly, P8 " *... some workers may act negligently because they have not worked in the mine before. They know the danger but cannot foresee the risks ...*" refers to the effect of knowing the mine on awareness, which enables foreseeing risks and knowing escape routes. However, the effect of the lessons learned from the accident on awareness is revealed by the following striking statement of P3.

"*... 301 people died in the Soma mine accident ten years ago. I reached a level of awareness that no training could give me when I saw the dead miners and their families on television…*"

Another factor that is effective in the formation and maintenance of risk awareness is the behaviour of employees to report any incident/situation that may endanger safety. P6 stated that awareness is the main factor that is effective in turning the behaviour of seeing the potential for harm that may affect the employee or the workplace into reporting it as follows.

"*… is promoted to the class that takes more initiative and reports dangers. However, we do not make the notification to upgrade our class but because we have internalized safety…*"

Awareness and being safety-focused effectively prevent work accidents in underground units for both participant groups. Risk awareness, which shows the degree of awareness of potential dangers throughout the organization, has received similar importance from both groups. For the managerial group, a constant alert environment is required to understand what risks exist, their effects, and how to deal with them. Formal training

activities are functionally practical in this alert situation. For example, P17 expressed his views on this issue " *... since working underground is inherently dangerous, we should always prioritize safety. We provide this with warnings, but trainings provide more effective results ...*"

On the other hand, it is seen from the references that internal processes are more effective in raising awareness among employees. For example, P5 stated, " *... a wrong move of ours can cause greater risks. The accidents I have seen have had very serious consequences. Therefore, I think about how myself, my colleagues, and my family will be affected if I act negligently ...* "

Audit theme

Most participants in both groups stated that inspection is essential in preventing occupational accidents. The functionality of inspection mechanisms developed by the organization in the context of a preventive approach, compared to legally mandatory inspection activities, was expressed in the following statement by P8.

"*... inspections in the mine where I worked before were limited to the obligations imposed by the legislation. I have not seen an inspection mechanism in this mine before. We are not only being inspected, we are also inspecting...*"

The effect of the dual role in which the inspector is also the inspector and the digital surveillance mechanisms and instant inspection applications in the context of preventive approach is highlighted in the following statement by P10.

"*... we have hazard analysis and risk elimination cards. We have to fill out these cards before starting work. Thanks to this card, we analyze the hazards and eliminate the risks before starting work. For example, if our colleague lacks PPE, we notify him and record it on this card. Even if you do not warn him, the superior will see it through the cameras and send you to the disciplinary board*."

On the other hand, P9 stated that the supervisory role created problems for him, saying, "*... if I report any of my colleagues' shortcomings to the management, I would see myself as a snitch ...*" and distinguished himself from the other participants.

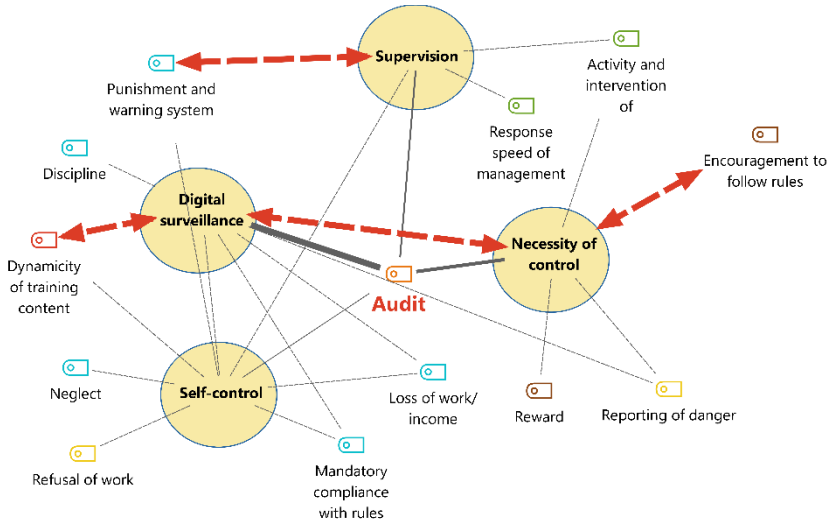

Fig. 4. Code relationships of the audit theme

The statements that for an effective audit, not only the support of the penalty and warning system should be used but also the encouragement and reward mechanisms should be implemented were prominent in both groups. For example, P4 explained the effect of rewarding with the statement, "*... if we were rewarded for the positive work we did in addition to the penalties such as salary deductions as a result of the audit, we would be more motivated to work.*" Similarly, P17 expressed the relationship between auditing and rewarding as follows.

