Safety Culture and Production Cost at a Selected Colliery in South Africa

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Keywords

Attitude

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Abstract

Perilous features of underground mine activities have made the everyday monitoring and management of safety and emergent rescue responses very challenging and costly. Regrettably, for decades, the mining industry's safety performance is of great concern, with both the number of fatalities and injuries increasing year on year. The study assesses safety culture by establishing commitment and adherence and attitude towards safety controls to establish the relationship between safety culture and production cost. A quantitative study determined safety culture at a colliery in the Free State province, South Africa and its influence on production cost. There was no correlation found between safety culture and production cost. A positive influence of safety control measures on production cost was established, indicating that the implementation thereof reduces safety-related costs. This is the first study that assessed safety culture and its relationship with production cost in South Africa. This study may assist mining companies to determine the gaps relating to safety culture enabling them to take corrective steps, which may lead to the reduction of safety-related costs. The study will also contribute towards the sustainable development goal number 8, decent work and economic growth.

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1. Introduction

1.1 Background

For decades, mine safety has drawn attention due to numerous catastrophes around the world. These include explosions that saw mine workers dying at the Courreires Coal Mine disaster in 1906 in France that killed 1 100 miners, 440 mine workers in 1913 at Senghenydd Colliery in the United Kingdom (UK) (Ivor and Davies, 1914), while 687 workers died at Mitsubishi Hojyo Coal Mine in Japan in 1914. In China, a methane explosion killed 684 mine workers and 1 549 miners at Laobaidong Colliery in 1960 and Benxihu Colliery in 1942, respectively (Tuttle, 2014). In 1972 in Zimbabwe (then Rhodesia) 425 people died at Wankie Colliery (Braithwaite, 1985) while the Coalbrook Mine devastation in 1960 in South Africa killed 435 miners due to a fragmentation of 900 pillars that were used to support the tunnel roof (Department of Mineral Resources – DMR, 2018). Nowadays, monitoring aspects related to sustainability and safety in mining activities worldwide are a priority, to mitigate socio-environmental impacts, promote efficient use of water, reduce carbon footprint, use renewable energies, reduce mine waste and minimize the risks of accidents and fatalities (Cacciuttolo, Guzmán, Catriñir, Atencio, Komarizadehasl & Lozano-Galant, 2023). These transformative proactive safety initiatives have implications on production costs in the mining industry. Wang, Cheng, Lu, Liu, Zhang and Huang (2024) noted that in the long run, the investment in safety and health sensors proves to impact on mining production costs.

The above calamities occurred between 1906 and 1972 due to explosions, except the Coalbrook Mine disaster in 1960. It was discovered during the Coalbrook tragedy that pillar mining was dangerous. However, pillar mining is still practised in the country’s mines with inadequate safety measures, highlighted Frans Baleni, the former general secretary of the National Union of Mine workers in South Africa - NUM (2006). Death in the mines emerges large, life takes safety in a tiny tunnel during those eight hours (see figure 1) and those who do not make it back to the surface, their skeletons are lingering in the mines. This is consistent with Pogrund (2010) who declared that although mine workers’ bodies were found during the Coalbrook mine disaster, the industry did not have the appropriate equipment to extract the bodies, hence the bodies were never brought back to the surface.

