



Investigate the factors affecting safety culture in the Malaysian mining industry

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ABSTRACT

Nowadays, safety culture is critical in preventing near-misses, accidents, and disasters. It has three dimensions: psychological, situational, and behavioural. To the best of the author's knowledge, lack of research has been done on psychological and behaviour safety culture in the Malaysian mining industry. The objective of the study is to investigate the factors affecting psychological and behaviour safety culture in the Malaysian mining industry. A two-round online Delphi method was performed among mining experts. The Delphi Experts (n = 21) with extensive experience in mining operations volunteered in this study. The Delphi I (open ended interview) and Delphi II (questionnaire survey) were completed by 100% (n = 21/21) and 87.5% (n = 18/21) of the experts, respectively. Thematic analysis was used to analyse the Delphi I and generate five and nine themes for psychological, situational and behaviour factors. For psychological safety culture, the Delphi II resulted median, IQD and percentage distribution analysis with 83.3%, 83.3% with the IQD cut-off (IQD ≤ 1) and 64.81% respectively.

For situational, safety culture, the consensus was achieved with median, IQD and total percentage distribution analysis with 94.4%, 61.1% and 73.15%, respectively For behavioural safety culture, the consensus was achieved with median, IQD and total percentage distribution analysis with 94.4%, 66.7% and 73.6%, respectively. To conclude, the Delphi analysis revealed that experts agreed and consensus were achieved on five, ten and nine factors that have major impacts on psychological, situational and behavioural safety culture in the Malaysian mining industry.

1. Introduction

The mining sector is now looking at establishing a safety culture in its operations. The goal is to prevent the occurrence of accidents (Jiang et al., 2020). Major of significant mining accidents have recently been reported as a result of a lack of safety culture (Jiang et al., 2020; Zhang et al., 2020). Many scholars have moved the focus of traditional accident prevention to fostering a positive safety culture in organizations (Stem et al., 2020; Jiang et al., 2019). The three primary components of safety culture are: (1) psychological, (2) situational, and (3) behavioural. According to Cooper (2000) and Alasamri et al. (2012), 'culture is a product of multiple goal-directed interactions between people (psychological), jobs (behavioural) and the organization (situational); while safety culture is that observable degree of effort by which all organizational members direct their attention and actions towards improving safety on a daily basis (Alasamri

et al., 2012; Cooper, 2000). Moreover, the Reciprocal Safety Culture Model introduced by Cooper (2000) stated that psychological aspect refers to "how people feel" for individual and group values, attitudes and perception about safety. Cooper proposes a model that recognizes the existence of an interaction or reciprocal link between psychological, situational, and behavioural dimension of safety culture. Previous study shows the important of developing a positive safety culture by strengthening psychological aspects of miners such as having a good safety attitude as reported by (Jiang et al., 2020).

Behaviour dimension of safety culture are focused on actions to be taken in organizations to inculcate the culture of safety among the employees and top management. The Reciprocal Safety Culture Model introduced by Cooper (2000) emphasized on "What people Do" on individual and group values, attitudes and perception about safety. The ineffectiveness of the safety program in the mining industry leads to

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mining disasters. The conventional accident prevention which was focused on safety engineering and human error have shifted to culture-based behavioural safety, which is the embedment of behaviour safety culture and transformation of safety issues in reducing mining accidents (Bloch, 2012). Managing the behavioural aspects of mining employees is important as part of the preventative mechanism of mining accidents. A positive behaviour of safety culture could lead to safe mining production and operation, produce a responsible miner, create a safe workplace environment and minimize mining accidents. A good behavioural safety culture is important in managing the resources in a proper way. For situational dimension it focuses on the “*what the organization has*” to ensure the safety culture exists. It refers to the management to provide safety rules, policy, standard operating procedure for example to ensure all workers abide the rules while performing the job.

Moreover, culture-based behavioural safety highlights the combination of behavioural safety culture and transforming the safety issues in the mining industry towards reducing mining accidents. The factors contributes to the behavioural dimension of safety culture such as management commitment (Jiang et al., 2020; Wang et al., 2019), ownership of safety (Zhang et al., 2020), safety training (Rubin et al., 2020; Jiang et al., 2020), safety communication (Stemm et al., 2020; Rubin et al., 2020), reward and recognition (Hussain et al., 2018) safety investment (Nikulin et al., 2017), and worker competencies (Miao et al., 2020). This is supported by previous studies on behavioural safety culture. The country that reported on the importance of behavioural safety culture to reduce mining accidents such as in China (Miao et al., 2020; Zhang et al., 2020; Fu et al., 2020), India (Bhattacharjee et al., 2020), United States of America (Yorio et al., 2020); Turkey (Düzgün et al., 2018), South Africa (Hussain et al., 2018), and Russia (Nikulin et al., 2017).

In the Malaysian context, the mining sector has existed for almost 200 years, and thankfully, no large-scale mining disasters have happened. The statistic of mining accidents keeps increasing for the past 10 years (Annual Report Year, 2019). There is also a lack of scientific articles that reported on the main cause of mining accidents in Malaysia. As a result, there has been also scarcity of studies on safety culture in the Malaysian mining industry. The mining industry in Malaysia is still far behind in conducting research on psychological and behavioural aspects of safety culture as mechanism to reduce mining accidents. This gap of knowledge exists has motivates the researchers since lack of study focusses on psychological, situational and behavioural dimension in the Malaysian mining sector. The main research question that drives this study is “What are the influencing factors of safety culture to reduce mining accidents?” Therefore, this study aimed to investigate the influencing factor of the psychological, situational and behavioural safety culture in the Malaysian mining industry by applying Delphi method with the involvements of panel experts.

2. Methodology

2.1. Study design and selection of participants

The Delphi method is a structured communication technique, originally developed as an interactive forecasting method which relies of a panel of experts. This method is highly used in Collective Intelligence (Dalkey and Helmer, 1963). It refers to shared or group intelligence that emerges from the collaboration, collective efforts and competition of many individuals and appears in consensus decision making (Dalkey and Helmer, 1963). Moreover, the Delphi technique is defined as “a group procedure involving interaction between the researcher and a group of identified experts on a certain issue, usually through a series of questionnaires” by definition (Skutsch and Hall, 1973). The panel of professional principles’ knowledge and experiences served as the foundation for reaching a group consensus. The number of rounds employed in a Delphi study varies depending on the research’s goal.

According to McDonald et al. (2009), most research requires only two or three rounds of Delphi. to achieve group consensus. If the goal of the study is to grasp the implications, and the sample size is small, it’s possible that fewer than three rounds will suffice to attain consensus, theoretical saturation, or reveal the information needed. Three rounds, according to Custer et al. (1999), are usually adequate to acquire the essential information and attain consensus. Furthermore, the number of rounds of questionnaires is determined by the consistency or convergence of results, not by consensus (Linstone and Turoff, 2011). “*The importance of the Delphi is not in producing high reliability consensus data, but rather in alerting the participants to the complexity of situations by compelling, cajoling, persuading, seducing them to think, by having them challenge their assumptions*”. This differs from a more traditional panel or forum, when unanimity is desired and often imposed, resulting in research data errors (Linstone and Turoff, 2011).

