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ORIGINAL ARTICLE

Investigation of the Factors Contributing to Unsafe Behaviour of Iron Ore Miners in Malaysia

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ABSTRACT – This study was aimed to investigate the influencing factors of unsafe behaviour of miners towards safety performance. A set of online questionnaires was distributed to the 50 mine workers from an iron ore mining company located in Kuantan, Pahang, Malaysia. The results were analysed using SPSS software and Pearson analysis. The results show six major factors that contributed to the unsafe behaviour of miners such as inadequate safety training; inadequate safety education, physical fatigue, lack of safety rules and regulations within the company, poor leadership behaviour and the miners' lack of experience contribute to unsafe behaviour of the miners. The factors were then related to the safety performance of the mining company to find the relationship between both variables by using Pearson correlation analysis. The findings of this study will help miners to reduce unsafe behaviour and how safety performance can affect the worker's behaviour by highligting the specific factors contribute to unsafe behaviour

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INTRODUCTION

Mining is the extraction of valuable mineral or geological material from the earth, usually metal ore, and coal. Mining is required to obtain the material that agricultural process cannot grow. The mining industry includes mineral extraction, processing, transportation, and marketing to remain cost-efficient and gain profit [1]. One of the biggest mining industries is coal mining with a whooping 3.5 billion tons excavated each year. The biggest mining nation in the world is China, followed by United States of America with 4.08 billion tons and 2.17 billion tons of mineral excavated each year, respectively [1]. Mining is one of the major industries in Malaysia. Malaysia produces different types of minerals from metallic, non-metallic, and energy minerals such as aggregate, bauxite, clay, coal, gold, limestone, and etcetera. Tin mining is one of the first mining operation in Malaysia, started in the 1820s in Perak and in 1824 in Selangor. Malaysia ranked world's top ten producers for refined tin, rare earth, and mined tin [2]. In 2003, the mining industry contributed to 7% of the Gross Domestic Product (GDP) of Malaysia [3].

Mining industry accidents fluctuated each year with the highest number of deaths of mining accidents coming from the processiong of coal mining and hard rock mining [4]. Usually, underground mining poses a higher risk to miners compared to surface mining. The most common mining accidents were due to coal dust explosion and blasting-related accidents such as fly rock, premature blasts, and misfires [5]. In addition, there are many causes of mining accidents as highlighted by previous scholars as shown in **Table 1** [6-16]. **Figure 1** showed the accident statistics of the mining industry in Malaysia between year 2017 to 2021. Based on the data given by Department of Occupational Safety and Health (DOSH) Malaysia [17]. Factors influencing miners' unsafe behaviour have been studied for over seven decades [18]. Previous research showed more than 94.09% of mining accidents were caused by human factors such as intentional violation, mismanagement, and defective equipment [19]. There are many reasons why unsafe behaviour is still uncontrollable. Some of the reasons are lack of anticipation of the miner's safety culture and avoiding the hassle of following safety procedures [20]. There is still lack of study investigate the influencing factors contribute to unsafe behaviour in the Malaysian mining industry. Therefore, the main objective of study was to investigate the influencing factors contribute to unsafe behaviour and its relationship towards safety performance.

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Table 1: Main causes of mining accidents

Author	Country	Type of Mine	Main Study Design	Main causes of mining accident															
				HE	UB	UA	LST	LSE	IW	LBS	OD	MF	GF	PWE	PSC	PSA	PSR	LRR	PSM
[6]	China	Coal	MM	✓	✓				✓									✓	
[7]	China	Coal	QL	✓	✓		✓		✓				✓					✓	
[8]	China	Coal	MM	✓						✓	✓			✓					
[9]	China	Coal	QN		✓		✓	✓					✓		✓				✓
[10]	China	Coal	QL	✓						✓					✓				✓
[11]	China	Coal	QN	✓							✓				✓				✓
[12]	China	Coal	QL		✓									✓	✓				✓
[13]	Australia	Coal	MM		✓				✓						✓	✓	✓		✓
[14]	China	Coal	MM	✓											✓				✓
[15]	China	Coal	QL	✓	✓					✓								✓	
[16]	Ghana	Gold	QN										✓	✓					✓

QL, qualitative; QN, quantitative; MM, mixed method; HE, human error; UB, unsafe behaviour; UA, unsafe act; LST, lack of safety training; LSE, lack of safety training; LSE, lack of safety education; IW, inexperience worker; LBS, leadership behavior of supervisor; OD, organizational deficiency; MF, mechanical failure; GF, geological factor; PWE, poor workplace environment; PSC, poor safety culture; PSA, poor safety awareness; PSR, poor safety record; LRR, lack of rules and regulation; PSM, poor safety management.