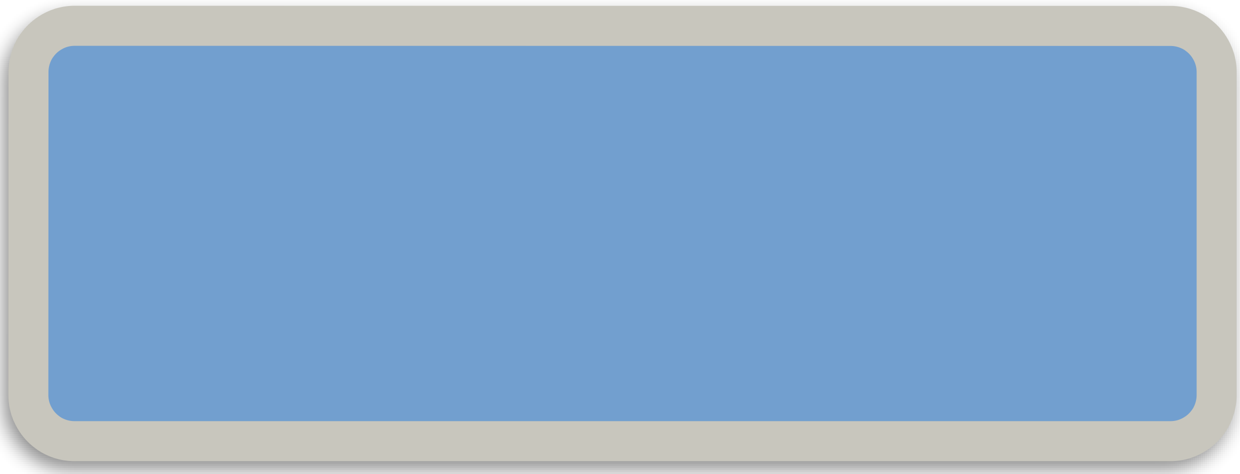


Figure 1: Mine tunnel with wooden pillars supporting the roof and entrance
Source: Image taken by the Author.

Mining remains a powerful force behind the economic growth of many countries around the world. In South Africa, the industry recorded 18.1% growth, contributing 1.2% to the overall 4.6% Gross Domestic Product (GDP) in the first quarter of 2021 (DMR, 2021). In China, the mining industry is an important growth engine for the country's economy. The sector had industrial sales value of 4620 billion yuan in 2016, occupying 4% of the total industrial sales value (Lin & Zhu, 2021). According to Guo and Yang (2023) in China, mining safety is an important factor, which ensures the sustainability and development of the mining industry. Hence, it is the responsibility of the mining industry in all countries to ensure the safety of mine workers to ensure economic growth, ethical and moral reasons as well as legal obligations binding employers. Safety is the protection from harm or danger (Noe, Hollenbeck, Gerhart, & Wright, 2006), which requires legislative frameworks regarding safety controls to be put in place by governments in different countries. Safety controls are the methods, procedures or standards used to ensure the safety of employees (Lu, Zhang, Tang, & Gong, 2015). However, if safety controls are overlooked and not applied, accidents will occur, resulting in injuries and fatalities.

A principal concern in the South African mining industry; the industry known to be production and profit-focussed; is the high fatality and injury rate Miners die every year due to accidents. If they do not die; they may suffer crippling injuries, leaving them in some cases with amputated limbs and incapable of earning an income. Between 2011 and 2022 as shown in Table 1 below, 974 miners died in South Africa while 31 133 were injured at work (DMR, 2014-2019; Minerals Council of South Africa 2019/2020; Minerals Council of South Africa, 2021/2022).

This fatality rate is in contrast with the United States of America (USA) and Australia, which are used as mine safety international benchmarks. These countries have experienced only 356 and 79 deaths during the same period, respectively. In South Africa, miners are three times more likely to be involved in fatal accidents than in these countries. Ural and Demikol (2008) declared that in 2000, in the USA, fatalities declined due to the strengthening of the safety legislations and enforcements while in Australia the fatality rate in the mining industry decreased by 65% from 12.4 worker fatalities per 100 000 employees in 2003, to 4.4 in 2015 (Safe Work Australia, 2015). In 2003, there were 12.4 fatalities per 100,000 workers; a decade later the figure was down to 3.4 (Sustainable Minerals Institute, 2024). It is evident that South Africa has a long way to go to ensure miners' safety (Kohler, 2010).