This research applied two-round Delphi (known as Delphi I and Delphi II) iterative consultation procedure with panel experts was used to conduct this research. This method is commonly used in research (Peeraer and Van Petegem, 2015; Yeh and Cheng, 2015), and its validity for questionnaire construction has been established (Blasco et al., 2010). The Delphi method or technique used in this study was cover the following aspects;

- 1) Delphi I (open ended online interview session). The volunteering panel of mining experts included 2 government enforcers or authorities, 3 mining consultants, 1 mine owner 1 or operator, 4 top management of mining companies (e.g., vice president, senior operating manager, mining manager), 6 safety and health managers and officers, and 5 academicians (professor and senior lecturer) with extensive experience in mining.
- 2) Delphi II (Online Questionnaires). The findings from Delphi I become the basis to construct a questionnaire. The panel of experts were given an online questionnaire to complete in the second round, known as Delphi II, in order to establish consensus within the panel; thus, allowing the panel of experts to: i) anonymously share information and ii) reflect on the information supplied by other panel members, which is how consensus is achieved.

Both the Delphi I and II studies were performed between March and May 2021. An open-ended survey was utilized in the first phase of the study, known as Delphi I, to obtain expert opinions on factors affecting psychological, situational and behavioural safety culture in the Malaysian mining sector. The Delphi II questionnaire was built using the discovered factors from the Delphi I study. A 5-point Likert scale questions were employed. Likert scales often varied from ‘strongly disagree’ (1) to ‘strongly agree’ (5). The steps of the Delphi studies are summarized in Fig. 1.

There are many points of view on how many respondents should be included in a Delphi survey. Delbecq et al. (1975) stated that ten (10) to fifteen (15) panellists might be adequate provided that their backgrounds are homogeneous, which was accomplished in the current study. According to Rowe and Wright (2011), the size of a Delphi panel in peer-reviewed research range from three (3) to eighty (80). A panel size of ten (10) to eighteen (18) people was also suggested by Okoli and Pawlowski (2004) and Skulmoski et al. (2007). According to Hallowell and Gambatese (2010), most studies have between eight (8) and sixteen (16) panellists, therefore a minimum of eight (8) is recommended. They also noted that the size of a panel should be determined by the study features, the number of experts available, the desired geographic representation, and the capacity of the facilitator.

2.2. Method for Delphi I analysis

The findings from Delphi I will be analysed using thematic analysis. With the participation of 21 Delphi I experts with extensive expertise in safety culture and the mining sector, the open-ended online interviews

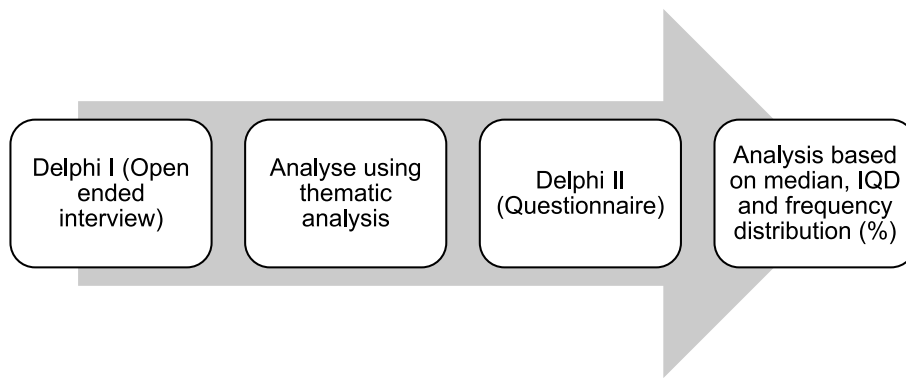


Fig. 1. Steps of Delphi I and II studies.

were successfully completed. A thematic analysis was conducted to identify themes linked to influencing factors of safety cultures. Six stages were followed in the thematic analysis and were acceptable for qualitative analysis in the Delphi I investigation, as recommended by Nowell et al. (2017). The steps are shown in Fig. 2.

2.3. Method for Delphi II analysis

This research includes Delphi experts who completed both the Delphi I and II studies. For questions with 5-point Likert scales, the mean, median, standard deviation, and Inter Quartile Deviation (IQD) were presented. The Delphi II data was analysed using Microsoft Excel. There are various interpretations to identify the consensus on Delphi I in order to establish consensus among the experts. Fig. 3 demonstrates the recommended steps by earlier researchers to determine consensus for the Delphi Technique (quantitative).

3. Results and analysis

This Delphi survey assembled a team of 21 mining professionals known as Delphi Experts. The Delphi I (open ended online interview) and Delphi II (online questionnaires) were completed fully by 100% (n = 21/21) and 85.7% (n = 18/21) of the whole panel of mining experts, respectively. The Delphi experts for this study are shown in Table 1. All these panels must have experience in mining industry for at least 10 years and understand well about safety culture. Table 1 shows the experts panel for delphi study and Table 2 shows the background of Delphi experts.

3.1. Analysis on Delphi I method

The open-ended questions were used in Delphi I with the involvement of 21 Delphi I Experts. The objective of this study is to investigate the influencing factor of psychological safety culture in the mining

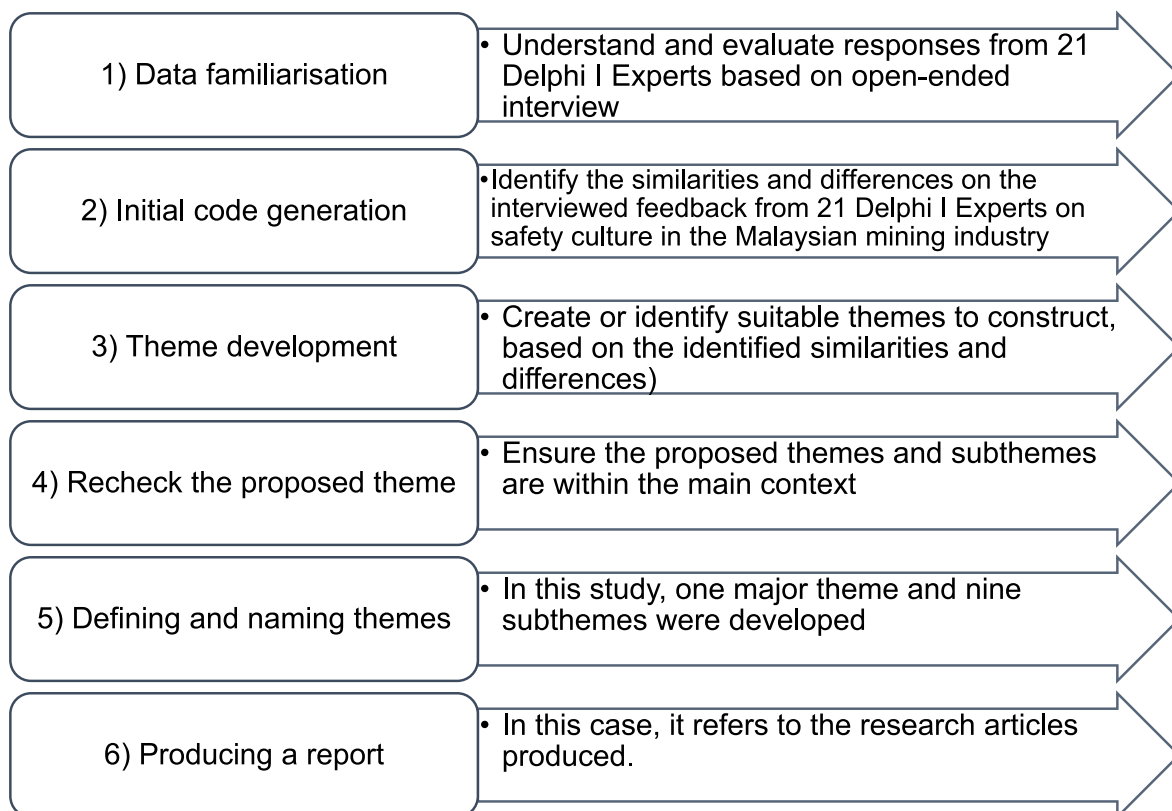


Fig. 2. Steps for thematic analysis for Delphi I.