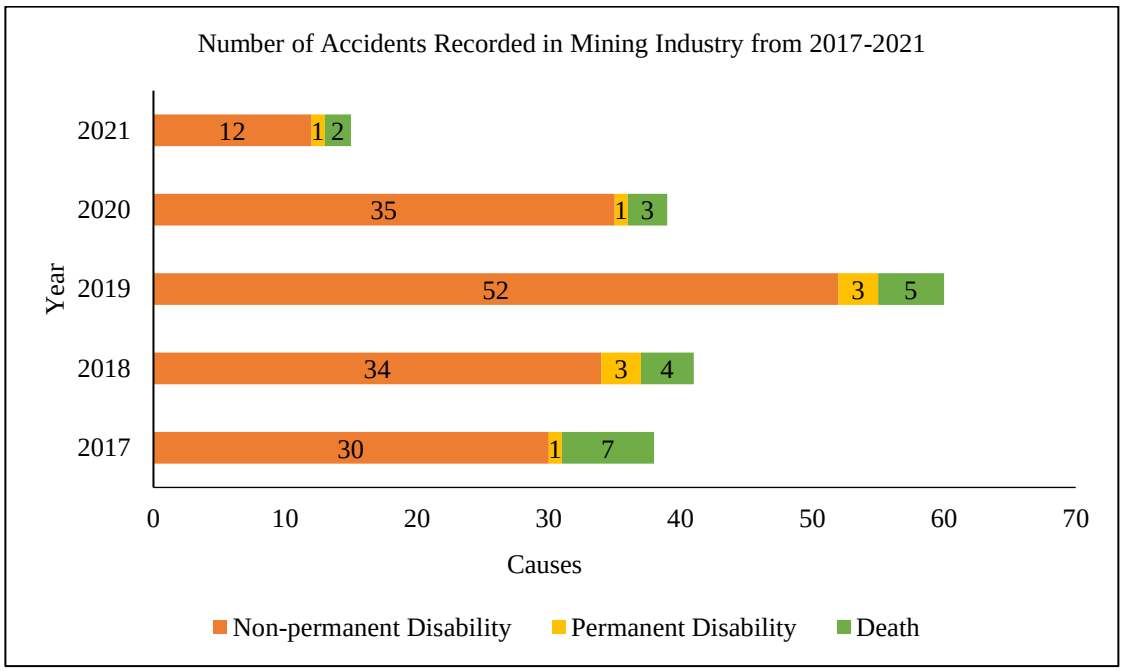

Figure 1. Number of Accidents Recorded in Mining Industry from 2017-2021 (Adapted from [17])

LITERATURE REVIEW

Unsafe behaviours of miners is one of the reason that responsible for mining accident or disasters [20]. Unsafe behaviours accounted for 97.67% of mining accidents according to statistical analysis of accident investigation [21]. Miners' unsafe behaviour is the biggest contributor to mining accidents. The unsafe behaviour management is very important and the key ensuring production safety [5]. To manage the unsafe behaviour of miners, the factor influencing miners' unsafe behaviour was determined. Previous scholars mentioned the influencing factors contribute to unsafe behaviour as in **Table 2. Table 2** are lacking of (1) safety training, (2) academic qualification, (3) fatigue, (4) rules and regulation, (5) leadership behaviour, and (6) miner's experience at the workplace.

Safety training refers to educational programmes that teach employees how to use preventative measures and procedures to reduce the danger of harm or death on the workplace. A well-run safety training program can help a company reduce employee turnover, boost productivity, and improve morale. According to [22], training is a proven and effective technique of intervention in building and maintaining effective hazard management operations. Academic qualification is the development of knowledge and skills for coping with situations that arise as a result of accidents, as well as for preventing accidents by removing dangers as soon as possible. Education can enhance miners' safety behaviour and safety awareness. This also helps miners complete their work by following a strict safety work procedure and achieve improvement on their safety level [6]. Fatigue usually happened to miners because of long working hours, poor working conditions, and heavy workload [21].