Table 1: South Africa compared to the USA and Australia

YEAR	SOUTH AFRICA		CHINA	USA	AUSTRALIA
	Injuries	*Fatalities*	*Fatalities*	*Fatalities*	*Fatalities*
2011	3 299	124	1 201	37	7
2012	3 377	112	779	36	2
2013	3 136	93	1 073	42	6
2014	2 186	84	931	30	11
2015	2 697	77	588	17	10
2016	3 036	79	528	25	6
2017	2 662	90	375	28	3
2018	2 447	81	333	28	3
2019	2 414	51	316	28	9
2020	1 680	60	225	27	5
2021	2 143	74	502	29	7
2022	2 056	49	245	29	10
TOTAL	**31 133**	**974**	**7 096**	**356**	**79**

Source: Mine Health and Safety Administration, 2023, Minerals Council South Africa – formerly Chamber of Mines, 2019/2020; 2021/2022, Liu, Li & Hassal, 2021, Department of Mineral Resources and Energy, 2022.

According to Table 1 above, when China is compared to its international counterparts in the mining industry namely South Africa, USA and Australia, the country reflects the highest fatalities totalling 7 096 between 2011 and 2022 with Australia holding the lowest record at 79 fatalities. China and Australia are considered the world's largest coal producers and exporters respectively. However, Australia is far ahead of China in terms of coal mine safety, which indicates that there remains a significant scope for improvement for China in relation to safety (Liu, Li and Hassall, 2021). Nonetheless, Chu, Jain, Muradian and Zhang (2016) declared that death and accident rates in China's coal industry have fallen consistently over the last two decades as revealed in the chart below (Figure 2). Thousands of miners died every year in the 2000s due to lack of regulations in the mining industry. The demand for coal decreased in the mid-2010s, and as a result hundreds of thousands of miners were laid off resulting in a decline in fatalities. Hence, China Labour Bulletin (2019) opined that the decline in fatalities can be attributed to mine closures and falling demand for coal than the introduction of new safety measures.

Figure 2: Decline in the number of fatalities in Chinese Mining Industry
Source: China Labour Bulletin, 2018.

Based on the aforesaid, Chinese coal mine safety is lacking compared with other countries followed by South Africa. This is an indication that China, just like South Africa, have a long way to go to ensure mine worker's safety. In 2003, world coal production was 5 billion tons and about 8 000 miners died worldwide, with China making up 80.4% of the total fatalities in coal mine accidents (Chu, Jain, Muradian, and Zhang, 2016). According to a 2011 report, in China, gas explosions were the most severe type of accident due to the number of fatalities per accident, and collapses were the most frequent type of accident statistics from 2001 to 2010. The Chinese government tried to improve safety in the mining industry by increasing financial investment and improving technology, government supervision, technical equipment, and miner training (Dai-yinga & Bai-sheng, 2011). Wang, Fu, Lyu, Wu, Jia, Yang & Li (2022) found that mine workers' overall education level has an obvious effect on enhancing coal mine safety. According to this study, long-term safety education and skills training, the number of unsafe actions caused by knowledge deficits and cognitive errors gradually fell.

1.2 Problem Statement

The study argues that the main cause of accidents, fatalities and crippling injuries is the poor safety culture within the South African mining industry. The absence of safety controls or failure to adhere to safety procedures that are in place result in the loss of quality of life for the mineworkers and the loss of economic potential and productivity in the country, owing to extended shutdowns of parts of the country's mining industry. Furthermore, mining companies may also incur far greater production costs such as safety monitoring and controls, property damage due to accidents, and other indirect costs which are not captured by the accounting system. Hence poor safety culture is expected to increase production cost at the Colliery.

1.2 Research objectives

The main objective of this study is to determine the safety culture at the mine and establish its influence on the production cost.

2. Literature review

Over the years, several studies have been conducted on safety culture. This includes Nieva and Sorra (2003) who assessed safety culture in the USA. This study indicated that safety culture is one of the pillars of safety and safety culture assessments provide tools that can be used to measure organisational conditions that lead to accidents. Safety culture assessments make visible shared understanding about 'the way we do things around here', which can be used to determine where efforts need to be focused on to improve safety within an organisation. The assessment of safety culture conducted by Lee and Harrison (2000) in the UK at the Nuclear Power Stations concluded that safety culture must be defined as safety related values, attitudes, beliefs, perceptions and the behaviour of all employees. Therefore, safety culture is the way safety is perceived, valued and prioritised in an organisation.