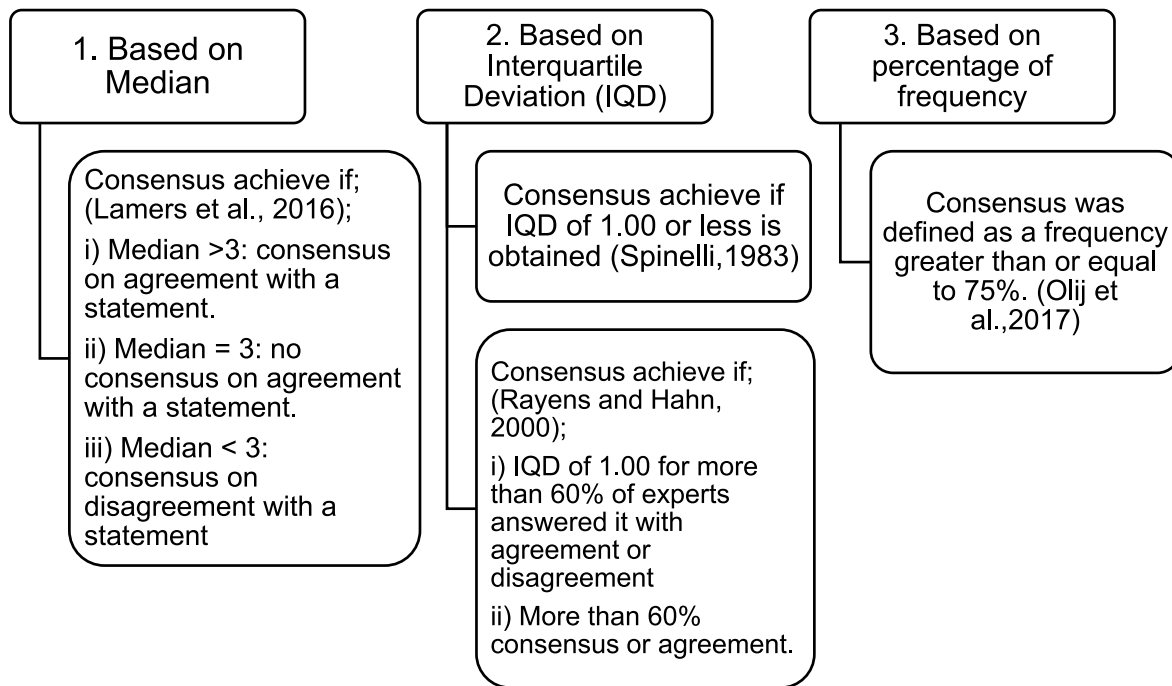


Fig. 3. Determination of consensus for Delphi II (quantitative) based on Lamers et al. (2016), Spinelli (1983) and Olij et al. (2017).

Table 1
Experts for Delphi I and II study.

Category	No of experts for Delphi I	No of experts for Delphi II
1. Government enforcers or authority	2	2
2. Mining Consultants	3	3
3. Mine Owner or Operator	1	1
4. Top Management of Mining Company (including Vice President, Senior Operating Manager and Mining Manager)	4	3
5. Safety and Health Managers and Officers	6	5
6. Academicians	5	4
Total	21	18

Table 2
Background of Delphi experts.

Code name	Gender	Years of Experience	Current Position
R1	Male	25	Senior Operating Mining Manager
R2	Male	24	HSE Manager
R3	Male	39	Mining Consultant
R4	Male	15	Associate Professor
R5	Male	22	Director of government agency
R6	Male	22	EHS Superintendent
R7	Male	30	Professor
R8	Male	25	Senior Lecturer
R9	Male	10	Safety and Health Officer
R10	Male	25	Safety Manager
R11	Male	14	Mining Manager
R12	Male	22	SHO
R13	Male	17	Professor
R14	Male	16	Senior Lecturer
R15	Male	30	Vice President Business Development (Mining)
R16	Male	36	Mining Consultant
R17	Male	36	Mining Consultant
R18	Male	25	Mine Owner
R19	Male	20	SHO
R20	Male	12	Mine Inspector
R21	Male	26	Senior Chief Geologist

industry. The important part of interview session was the questions related to the construction of safety culture in the Malaysian mining industry such as;

1. Based on your experience, what are the individual/personal factors (how people feel) that contribute to a positive safety culture in mining industry?
2. How the working environment (what the organization has) contribute to a positive safety culture in mining industry?
3. What are the behavioural factors (what people do) that contribute to a positive safety culture in mining industry?

Based on the feedbacks of Delphi Experts, the thematic analysis (Nowell et al., 2017) was applied for analysis. The analysis based on thematic analysis was shown in Table 3.

Table 3 shows the results of mapping table on thematic analysis for Delphi I based on respondents’ feedbacks. The definitions for each factor also highlighted in the table. Based on Table 3, five main influencing factors of psychological factors on safety culture were generated namely (i) management care for workers, (ii) safety attitude, (iii) job satisfaction, (iv) worker’s health, and (v) peer influence. Moreover, the percentage were calculated based on the frequency of the word used or highlighted by all the Delphi I Experts during the interview session as shown in Fig. 4. Based on Delphi I, safety attitude was the most influencing factor of psychological dimension with 85.7%, followed by management concern (28.6%), Health of workers (28.6%), peer influence (9.5%) and job satisfaction (4.8%), as shown in Table 3. The percentage frequency (%) was calculated based on number of panels highlighted the words during the interview session. For example, safety attitude factors reported 18 experts were highlighted on it therefore 18 experts were divided with 21 total experts and multiply with 100% and therefore 85.7% was obtained. The calculation was repeated for each of factor for psychological, situational and behavioural dimension.

For situational safety culture, nine subthemes or factors were created based on responses from 21 Delphi I experts. These factors are (1) Safety Policy, (4) Competent SHO, (5) Safety Education, (6) Safety Programme, and (10) Safety Signage. Based on Table 2, safety education (81.6%), safety competency (76.2%) and safety signage (61.0%) were the top 3

Table 3
Mapping table on thematic analysis for Delphi I (Interview).

Dimensions (Themes)	Factors (subtheme)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	Frequency	Percentage frequency (%)
Psychological	1. Management concern/care on workers	/	/	/			/		/	/													6	28.6
	2. Safety attitude	/	/	/		/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	18	85.7
	3. Job satisfaction											/											1	4.8
	4. Health of worker			/			/		/	/									/			/	6	28.6
	5. Peer influence										/	/											2	9.5
Situational	1. Safety policy	/	/		/				/	/	/	/	/		/		/		/	/		/	12	57.1
	2. Safety audit									/	/										/		3	14.3
	3. Safety rules	/	/	/		/		/	/	/	/	/		/	/				/	/	/		13	61.9
	4. Competent SHO/	/	/					/	/	/	/	/	/	/					/	/			11	52.4
	5. Safety education	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	17	81.0
	6. Safety programme		/			/	/	/	/	/	/	/			/	/	/	/	/	/			10	47.6
	7. Safety planning						/				/			/	/							/	5	23.8
	8. Medical surveillance	/	/				/		/	/	/				/	/	/	/	/			/	7	33.3
	9. Safety competency	/	/		/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/		/	16	76.2
	10. Safety signage	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/		/	13	61.9
Behavioural	1. Management commitment and action	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	21	100
	2. Safety communication	/	/		/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/		/	15	71.4
	3. Leadership	/	/	/				/	/	/	/	/		/	/				/	/			10	47.6
	4. Safety training	/	/	/	/	/	/	/	/	/	/	/		/	/	/	/	/	/	/		/	17	81.0
	5. Safety awareness		/	/		/		/	/	/			/	/	/			/	/			/	7	33.3
	6. Safety reporting					/				/			/	/							/		4	19.0
	7. Safety promotion					/				/			/	/		/	/	/	/			/	5	23.8
	8. Enforcement on wearing PPE	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	17	81.0
	9. Reward and punishment	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	16	76.2