Long working hours, poor working conditions, and heavy workload may cause a fatigue among workers.Fatigue is a phrase that refers to a general feeling of exhaustion or a lack of energy. It's not the same as feeling sleepy or drowsy. Fatigue is known as one of the factor influencing unsafe behaviour among workes [23]. Investment in safety is the basis for ensuring the implementation of all relevant rules and regulations, the correct operation of equipment, and the improvement of safety protection facilities. Adequate safety investment will make the implementation of the safety system smoother, operation of equipment smoother [24]. The influence of leadership behaviours on employees in different situations also varies [25-26]. Leadership is often seen as one of the important factors in the success or failure of an organization. As the direct leaders of miners, the supervisors inspire the miners' enthusiasm in daily work by encouraging, caring and leading by example, and take the lead in complying with various safety rules and regulations of the iron mine and create a good safety atmosphere [27]. Work experience is time spent learning about a job role, an organization, or a career sector in the workplace. Based on [7], the more experience the miner, the likely they have unsafe behaviour, and new inexperienced miners tend to follow safety behaviour.

Table 2. Literature review focused on unsafe behaviour factors

Research Articles	Knowledge Gap Filled
[4]	This study stated that poor working environment, poor site safety management, work pressure, overtime, and work intensity are the major reasons for unsafe behaviour.
[5]	This research finds that unsafe behaviour contributed to most of the accident in mining industry.
[12]	Stated that external environmental factors and no management strategies are the main reason for miners' unsafe behaviour
[7]	Finding that the miners' age and risk-taking is the main reason for workers' unsafe behaviour.
[6]	Finding that the influencing miners' unsafe behaviour that training, attendance, experience, and age are main factors.
[9]	The education of miners' contributed to unsafe behaviour.
[8]	The factor influencing miners' unsafe behaviour are divided into 5 aspects including individual factors, physical environment, safety leadership, safety management, and group factors.
[10]	This study stated that poor training and poor safety management can cause unsafe behaviour of miners.
[11]	Stated that individual perception, environment support, and organizational management system is related to miners' unsafe behaviour.
[13]	Lack of leadership behaviour contributing to miners' unsafe behaviour directly or indirectly.
[14]	External environment, organizational influence, poor leadership, precondition of unsafe act contributes the most to miners' unsafe behaviour

METHODOLOGY

A set of online questionnaires was prepared using Google form and distributed to 50 mine workers consists of 17 office workers and 33 mining site workers from a mining company in Kuantan, Pahang, Malaysia as an online survey. The sample size was determined by Krejcie and Morgan 1970 sample size formular[28]. The sample of the research used a simple random sampling in which every miner has an equal chance of getting selected and the randomness of the sample was determined by drawing process to select sampling unit from the sampling frame. Simple random sampling was selected for this research because it does not consume much time and low cost [29]. The targeted respondents who answered the questionnaires are 30 respondents based on Krejcie and Morgan's sample size [29]. A 5-point Likert scale

was adopted, which involves scores ranging from 1 (completely disagree) to 5 (completely agree) and the data were analysed using SPSS software.

Construction of Questionnaire

The questionnaires consisted of three parts which were socio-demographics, factors influencing miners' unsafe behaviour, and safety performance of miners. The questionnaires were covered the following factors and sub-factors of unsafe behaviour as shown in **Table 3.** The first factor influencing miners' unsafe behaviour is safety training to the workers which has 5 sub-factors consists of lack of training, inadequate training, continuous training, training suitablity, and training are given by the certified trainer. The second factor is safety education which consists of 2 sub-factors such as lack of safety education and inadequate safety education. Fatigue or tiredness is one of the biggest factors contributing to unsafe behavior which consists of the working duration and heavy work frequency. Rules and regulations are to ensure the safety of miners at site, however, if the company lack of safety policy and safe work procedure, it will also contribute to unsafe behavior. Leadership behavior will contribute to unsafe behavior if there is a lack of supervision and work pressure from the leader. Miners' experience is divided into two categories: work experience that adds to safety performance and work experience that makes miners feel comfortable while working at the mine site. Based on results obtained from factors of unsafe behaviour data collection, a total of 6 main factors and 15 sub-factors were constructed into a questionnaire used to obtain data for analysis purposes.