Zang, Fu, Hao, Fu, Nie, and Zang's study (2020) in China discovered that non-compliance with safety legislation, lower levels of safety commitment, failure to apply safety procedures and lack of training were the root causes of coal mine accidents and highlighted deficiencies in safety culture. This is consistent with the study by Amirah, Asma, Muda and Amin (2013) in Malaysia in the manufacturing industry, which highlighted that high accident rates were due to lack of a safety culture and non-compliance with the requirements of the Act. The authors argued that the right combination of rules, beliefs, attitudes and good practices lead to positive culture and reduction of accidents. This was confirmed by Stemn, Bofinger, Cliff and Hassall's study (2019) in Ghana, which found a negative correlation between accident rate and safety culture. Their study discovered that mines with higher accident rates had less of a safety culture, while mines with lower accident rates had more of a safety culture.

Chen, Qi, Long and Zhang (2012) conducted research on 10-year tendency of China coal mine accidents and the characteristics of human factors. Ismail, Ramli and Aziz (2021) conducted a systematic literature review whereby they applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses review method to identify 33 articles on safety culture in mining from twelve countries: Brazil, China, Ghana, India, Kenya, Mongolia, Russia, South Africa, Sweden, Taiwan, Turkey and USA. The authors are of the view that safety culture is a promising solution to reduce mining accidents. The objective of their study was to investigate the influencing factors of safety culture in the mining industry and the study concluded that safety culture is still lacking in these countries. Furthermore, Ismail and Ramli (2023) investigated the factors affecting safety culture in the Malaysian mining industry.

The Extensive research on safety has been conducted in South Africa as well. Leger's study focused on the perceptions of workers regarding the organisation of work and established the contribution of this to the high accident rates (Leger, 1986). Eisner and Leger (1988) examined accident experiences in South African mines and looked at the international safety rating system as applied in the South African mining industry. In 1991, Leger (1991) analysed the trends and causes of fatalities within the mining industry in South Africa. Other studies, such as that by Masia and Pienaar (2011), investigated safety compliance, while Moller (2003) determined the drivers that motivate safety and risky behaviour. Masia (2010) paid attention to the relationship of work stress and safety compliance while Eweje (2005) examined the behaviour and the ethical position of mining companies regarding hazardous employment and health and safety of employees. Muthelo, Mothiba, Malema, Mbombi and Mphekgwana (2022) explored the compliance of the mining industry with Occupational Health and Safety Standards in the Limpopo Province of South Africa. According to the knowledge of the author, the current study is the first one to assess safety culture in the South African mining industry and its relationship with production cost.

The current study was conducted at a selected colliery in the Free State province, South Africa. It is one of the collieries owned by a company with several large-scale open cast and underground thermal coal mines, with almost 20 000 employees accounting for 4.26% of the 469,353 employees within the South African mining industry (Minerals Council, 2022). It supplies coal to different power stations, provides export markets with high quality coal and contributed to the 306 million tons of coal production in 2019 when coal dominated the country's mining industry. The colliery is committed to the pursuit of zero harm and requires collaboration of all employees within the organisation. However, South Africa is still considered one of the many countries with a poor safety culture in the mining industry (Naidoo, 2010). Likewise, in China, insufficient skills of miners, the increasing mining depths of underground coal mines, geological conditions have become more complicated, rudimentary technology and equipment, inadequate safety investment, and poor safety management are all the factors that contribute to the frequency and catastrophic nature of China's fatal mine accidents. Furthermore, Liu, Li and Hassall's study 2021) suggests that the shortcomings from the new coal mine safety regulatory regime might be contributing to China's dreadful safety performance. With extraordinarily severe coal mine accidents (ESCMAs) that occurred between 1950 and 2018 causing 11 526 deaths, this is considered inherently a high-risk profession (Zang, Xu, Reiniers & You, 2020).