Psychological dimension

1. Management care on workers: Refers to management's interest with workers' psychological conditions as they relate to their work environment and performance.
2. Safety Attitude: Refers to mine workers' psychological attitudes regarding workplace safety culture, procedures, and accident prevention.
3. Job satisfaction: Refers to a worker's satisfaction with the task he or she has been assigned without undermining the employer's efforts.
4. Health of Worker: Refers to a worker's physical and mental ability to do the task at hand
5. Peer influence: Refers to co-workers or colleagues who have a significant impact (good or bad) on the development of a workplace safety culture.

Situational dimension

1. Safety policy: Refers to the mining companies stated OH&S policy and OH&S objectives, which include compliance with OSH legal requirements and other government-imposed requirements.
2. Safety Audit: Refers to the auditor's internal and external audits, and ensure that all records are appropriately documented for future reference.
3. Safety rule: Refers to all of the mining company's developed standard operating procedures, guidelines, rules, regulations, and safety practices, which must be followed by all mine personnel and do not conflict with local authorities' and government's requirements.
4. Competent SHO: SHO who is well-trained and experienced in mining operations and activities is referred to as a competent SHO.
5. Safety education: Refers to any training offered by management to improve employees' safety skills and knowledge.
6. Safety programme: Refers to current and completed programmes, events, and activities such as safety awareness week, safety first, and others.
7. Safety planning: Refers to all short and long-term plans, as well as ongoing safety planning offered to employees by senior management. For future reference, everything forthcoming and completed planning must be carefully documented.
8. Medical surveillance: Top management assigns an Occupational Health Doctor to evaluate employee health and safety to ensure that employees are physically and psychologically capable of doing their duties.
9. Safety competency: Refers to employees' prior safety knowledge and work experience, as well as any ongoing safety training or education they get to improve their professional abilities and competences.
10. Safety signage: Refers to any chemical signage, working station signage, mining site signage, or safety promotion signage is used to keep personnel informed of impending dangers.

Behavioural dimension

1. Management action and responsibility: Refer to top management's commitment to ensuring that all employees follow the company's safety policies and rules.
2. Safety communication: Refer to management's communication channels, such as email, memos, safety briefings, bulletin boards, reporting systems, and others, to guarantee dual communication between employees and employers.
3. Leadership: Refer to a well-trained and experienced SHO, supervisor who is capable of effectively leading and supervising personnel.
4. Safety training: Refers to management's commitment to offer staff with sufficient training and competence courses.
5. Safety awareness: Refers to employee knowledge of the significance of safety and the culture of safety at work, as well as comprehension of safety policies. Standard Operating Procedures (SOPs), standards, and regulations
6. Safety reporting: To report misbehaviour or unethical concerns involving workers or supervisors, use the management-provided method, which may be used either offline (manually) or online.
7. Safety promotion: Any promotion, including activities and programmes created by management to instil a safety culture at work, such as safety week, safety film, safety signs, safety talk, and safety seminar and others
8. Enforcement on safety rules: Refer to the established SOP, regulations, and standards, which must be adhered to by all levels of personnel.
9. Reward and punishment: Refer to bonuses to reward excellent employees, or any misbehaviour and unethical behaviour by employees must be penalized.

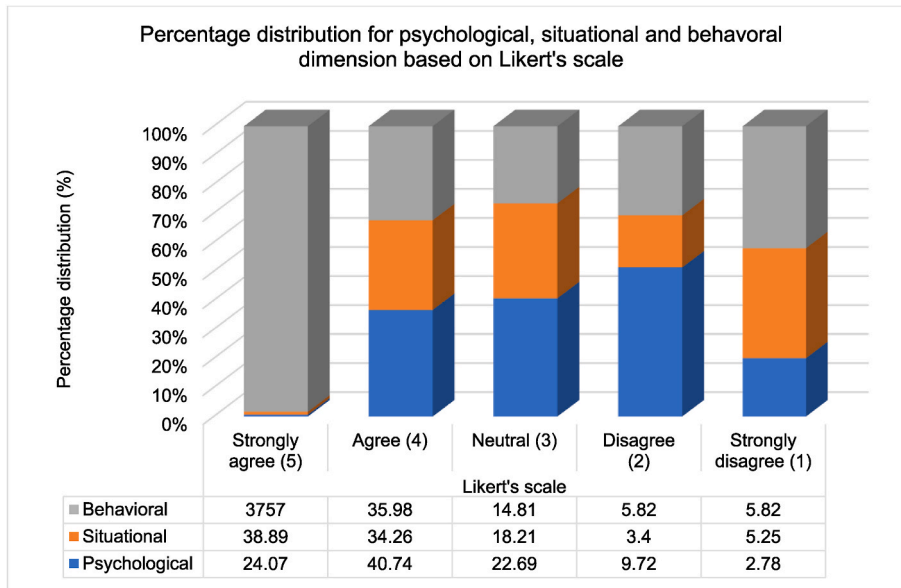


Fig. 4. Bar chart on percentage of rating distribution for psychological factors of safety culture for Delphi II.

important factors to create safety culture in Malaysian mining industry as reported by experts. The factor that had the least influence on situational safety culture is safety audit with 14.3%. The reason of safety audit is less importance is according to one of mining experts said (R9), “if the safety policy, safety rules and all guidelines and SOP were carefully established by management and followed by all level of mine workers, the safety culture can be built easily”.

For behavioural safety culture, nine subthemes or factors were created based on responses from 21 Delphi I experts. These factors consist of; (i) Management action and responsibility, (ii) Safety communication, (iii) Leadership, (iv) Safety training, (v) Safety awareness, (vi) Safety reporting, (vii) Safety promotion, (viii) Enforcement on safety rules, (x) Reward and punishment. Fig. 5 shows the percentage for each factor highlighted by all panels. The three main factors that greatly