Table 3. Factors and sub-factors of unsafe behaviour

Factors	Sub Factors	
Safety training (ST)	1.	Lack of training provided
	2.	Inadequate training
	3.	Continuous training
	4.	Training suitability
	5.	Certified safety training
Academic Qualification (AQ)	1.	Lack of safety education
	2.	Inadequate safety education
Fatigue (FA)	1.	Working duration
	2.	Heavy work frequency
Rules and regulations (RR)	1.	Safety policy
	2.	Safety work procedure
Leadership behaviour (LB)	1.	Leadership supervision
	2.	Leadership pressure
Miners' experience (ME)	1.	Experience contributes to safety performance
	2.	Experience make miner safer

RESULTS AND DISCUSSION

30 out of 50 respondents were completed and answered the online questionnaire survey. To ensure reliability of the variables measure, the reliability analysis was used. The feedbacks of respondents were analysed using SPSS Data Editor version 19 for reliability test and Pearson correlation analysis

Demographic analysis of respondents

The analysis of respondents' traits and criteria such as age, gender, years of experience, mode of work, and state of work. **Table 4** shows the demographic result for this research

Table 4. Demographic results of respondents based on SPSS analysis

Background of Respondents	Item	Frequency	Percent	Valid Percent
Age	21-30 years old	3	10.0	10.0
	31-40 years old	7	23.3	23.3
	41-50 years old	19	63.3	63.3

	More than 50 years old	1	3.3	3.3
Gender	Male	30	100.0	100.0
	Female	0	0.0	0.0
Years of experience	1- 5 years	12	40.0	40.0
	6-10 years	15	50.0	50.0
	11-15 years	3	10.0	10.0
Mode of work	Full-time	30	100.0	100.0
	Part-time	0	0.0	0.0
Scope of work	Site-based	30	100.0	100.0
	Office	0	0.0	0.0

Reliability Analysis of the Influency Variables

To ensure reliability of the variables measure, Cronbach's Alpha coefficients are computed as an internal consistency reliability test. Cronbach's alpha measures how well a set of items (or variables) measures a single unidimensional latent trait [30]. When data have a multidimensional structure, Cronbach's alpha will usually be low. Cronbach's alpha can be written as a function of the number of test items and the average inter-correlation among the items. The values for Cronbach's Alpha of the variables are shown in **Table 5.**

Table 5. Cronbach's Alpha Value for Unsafe Behaviours

Variables	No. of items	No. of items deleted	Cronbach's alpha value
Safety training (ST)	5	3	0.613
Academic Qualification (AQ)	2	-	0.772
Fatigue (FA)	2	-	0.626
Rules and regulations (RR)	2	-	0.647
Leadership behaviour (LB)	2	-	0.720
Miners' experience (ME)	2	-	0.890

The analysis showed that the Cronbach's Alpha value range from 0.626 to 0.890 with the lowest value is the fatigue and the highest is miners' experience which is the dependent variable for this research. The value of Cronbach's Alpha lower than 0.35 indicates low reliability while the value from 0.35 to 0.7 as acceptable and above 0.7 is considered as high reliability. Cronbach's alpha usually used the Likert test index and used it to verify the reliability in the current research. The reliability of the questionnaire data was tested by the SPSS statistic data editor. High Cronbach's Alpha value indicates that there is an inter-correlation among the items when the inter-correlation is high and there is evidence that the items are measuring the same underlying construct. Items measuring the same underlying construct are means 'good' or 'high' reliability which also referred to how well the items measure a single unidimensional latent construct. As for safety training, there are 3 items deleted to achieve a good Cronbach's Alpha value as shown in **Table 6.** The analysis showed that the value of Cronbach's Alpha is 0.751 which is considered as high reliability and acceptable. The original number of items was 8, of which 4 items were deleted to obtain a high Cronbach's Alpha value. The finalized questions consist of 15 questions. The question is constructed based on data gathered from a systematic literature review, a set of 6 main factors and 15 sub-factors obtained were shown in **Table 7**. Safety performance factors gathered through

the literature review are consists of 8 items which are safety culture, safety compliance, safety participant, safety record, safety awareness, safety management, safety audit, and number of accidents in the company.