"… inspections and punishments are as important as training for a person to behave safely, but *sometimes they are insufficient. We will soon start a practice where we will reward those who report the most dangers. There is a demand from employees in this direction...*"

It was determined that there is a reflexive relationship between the audit mechanisms in the organization and the training system. P19 expressed the dynamism provided by the audit process by using the data obtained from the audit in the training content, as follows.

"*... in addition to detecting negligence and warning the person. As a result, we realized that issues such as why this negligence was done were integrated into the training, the subject remained hot, and negligence or similar behaviours decreased...*"

Encouragement theme

The references to the necessity of a multi-faceted approach and the supervision of employees in preventing work accidents led to the emergence of the encouragement theme. It was determined that the prominent factor in encouragement mechanisms that include proactive safety measures is guidance for compliance with the rules. All participants except P8 in the first group emphasized that management is the main factor in compliance with the rules. P8 " *... sometimes things seen as encouragements can be perceived as sanctions. I think we should comply with the rules not because management wants us to but because it is a conscientious responsibility…*". The necessity of working worthy of human dignity with managerial guidance in compliance with the rules was expressed by P4 as " *... our working conditions are good in every way. In addition, the wages we receive and practices such as giving gold as a gift when we have a child hold us responsible for complying with the rules.*" Regarding the management's guidance, P7 expressed his concerns about loss of income or job with the statement, " *... we can be fired because we do not comply with the rules and instructions, and then you cannot claim any rights...*". However, the necessity of supervision that should be provided by the management in complying with the rules and the functionality of the surveillance mechanisms were expressed by P1 with the statement, " *... if there is no supervision, no one will comply with the rules. It is very hot underground in the summer, so the workers want to remove their helmets and masks. However, there are cameras, and the superiors warn them immediately.*"

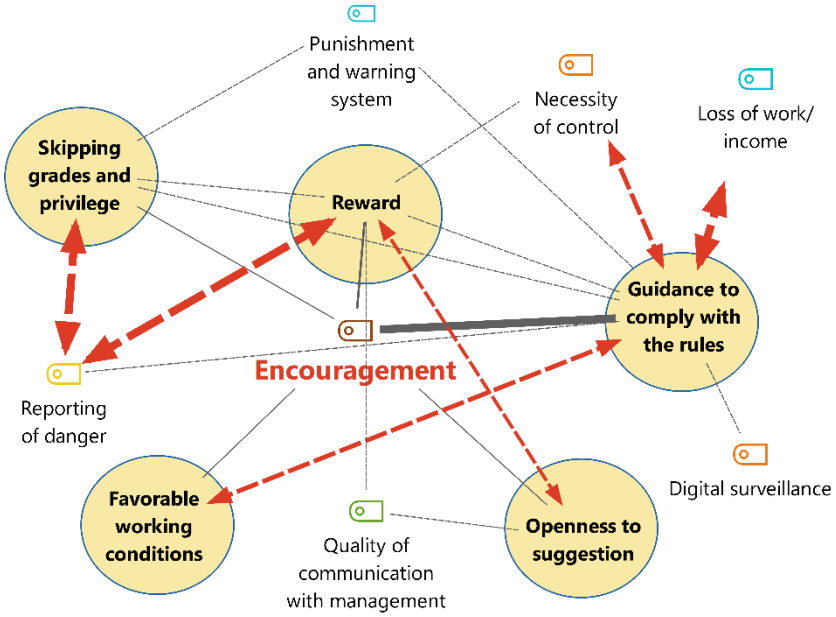

Fig. 5. Encouragement theme code relationships

It has been observed that the employees' notification of hazards and near-miss incidents to the management is effective in both the context of reward and promotion/privilege. The effect of reward, which allows the employee to report any situation that may put safety at risk, on preventing work accidents was expressed by P19 as " *...we reward the employees who comply with the rules in production, and even take more initiative and report hazards so that we can prevent possible accidents ...*" Another factor that ensures the effectiveness and sustainability of hazard reporting to prevent occupational accidents is the promotion and privilege rights provided to employees. P6 stated this effect as " *... those who report the most hazards or prevent occupational accidents get promoted and get promoted. I got promoted and have a higher salary than someone who started working four years before me ...*"