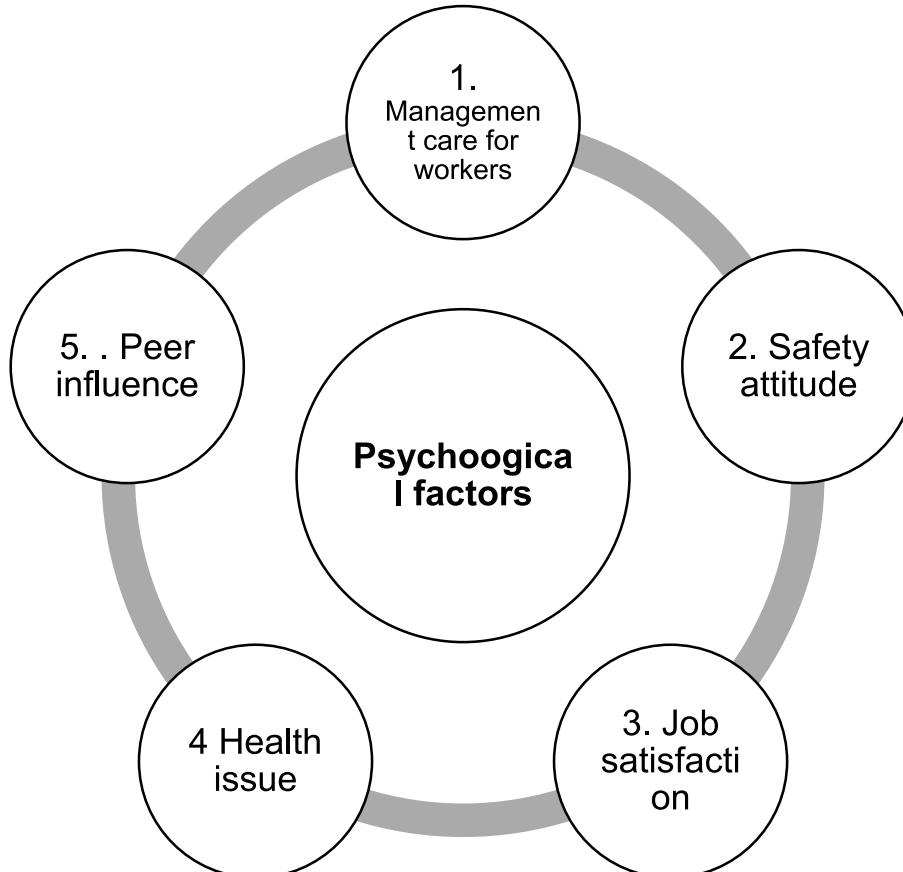


Fig. 5. Five factors of behaviour safety culture in the Malaysian mining industry.

influence behaviour safety culture are Management commitment (100%), enforcement on safety rules (81%) and safety training (81%). The factor that had the least influence on behaviour safety culture is safety reporting with 19%.

3.2. Analysis on Delphi II method

For Delphi II, the influencing factors of psychological safety culture were assessed with the involvement of 18 Delphi II. 3 Experts did not submit the questionnaire survey. Twelve (12) questions were constructed and the questionnaires were aims to investigate the influencing factors of psychological dimension. For behavioural safety culture. Twenty-one (21) questions were constructed based on identified factors in Delphi I; (1) Management action and responsibility, (2) Safety communication, (3) Leadership, (4) Safety training, (5) Safety awareness, (6) Safety reporting, (7) Safety promotion, (8) Enforcement on safety rules, (9) Reward and punishment. The rating used for questionnaire was based on the 5-point Likert scale. A rating of “5” on the scale is “strongly agree”, a rating of “4” is “agree”, a rating of “3” is “neutral”, a rating of “2” is “disagree” while a rating of “1” is “strongly disagree”.

Table 4, Table 5 and Table 6 show the analysis on Delphi II survey and individual ratings for psychological, situational and behavioural safety culture respectively. Both results showed the analysis on Delphi II survey based on median, IQD and percentage distribution and their respective individual ratings.

For psychological dimension as shown in Table 4, 10 out of 12 questions for psychological factors obtained a median >3, which means the consensus achieved for the statement was 83.3%. The median analysis is shown in Table 4. One question 2(ii) under Safety Attitude obtained a median = 2 which means the consensus disagreed with the statement. For Item 5(i) under Peer Influence factor, the median was equivalent to 3, indicating that there was no consensus for the statement. Overall, 83.3% of Delphi II Experts achieved consensus based on median analysis even though two questions did not show a consensus.

As indicated in Table 4, the interquartile deviation (IQD) was used to determine whether the influencing factors reached a consensus or not. Three (3) factors, including Safety Attitude, Job Satisfaction, and Peer Influence, obtained a consensus with the IQD cut-off (IQD 1) score established. However, just one item I (v) in the element of management care for workers did not obtain consensus. The IQD cut-off (IQD 1) was agreed upon by the others. There was no agreement on the Health Issue component, with an IQD of 1.5. In the case of IQD, 83.3% of participants agreed on the IQD cut-off (IQD 1). According to Rayens and Hahn (2000), a 60% consensus of agreement was reached. Overall, using IQD analysis, an agreement was made.

Furthermore, as indicated in Table 4, 9 of the 12 questions had a level of agreement greater than 70%. Furthermore, the bar chart in Fig. 2 revealed that a total of 64.81% of the rating distribution overall percentage for psychological factors (percentage replies) came from the responses of “highly agree” and “agree”. From the total of 12 questions pertaining to psychological factors, just 9.72% and 2.78% had responses with “disagree” and “strongly disagree”, respectively. As a result, it denotes a high level of agreement or consensus on the items for each psychological safety culture factor. Olij et al. (2017) agreed that a frequency of more than or equal to 75% was considered a consensus.

To summarise, the Delphi I and Delphi II were successful in reaching an agreement or degree of consensus of 83.3%. IQD cut-off (IQD 1) and median >3 were obtained. With 64.81%, the percentage of rating distribution was likewise reached. Five psychological influencing factors, namely (1) management concern/care for workers, (2) safety attitude, (3) job satisfaction, (4) health issue, and (5) peer influence factors, have a significant impact on psychological aspects of safety culture, according to a panel of mining experts.

For situational, the Delphi II results were shown in Table 5. By applying the interquartile deviation (IQD) to determine whether the

Table 4
Delphi II survey results and individual ratings for psychological safety culture.

PSYCHOLOGICAL FACTORS					
Factors	No.	Question	Median	IQD	Percentage (agree & strongly agree)
1. Management care for workers	1(i)	Top management able to identify and recognize the workers that work under pressure and have intention to take shortcuts about safety.	4	1	55.6%
	1				
	(ii)	Top Management concerns on mine workers involved in mining accidents or any injuries	4.5	1	77.8%
	1				
	(iii)	Top management alerts on worker's ability to identify the potential hazard and risk while handling machinery or performing the given task	4	0.75	72.2%
	1				
2. Safety Attitude	(iv)	Top management concerns on the workers that affects or can affect the company OH&S performance.	4	1	77.7%
	1				
	(v)	Top management listens and gives importance to my opinion for improving work safety.	4	1.75	72.2%
	1				
	(vi)	The safety of workers is a big priority with management where I work.	4	1	88.9%
3. Job satisfaction	2(i)	I feel free to report safety violations where I work.	4	0.75	83.4%
	2				
4. Health issue	(ii)	Completing my work is more important than doing work in safe ways.	2	1	16.7%
	3(i)	Worker's satisfaction in performing the job is the main priority of top management.	4	1	55.6%
5. Peer influence	4(i)	Top management concerns and care on worker's health issue including mental health issue.	4	1.5	72.2%
	5(i)	My colleagues point out each other's deficiencies in a work safety.	3	0.75	27.8%
	5				
	(ii)	I alert my colleagues who act contrary to work safety rules,	4	0	77.7%

influencing factors reached consensus or not, 11 out of 18 items reached consensus with the IQD cut-off (IQD ≤1) score set equivalent to 61.1%, as shown in Table 5. Four influencing factors, namely (1) Safety Policy, (4) Competent SHO, (5) Safety Education, (6) Safety Programme, and (10) Safety Signage, reached consensus with the IQD cut-off (IQD ≤1) score set. Seven (7) items were recorded with an IQD >1 which came from items 2(i) and 2(ii) for Safety Audit, item 3(i) for Safety Rules, item 7(ii) for Safety planning, item 8(ii) for Medical Surveillance, and items 9 (i) and 9(ii) for Safety Competency. These items or factors did not

Table 5
Delphi II results and individual ratings for situational dimension.