Table 6. Cronbach's alpha value for safety performance

Variables	No. of items	No. of items deleted	Cronbach's alpha value
Safety Performance	8	4	0.751

Table 7. Questions Related to Six Main Variables of Unsafe Behaviour

Variables	No. of items	Question
Safety training (ST)	5	ST1: The company provides training for personnel on engagement in safety behaviour. S2: The company provides adequate training for personnel throughout the year. ST3: Company provides continuous training for personnel to maintain safety compliance. ST4: Company provides suitable training for personnel position of work. ST5: is given to personnel by certified training provider.
Academic Qualification (AQ)	2	AQ1: The company provides safety education for personnel on engagement in safety behaviour. AQ2: The company provides adequate safety education for personnel on engagement in safety behaviour
Fatigue (FA)	2	F1: The work duration of the workplace makes personnel fatigued. F2: The heavy workload of the workplace makes personnel fatigued.
Rules and regulations (RR)	2	RR1 Safety policy of company updated annually to improve safety. RR2: Safety work procedure is provided by company for each task.
Leadership behaviour (LB)	2	LB1: The leader helps supervise if personnel do not know how to do the work. LB2: The leader pressure personnel to achieve key performance indicator.
Miners' experience (ME)	2	ME1: Personnel work experience contributes to the safety attitude while doing the work. ME2: Personnel work experience makes personnel feel safer.

Percentage analysis of respondents' feedbacks

The feedbacks from 30 respondents were analyzed and shown in **Fig.2** and **Fig.3** respectively. Based on **Fig.2,** the responding on the question ST1 (the company provides training for personnel on engagement in safety behaviour) return the feedback of strongly agree (40%), agree (33.3%), neutral (20%) and disagree (6.75%).In contrast, the responding on the question for ST2 (the company provides adequate training for personnel throughout the year) return the feedback of strongly agree (16.67%), agree (13.33%), neutral (23.33%), disagree (40%) and strongly disagree (6.67%). Based on ST3, the feedback on the company provide continuous training for personnel to maintain safety compliance resulted strongly agree (43.33 %), neutral (6.67%), disagree (40%) and strongly disagree (6.67%). Based on ST4, the feedbacks on company provide suitable training for personnel position of work resulted strongly agree (30%) with the statement. For

ST5, the training is given to personnel by certified training provider resulted strongly agree (40%) and agree (36.67%) with the statement.

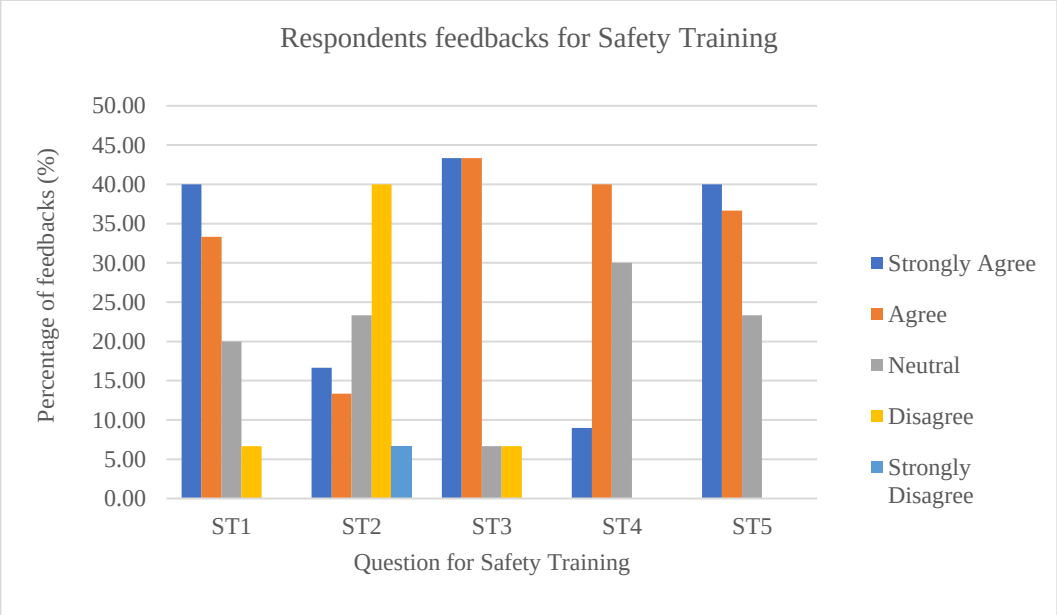

Figure 1. Respondents Feedbacks for Safety Training (ST1 to ST5)