On the other hand, P10 stated that the different approach in terms of status creates injustice in rewarding by saying, " *... management rewards permanent workers who report hazards. However, we, subcontracted workers, are not given such privileges…*" Another factor cited by employees who take more initiative and come forward in hazard reporting is that management is open to suggestions. Most participants in the first group attribute the formation of an organizational climate that enables them to make suggestions about the quality of communication established with management, along with rewards. For example, P6 explained the effect of communication quality " *... we can communicate directly with management when reporting hazards. This allows us to find quick solutions. In this way, the problem is prevented before it occurs…*"

Discussion and Results

The literature review showed that although there are some quantitative studies on the causes of occupational accidents in mines and how they can be prevented, there is no research investigating workers' perceptions, specifically in underground units. This deficiency made it challenging to compare this study's results with those obtained from other studies. The literature on the causes of occupational accidents and the preventive factors outside the mining sector has primarily focused on identifying themes regarding workers, mechanical processes, and the work environment. This study provides a unique and new understanding of how workers in the mining sector, especially in underground units, interpret the process of preventing occupational accidents. The findings show that the prevention of occupational accidents in underground units can be achieved through the interrelated factors of management commitment to safety, rules, risk awareness and safety focus, audit and encouragement.

Firstly, it was revealed that the most important factors explaining how to prevent occupational accidents among employees working in underground units are the management's commitment to safety and the rules regulating work in the workplace. The findings obtained from the participants regarding the priority factors showing how to prevent occupational accidents are similar to the studies conducted in this field. However, the finding that prioritizing safety is essential in management's commitment to safety offers a new perspective on preventing occupational accidents. For example, this situation showed that the initiative given to the employee to refuse work is the most crucial factor in preventing occupational accidents in underground units. It was determined that leaving the action of stopping the work that the management can carry out to the employee's initiative strengthened the employee's perception of safety priority. Safety commitment, the essential starting point of the safety values shared by employees, requires the management's continuous participation in regulating working conditions (Agumba et al., 2013) and leadership in occupational safety activities (Ajith et al., 2020).

Safety-focused leadership ensures that safety commitment becomes a shared vision among employees by making it visible and sustainable throughout the organization (Ghahramani & Amirbahmani, 2022). Another prominent finding regarding the management's commitment to safety is the necessity of an effective safety communication network within the organization and support for safety training in forming this vision. The safety culture accompanying an adequate safety vision should be supported by activities requiring managerial performance and safety policies reflecting the organization's principles and values in occupational safety (Purnama & Soekiman, 2022; Fernández-Muñiz, 2007). Motivating employees to participate in safety activities at the entire organization level and providing information about the risks they will be exposed to and the methods of combating them are also prominent basic activities (Chen et al., 2021; Mashi & Subramaniam, 2020). In addition, the management's commitment or commitment to occupational safety must be sufficiently understood and internalized by employees (Yılmaz & Turan, 2023; Zara et al., 2023). It has been determined that the perception of value management gives employees is also an essential factor in the internalization of safety culture. Prioritizing safety rather than production reveals management's sincerity in safety and ensures employees have a positive perception of safety. Integrating the functions of safety planning, safety organization, and safety movement management into other administrative functions of managers in the organization can ensure more active participation of employees in safety activities (Ajmal et al., 2022). Integrating "good safety management" practices into daily business management at all management levels, from top management to the lowest management (Mckinnon, 2014), significantly contributes to the prevention of work accidents.

Commitment to safety also requires management to positively change employees' attitudes, beliefs, and behaviours regarding safety. Most occupational accidents in coal mines occur due to unsafe behaviours of miners (Di et al., 2021) and behavioural patterns and attitudes that do not change quickly (Donkor et al., 2023). Therefore, creating a culture that adopts safe behaviour patterns and a safe work environment is essential to prevent accidents. A positive safety culture, which effectively prevents occupational accidents, provides individuals in the organization with an identity that includes the same behaviours and attitudes and directs them to safe behaviour (Duarte et al., 2019).