Factors	No.	SITUATIONAL DIMENSION	Median	IQD	Percentage (%) (agree & strongly agree)
		Question			
1. Safety policy	1(i)	The established OH&S policy and OH&S objectives of the mining company is compliance with OSH legal requirement and others requirement set up by government.	5	1	88.9
	1(ii)	All workers understand and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job	4	0.75	77.8
2. Safety Audit	2(i)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an internal audit	4	2	66.6
	2(ii)	All the requirements and outcomes of OH&S management system, including the OH&S policy and OH&S objectives of company will undergo an external audit.	4	1.75	72.2
3. Safety rules	2	The audit results are well reported and shared to all level of management and workers	4	1	71.2
	(iii)				
	3(i)	Top Management provides a clear standard operating procedure (SOP) to workers in handling machinery and handling chemical.	4	1.75	72.2
	3(ii)	All workers use proper Personal Protective Equipment (PPE) while performing job (such as noise, working at height, handling chemical, use machine etc.)	4	1	77.7
4. Competent SHO	4(i)	Providing a competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	4	1	88.9
5. Safety/ education	5(i)	All workers are provided with the relevant training on OSH legal requirement and other requirement.	4	0.75	72.2
6. Safety programme	6(i)	All the safety programmes, activities or events are intended to support the OH&S policy and OH&S objectives of the mining company	4	1	77.7
7. Safety planning	7(i)	Top Management responsible to take action in addressing nonconformities and continually improve its OH&S performance is important to construct safety culture.	4	1	77.7
	7(ii)	Top Management responsible in identifying, solving and providing preventative action related to ergonomics problem facing by workers	3	2	44.4
	7	Top Management implement the engineering controls, reorganization of work, or both at workplace	4	0.75	72.2
8. Medical surveillance	(iii)				
	8(i)	Top Management provides Occupational Health Doctor to handle health issues among worker including mental health issue	3.5	1	50.0
	8(ii)	Top Management provides annual medical check up to workers	4	1.75	72.2
9. Safety competency	9(i)	Top management consider the previous educational background of workers to create safety culture at current workplace	4	1.75	72.2
	9(ii)	Top management consider the previous working experience of worker to create a safety culture at current workplace	4	1.75	72.2
10. Safety signage	10 (i)	Top management provides a clear safety signage at mine site and working area.	5	0	94.5

achieve consensus. However, according to Lamers et al. (2016), the level of consensus for 5 points Likert's scale can be analysed based on the median, as categorised below;

- i. Median >3: consensus on agreement with a statement.
- ii. Median = 3: no consensus on agreement with a statement.
- iii. Median <3: consensus on disagreement with a statement.

17 out of 18 questions for Situational Dimensions obtained a median of >3, which means consensus on agreement with the statement was 94.4%. Only one question 7(ii) under Safety Planning obtained a median of 3, which means there was no consensus on agreement with a statement. Furthermore, in terms of the percentage of rating distribution for the Situational Dimension (percentage responses), the bar chart in Fig. 4 shows a total of 73.15% came from strongly agree and agree responses. Only 3.40% and 5.25%, respectively, were rated as disagreeing and strongly disagreeing on the overall questions related to the Situational Dimension. Therefore, it indicates strong agreement or consensus on the items for each factor in the Situational Dimension.

For behaviour dimension, the Delphi II results were shown in Table 6. The interquartile deviation (IQD) was applied to determine whether the influencing factors reached consensus or not, 14 out of 21 items reached consensus with the IQD cut-off (IQD ≤1) score set, which is equivalent to 66.7% as shown in Table 6. Six influencing factors, namely Safety communication, Leadership, Safety training, Safety promotion, Enforcement on wearing PPE, and Reward and punishment reached consensus with the IQD cut-off (IQD ≤1) score set. Among them, the Leadership factor has the strongest consensus with IQD = 0, followed by Safety Communication, Safety training, Reward and punishment, Safety promotion and Enforcement on wearing PPE. For the median, 20

out of 21 items for Behaviour dimensions had a median >3, which means consensus on agreement with statement was equivalent to 94.4%. The question 1(v) under management action and responsibility had a median = 2, which means no consensus on agreement with the statement.

However, in terms of the overall percentage of rating distribution for Behaviour Dimension (percentage responses), the bar chart in Fig. 4 shows a total of 73.55% came from strongly agree and agree responses. Overall, only 5.82% disagreed and 5.83% strongly disagreed on questions or items related to the Behaviour dimension. Therefore, it indicates that strong agreement or consensus on the items for each factor for behaviour dimension was achieved. To conclude, the influencing factors of Behaviour Dimension that achieved consensus with (IQD ≤1) was 67.6%, median >3 was 94.4% and the percentage distribution was 73.6%.

4. Discussion

To the best of our knowledge, this is the first Delphi study focusing on the psychological and behaviour safety culture in the Malaysian mining industry. Delphi was successfully completed in two phases with the help of mining experts. According to the Delphi I and II studies, five major factors consist of (i) management care for workers (ii) safety attitude, (iii) job satisfaction, (iv) health issue and (v) peer influence have a significant impact on the psychological safety culture in the Malaysian mining industry as shown in Fig. 5.

The concern for workers by the management is a key component of developing a healthy safety culture at work so that employees may function with little stress. Top management can create a solid communication channel to guarantee that all problems or issues relating to

Table 6
Delphi II results and individual ratings for behaviour dimension.

Factors	No.	BEHAVIOR DIMENSION Question	Median	IQD	Percentage (%) (agree & strongly agree)
1. Management action and responsibility	1(i)	Top Management committed to ensure each level of workers able to understand, apply and support the established OH&S policy and OH&S objectives of the company.	4	1.75	72.2
	1	The organization should examine the resources required (e.g., financial, human, equipment, infrastructure) to achieve OH&S policy and OH&S objectives of the company.	4	1	77.7
	(ii)	The Top Management has allocation or budget to support the intended outcome of OH&S policy and OH&S objectives of the company	4	1.75	71.2
	1	Top Management shows the commitment by providing the resources needed for the establishment, implementation, maintenance and continual improvement of the OH&S management system.	4	1.75	71.2
	(iv)	Establishing a planned response to emergency situations, including the provision of first aid are not important in mining industry.	2	3	33.3
2. Safety communication	2(i)	The OH&S policy, objectives, requirement and information are well documented and easily accessed by workers	4	0.75	72.2
	2	Communicating relevant safety information to contractors, visitors, emergency response services, government authorities and the local community is important to create a safety culture.	5	1	88.9
	(ii)	The dissemination and communication of OH&S information is consistent and reliable with information generated within the OH&S management system.	4	0.75	77.8
3. Leadership	3 (i)	Appointing competent Safety and Health Officer in supporting the OH&S management system, including the OH&S policy and OH&S objectives.	4	0	77.8
4. Safety training	4(i)	Top Management is committed to have competent workers by providing adequate and appropriate education and training.	4.5	1	77.8
	4	Determining competence requirements, training needs, training and evaluating training for workers are important to construct safety culture.	4.5	1	88.9
5. Safety awareness	5(i)	All workers give full commitment and comply with the relevant OH&S policies/procedures, legal requirement and other requirement of company while performing their job.	4	2	65.7
	5	Each level of workers is aware and have clear understanding on the OH&S policy and OH&S objectives of company.	4	1	60.1
	(ii)	Workers are able to apply and comply relevant OSH legal requirement and other requirement to do their job.	4	1	61.1
	(iii)	Does eliminate hazards and reduce OH&S risks are important for safety culture?	4.5	1	88.9
6. Safety reporting	6(i)	All incidents, non-compliance and non-conformity are investigated quickly in order to improve safety at the workplace as soon as possible. Preventive reports are recommended for future reference.	4.5	1	77.8
	6	Any safety concerns raised are treated with high urgency in mining organization.	4	1.75	72.2
	(ii)	Improving the occupational health and safety culture, such as by extending competence related to occupational health and safety beyond requirements or encouraging workers to report incidents in a timely manner.	4.5	1.75	72.2
7. Safety promotion	7(i)	Does safety activities or events are actively promoting safety culture in mining industry?	4	1	83.4
8. Enforcement on wearing PPE	8(i)	Does wearing proper Personal Protective Equipment (PPE) and understand the instructions to wear PPE are actively promoting safety culture in mining industry?	5	1	72.2
9. Reward and punishment	9(i)	Top Management acknowledge and reward the workers based on the contribution and commitment towards OH&S management system, including the benefits of improved OH&S performance of the company.	4	0.75	

worker safety or satisfaction are effectively addressed. This concern was raised by one of the Delphi Experts that stated:

“Management should pay attention on the psychological aspects of workers such as worker’s health, safety attitude and their work satisfaction (R1)”.