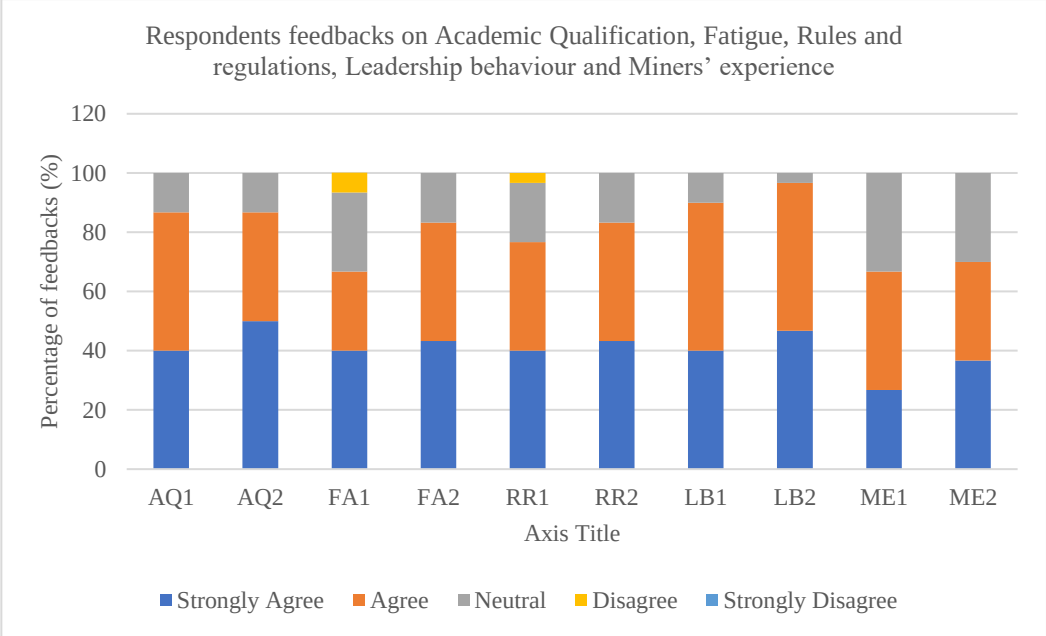

Figure 3. Respondents feedbacks on Academic Qualification, Fatigue, Rules and regulations, Leadership behaviour and Miners' experience

Based on **Fig.3** the responding question AQ1 (The company provides safety education for personnel on engagement in safety behaviour) returns the feedback of strongly agree (40%), agree (46.67%), and neutral (13.33%). For question AQ2 (The company provides adequate safety education for personnel on engagement in safety behaviour) the feedback comes with strongly agree (50%), agree (36.67%), and neutral (13.33%).

Based on FA1 (The work duration of the workplace makes personnel fatigued), the feedback resulted to strongly agree (40%), agree (26.67%), neutral (26.67%), and disagree (6.67%). Based on FA2 (The heavy workload of the workplace makes personnel fatigued) resulted in strongly agree (43.44%), agree (40%), and neutral (16.67%).

Based on RR1 (Safety policy of company updated annually to improve safety) resulted in strongly agree (40%), agree (36.67%), neutral (20%) and disagree (3.33%). Based on RR2 (Safety work procedure is provided by the company for each task) resulted in strongly agree (43.33%), agree (40%), and neutral (16.67%).

For LB1 (The leader helps supervise if personnel do not know how to do the work), the result of feedback with strongly agree (40%), agree (50%), and neutral (10%). Based on LB2 (The leader pressure personnel to achieve key performance indicator) resulted in strongly agree (46.67%), agree (50%), and neutral (3.33%).

Based on ME1 (Personnel work experience contributes to the safety attitude while doing the work), the feedback comes in with strongly agree (26.67%), agree (40%) and neutral (33.33%). Lastly, based on ME2 (Personnel work experience makes personnel feel safer) resulted strongly agree (36.67%), agree (33.33%), and neutral (30%)

Pearson Correlation analysis

Pearson correlation analysis is used to verify the relationship of the dependent variable, independent variable, and moderator variable. From Pearson correlation analysis, it can be determined either the variables have positive, negative, or no relation at all. The Pearson correlation value refers to the direction of the relationship and the largest value of Pearson correlation is 1 and the lowest is -1. If the value moves towards -1, the relationship will be negative and vice versa. **Table 8** showed the value of Pearson Correlation and the level of significance between variables and **Table 9** shows safety performance result. This research involves 6 independent variables and 1 dependent variable.