The finding that the most critical factor in creating a shared identity towards safe behaviour is the penalty and warning system that ensures employees comply with the rules is consistent with previous research results. The research findings show that the functionality of the penalty and warning system is the concern that employees will lose their jobs and income due to continuing unsafe behaviours. Severe sanctions such as dismissal and wage deduction prevent employees from complying with rules and procedures and engaging in negligent behaviours. In addition to rules and procedures for regulating safe behaviours, control mechanisms in the organization also have essential functions. Safety rules and procedures serve as a guide to do the job more safely and efficiently. The control mechanism prevents rule violations and negligent behaviours (Zakaria et al., 2012; Amponsah-Tawiah & Mensah, 2016; Duarte et al., 2019). It is necessary to have safety guidelines (Rahimdel, 2021) and warning signs against hazards in underground units to encourage employees to use the necessary PPE and monitor this entire process with inspections (Duarte et al., 2019). It has been determined that the employee whom the organization and other employees supervise also has a supervisory role. The instant and widespread control network provided by digital surveillance mechanisms prevents negligence and unsafe behaviours. In addition, the findings show that

integrating the organization's training activities with the control process plays a vital role in preventing work accidents. The use of audit data, hazard notifications, and near-miss events in training content reveals the reflexive relationship between the training system in the organization and the audit process. This reflexive relationship ensures the formation of a dynamic preventive approach throughout the organization.

The findings show that safety awareness, which allows foreseeing risks in underground units, can be provided by managers through formal training and inspection activities. At the same time, it is seen that employees are referred to intrinsic motivation rather than formal training processes. Unlike the findings of the studies conducted in the field, it has been determined that risk awareness, which is the leading supporter of the preventive approach in the context of the research, cannot be provided only through formal training mechanisms, and intrinsic motivators should also be supported in internalizing awareness. In addition, it has been observed that knowing the mine and working conditions and increasing the time spent in the mine are effective in risk awareness. One of the main factors that ensure the sustainability of risk awareness is the behaviour of employees in reporting any dangerous event/situation that may endanger safety. With the danger notification, which is considered an output of safe behaviour, employees either prevent the occurrence of the risk or minimize the possible damage by reporting the potentially harmful situation or events to the management. However, the research findings have revealed that an effective penalty and warning system is insufficient for functioning the danger notification mechanism and that a fair incentive and reward system is also needed.

Conclusion

The mining sector contributes significantly to employment and the economy and includes risky activities that result in occupational accidents worldwide. The sub-sector with the highest rate of occupational accidents in the mining sector is coal mining. Although the number of people working in mines worldwide represents 1% of the total employees, 8% of occupational accidents occur in the mining sector (Ajith et al., 2020). In addition to this high rate, occupational accidents that occur in underground units, such as coal mining, cause both human, economic, and social traumas and have mass effects in this respect. It is impossible to completely prevent occupational accidents in mining activities. Due to the nature of the work in mines and unaccountable reasons, accidents can always occur in mines. The fact that unsafe behaviours cause 80% of mining accidents (Zhang et al., 2020) reveals that safe behaviour is the priority area to focus on in preventing occupational accidents. Therefore, establishing a safety culture prioritizing safe behaviour is necessary to prevent occupational accidents. The most common causes of accidents in coal mining in Turkey are administrative deficiencies. Due to these deficiencies, firedamp and dust explosions, landslides, mine fires, and technical failures related to transportation and mechanization are listed as the leading causes of accidents (Küçük & Ilgaz, 2015). As seen in the enterprise in the context of the research, management needs to prioritize safety to eliminate administrative deficiencies. Safety priority, the primary indicator of management's commitment to safety, should be supported by rule-making, training/awareness, inspection, and incentives. Management's safety priority ensures active safety and risk awareness participation by establishing active communication with employees. On the other hand, it can be said that rewarding, promotion, and disciplinary practices will support employees in internalizing the safety culture. Thanks to these practices, employees will proactively participate in safety, warn their colleagues about the dangers, be more conscious of the dangers, and be able to report the danger to management without hesitation.

There are several limitations to the study. One of these limitations is that the study was conducted in a single mining operation. Addressing the issue with different workplaces is valuable in bringing different perspectives on preventing accidents. On the other hand, the current safety culture in the workplace has yet to be entirely determined. For future studies, conducting such studies in more than one workplace or comparing workplaces with low and high accident frequency rates will add a different dimension to the subject.

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