Safety attitude, according to Hu et al. (2011) and Wang et al. (2018), is the psychological view of a safe culture, processes, and accident prevention. Experts agreed that safety attitude has a substantial impact on influencing a positive safety culture at work, based on the findings of Delphi I and II. Mine employees will have a negative psychological status as a result of their poor safety attitude. According to Jiang et al. (2020), poor physiological state and inadequate safety behaviours are examples of safety attitudes among 27 coal mining firms. One of the challenges in implementing a safety culture is the miners’ lack of knowledge about safety (Löow et al., 2019).

Job satisfaction is also a key psychological component in fostering a positive workplace safety culture. Mine personnel must be satisfied with their work and perform it with a high level of responsibility. Job satisfaction may be obtained by demonstrating the leadership of the supervisor or top management in equitably distributing responsibilities among the workers and matching each worker’s skills. It is difficult because small-scale mining operations prefer to minimize labour costs by hiring unskilled employees to undertake mining tasks.

Another major issue raised by the Delphi experts was the health of mine workers. They think that if workers are in good shape, they will be more focused at work and near-misses or workplace accidents will be prevented. Mine employees’ psychological well-being is strongly linked to their physical health. Workers that are unwell will have a detrimental impact on the company, such as interruptions in daily output.

Peer influence is another component that has an impact on the psychological aspect of safety culture. Rubin et al. (2020) stated that peer influence and commitment were critical in fostering a healthy safety culture. Miners that have a negative peer impact will have mining catastrophes. This conclusion was backed up by a study of 233 coal miners conducted over the course of ten months. Jiang et al. (2020) performed a study of 82 coal mine businesses and found that peer or colleague influence had a significant impact on the development of a safety culture among miners.

For situational dimension, 10 influencing factors were obtained namely; (1) Safety Policy, (2) Safety Audit, (3) Safety Rules, (4) Competent SHO, (5) Safety Education, (6) Safety Programme, (7) Safety Planning, (8) Medical Surveillance, (9) Safety Competency, and (10) Safety Signage. The key findings of the situational safety culture system in the Malaysian mining industry are illustrated in Fig. 6. The safety policy needs to be understood at the top management level, all of the mining professionals agreed. With the help of its mine workers, the mine owner or senior management can play a significant part in establishing a

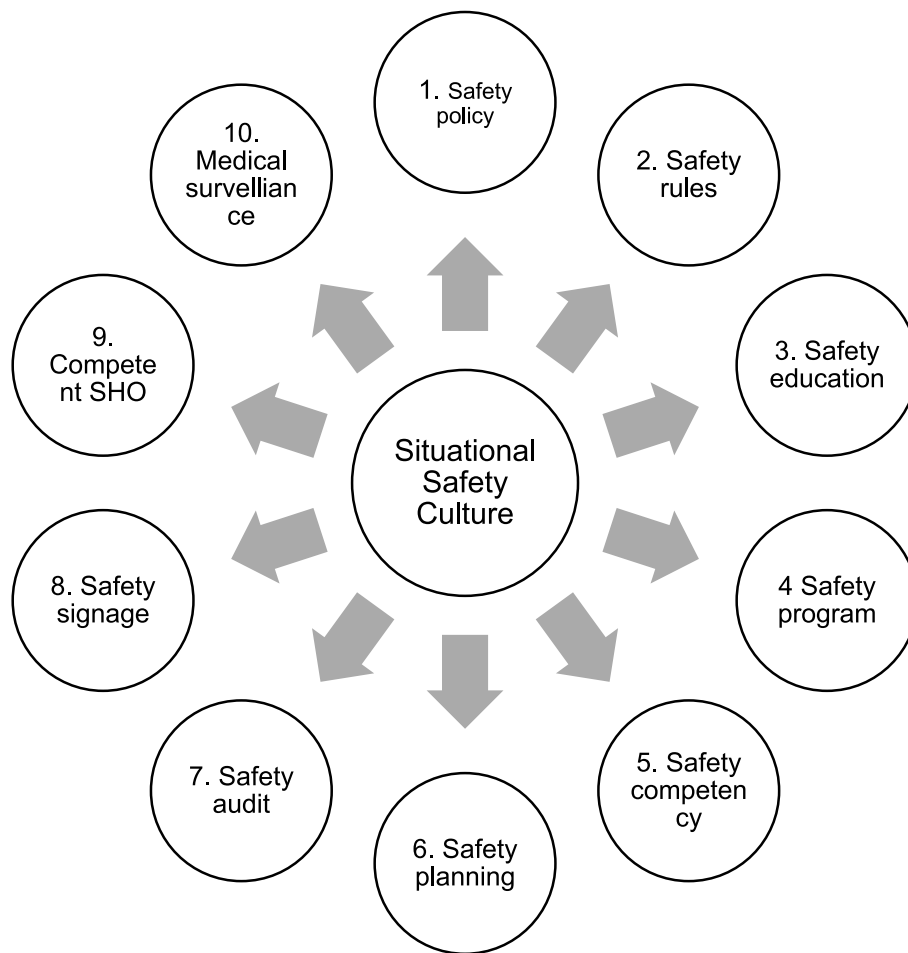


Fig. 6. Situational safety culture factors for the Malaysian mining industry based on Delphi I and Delphi II.

safety culture inside their firm. A robust safety policy, safety training, and a safety programme are all critical components of senior management's attempts to make safety culture their top priority. In order to inspire the workforce to take part in and support any actions planned by top management, management must also lead by example.

The HSE Manager (R2) emphasized one of the study's intriguing results, which was the current state of safety culture awareness and practises across Malaysian mining businesses. At 30% and up to 80%, respectively, the vast difference in safety culture awareness between small- and large-scale mine operations is very concerning. Small-scale mining operations prioritize speed of return over safety because they want to see a quick rate of return. The gap can be closed in this instance, though, provided the owner of the small-scale mine is willing to alter their perspective and realise that the safety issue is a component of their investment. For instance, in the event of an accident, their manufacturing will encounter issues.

In order to avoid injuries or near misses while working at the mine site, they needed a clear safety policy with strong safety planning, and at the very least, all the workers recognised the significance of following safety procedures when handling any apparatus. Additionally, the top management of both small- and large-scale mine operations is necessary to lay out clear occupational safety and health (OHS) and safety guidelines because doing so will encourage the miners to develop safer habits and more disciplined work practises. Because they have substantial financial resources and are able to supply and coordinate safety initiatives for their employees, large-scale mine operations have many benefits and can more easily foster a healthy safety culture in enterprises, as mandated by the government.