Based on Table 8, the safety training factor of unsafe behaviour is related to safety performance. The value of Pearson correlation for safety training factor is 0.884**. Since the value of Pearson correlation moves towards 1, the factor is positively related to safety performance with 1% significant level. This result shows that inadequate safety training impairs safety performance in a company. According to [22] study, training is a proven and effective technique of intervention in building and maintaining effective hazard management operations. A study [31] in Indonesia also proved that there was significant relationship between training with unsafe actions.

Another factors was the safety education factor of unsafe behaviour which was related to academic qualification. Academic qualifaction in this study means safety education for personnel on engagement in safety behaviour provided by the company. The value of Pearson correlation for safety education factor is 0.677**. Since the value of Pearson correlation moves towards 1, the factor is positively related to safety performance with 1% significant level. This result shows that inadequate safety education worsens safety performance in a company. Education can enhance miners' safety behaviour and safety awareness. This also helps miners complete their work by following a strict safety work procedure and achieve improvement on their safety level [6].

Table 8 Pearson correlation between factors of unsafe behaviour and safety performance

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
SP1	29.53	4.878	.357	.146
SP2	29.40	5.145	.332	.175
SP3	29.23	4.944	.398	.136
SP4	29.37	6.654	-.131	.416
SP5	29.63	4.378	.324	.132
SP6	29.47	5.085	.298	.185
SP7	29.40	8.179	-.497	.533
SP8	29.17	6.006	.033	.334

Table 9 Safety Performance result

Variables	Safety performance		
	Pearson Correlation	Sig. (2-tailed)	N
Safety training (ST)	.884**	.000	30
Academic Qualification (AQ)	.677**	.000	30
Fatigue (FA)	.589**	.001	30
Rules and regulations (RR)	.581**	.001	30
Leadership behaviour (LB)	.491**	.006	30

Miners' experience (ME)	.109	.568	30

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

In addition, the fatigue factor of unsafe behaviour is related to safety performance. The value of Pearson correlation for fatigue factor is 0.589**. The factor is positively related to safety performance with a 1% significant level. This result shows that if the worker has fatigue at the workplace, the safety performance will decrease. Employee fatigue is one of the main factors that affect the occurrence of work accident. The most dangerous effects of fatigue occur in very dangerous professions such as underground work, one of which is coal mining workers[32] . It is proven that fatigue is a factor influencing unsafe behaviour by simulating typical construction work [23].

The rules and regulations factor of unsafe behaviour is related to safety performance. The value of the Pearson correlation for the rules and regulations factor is 0.581**. The factor is positively related to safety performance with a 1% significant level. This result shows that inadequate safety rules and regulations such as safety policy and safe working procedures worsen safety performance in a company. Adequate safety investment will make the implementation of the safety system smoother, the operation of equipment more stable [24].

The leadership behaviour factor of unsafe behaviour is related to safety performance. The value of the Pearson correlation for this factor is 0.491**. The factor is positively related to safety performance with a 1% significant level. This result showed that poor leadership behaviour will decrease safety performance in a company. As the direct leaders of miners, the supervisors inspire the miners' enthusiasm in daily work by encouraging, caring, and leading by example, and taking the lead in complying with various safety rules and regulations of the mine and creating a good safety atmosphere as quote in [27] for the example in the coal mine. In contrast, the study showed the miner's experience factor was not related to safety performance. This is because the value of the Pearson correlation is insignificant. It shows that the experience of mining workers has low contribution to safety performance in the company. This was supported by[7]. He mentioned that the more experience the miner, the more likely they have unsafe behaviour, and new inexperienced miners tend to follow safety behaviour.

CONCLUSION

The research was successful to investigate the contributing factors of unsafe behavior toward safety performance. An iron ore mine company was selected as a case study for this research. The study showed six major factors that contributed to the unsafe behaviour of miners were (1) inadequate safety training; inadequate safety education, physical fatigue, lack of safety rules and regulations within the company, poor leadership behaviour (6) and the miners' experience contribute to unsafe behaviour of miners. This research suggests that to reduce the miners' unsafe behaviour, the organization must increase its safety performance. For future research, different approaches of techniques to reduce the number of accidents in the mining industry shall be considered.

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