For the behaviour safety culture, nine major factors have a

significant influence to construct safety culture in the Malaysian mining industry as shown in Fig. 7. Management action is the key element to drive the implementation of safety culture in the mining industry. The management should be aware that safety is the kind of investment to ensure all the employees can work in a convenient working environment that prioritizes safety issues at all times. To make it successful, the top management of mining companies must provide good safety communication, such as safety notice board, email, memo, reporting system, safety briefing and many more. This is important to ensure all the safety issues or safety information can be disseminated effectively to all levels of employees and avoid miscommunication among them.

According to [Noraishah et al. \(2021\)](#), sixteen main causes of mining accidents came from; (1) Human Factor, (2) Unsafe Behaviour, (3) Unsafe Act, (3) Lack Of Safety Training, (5) Lack Of Safety Education, (6) Inexperience Worker, (7) Poor Leadership, (8) Organizational Deficiencies, (9) Mechanical Failure, (10) Geological Factor, (11) Poor Workplace Environment, (12) Poor Safety Culture, (13) Poor Safety Awareness, (14) Poor Safety Record, (15) Lack Of Rules And Regulations and (16) Poor Safety Management. The main causes of mining accidents can be reduced or prevented if the top management is aware on the importance to inculcate behaviour safety culture at the mining workplace. Therefore, it requires full cooperation from all levels of employees to make it successful.

Moreover, safety training is important to educate the employees on the importance of safety at the workplace and increase awareness among the employees. Enforcement on wearing complete Personal Protective Equipment (PPE) while handling machines or heavy-duty machines and transportation is also important to prevent from any near misses, incidents or even any mining accidents or disasters. The culture to wear

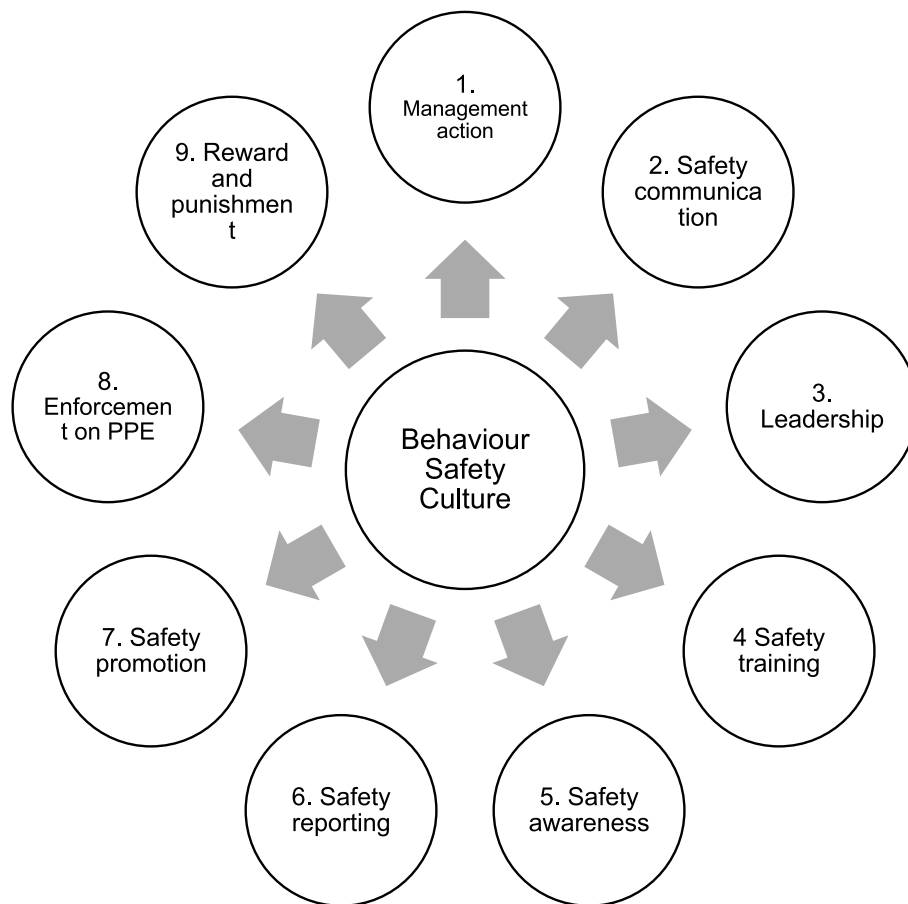


Fig. 7. Nine factors of behaviour safety culture in the Malaysian mining industry.

PPE must be emphasized, especially at mining sites.

5. Limitations, strengths and future direction

According to Cooper (2000), the safety culture itself is built by three main dimensions: psychological, situational, behavioural dimensions. Even though, the author's work was focused on the psychological, situational and behaviour dimension of safety culture, it can be further enhanced and investigated in depth in the future such as conducting questionnaire survey at various mining companies in Malaysia to ensure what is the best model for safety culture in the Malaysian mining industry. This study gave a good indicator on the readiness and awareness among mine owners or operators as well as to government enforcers on the importance of safety culture in the mining industry. These factors obtained from this study can be emphasized and implemented to all mining industries in Malaysia.

For future direction, it is very useful to strengthen the behaviour safety culture in the mining industry. All mining owners or operators must be aware that there are many benefits of introducing good behaviour safety culture among employees, such as increasing work productivities, preventing mining accidents as well as reducing operation loss. The employees must also be ready to accept and abide the rules provided by the mining management and ensure that safety is their top priority while handling heavy duty machines or transportation during mining operations and activities.

6. Conclusion

The Delphi I and Delphi II studies were successfully executed with participation of 21 and 18 experts, respectively. The study shows a clear

direction on the most influencing factors in the psychological dimension of safety culture in the Malaysian mining industry that consists of (1) Management care for workers, (2) Safety Attitude, (3) Job satisfaction, (4) Health of workers and (5) Peer influence. To conclude, this study had achieved a consensus among Delphi Experts. The median analysis and IQD cut-off ($(IQD \leq 1)$) were both at 83.3% and 64.81% (agree and strongly agree) for the total percentage distribution was achieved. For situational, safety culture, the consensus was achieved with median, IQD and total percentage distribution analysis with 94.4%, 61.1% and 73.15%, respectively. The factors of situational obtained; (1) Safety Policy, (2) Safety Training/Safety Education, (3) Safety Programme, (4) Safety Rules include Wearing PPE, (5) Safety Planning, (6) Safety Competency (7), Safety Audit, (8) Safety Signage, (9) Competent SHO/Leader, and (10) Workers' Health.

Moreover, nine factors of behavioural dimension of safety culture in Delphi I were obtained: (1) Management action and responsibility, (2) Safety communication, (3) Leadership, (4) Safety training, (5) Safety awareness, (6) Safety reporting, (7) Safety promotion, (8) Enforcement on wearing PPE, (9) Reward and punishment. For Delphi II, median, Interquartile deviation (IQD) and percentage distribution were used to analyse the responses. The consensus was achieved for median analysis, IQD analysis and total percentage distribution with 94.4%, 66.7% and 73.6%, respectively. This study will hopefully be a good indicator for the Malaysian mining industry to strengthen and improve the psychological and behaviour aspects of safety culture at their workplace. To conclude, this study shows a clear direction to prioritize safety culture in the working environment based on successful identified factors that influenced the formation of psychological and behaviour safety culture for the mining industry in Malaysia.

Credit author statement

Azizan: Conceptualization, Writing - Reviewing and Editing, Siti Noraishah: Methodology, Visualization, Writing - Reviewing and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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