China and Australia have developed a sophisticated and complex legal regime to regulate their coal mine safety. The regulatory regimes share a multiple of attributes. Despite similarities between the separate regulatory regimes, China significantly lags Australia as regards to coal mine safety. It may not be completely valid to compare those two countries due to their differences in economic development, particularly the Gross National Income (GNI) per capita.

However, empirical evidence demonstrates that China is underperforming in some even poorer large coal producing countries which possess similarities in economic development with regards to safety performance (Liu, Li, & Hassall, 2021). Jiang, Liang and Han (2019) highlighted the relevant proof of safety culture in coal mine industry. The behaviour safety "2-4" model points out that safety culture directly affects the safety management system, the safety management system directly affects people's safety knowledge, safety awareness, safety habits, safety physiological and safety psychology, and safety culture indirectly affects safety knowledge, safety awareness and safety habits through the safety management system. However, the correlation between the safety culture, safety management system, safety knowledge, safety awareness and safety habits that caused the accident has not been studied.

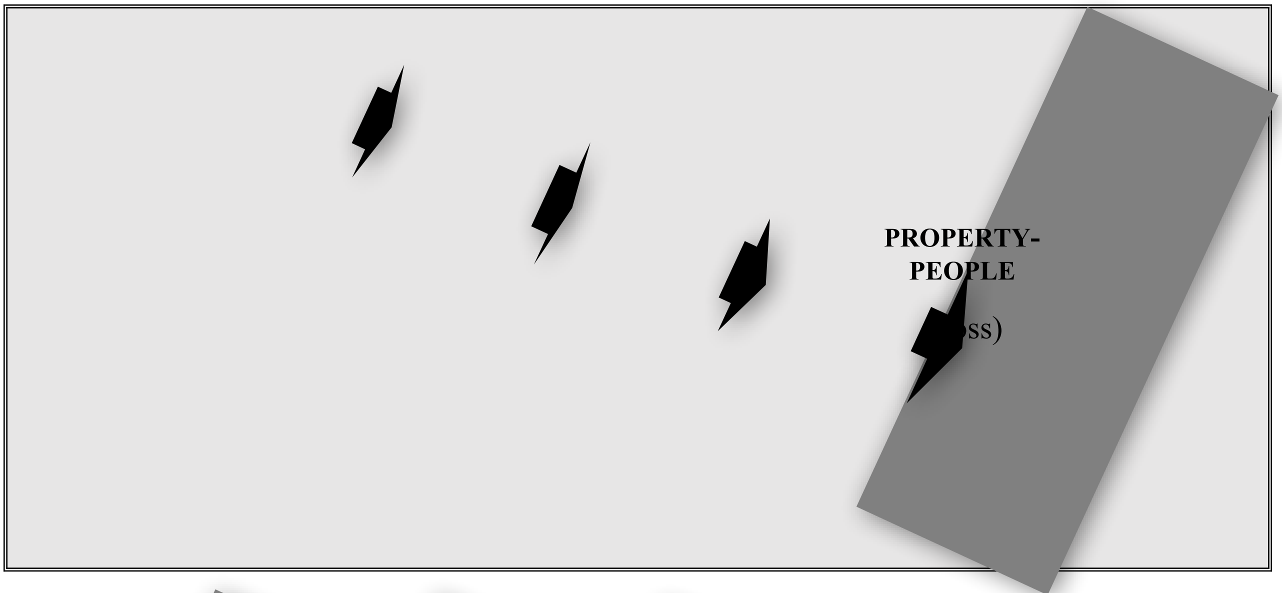
Landis (1962) believes that the poor safety culture in South Africa can be attributed to the fact that, for decades, the country had institutionalised racism and made use of foreign labour. This enabled the government to control the labour force and gave the mining companies dominance over labour; hence, miners could not force the mining corporations to improve the health and safety of black mine workers who constituted 90% of the labour force (Coupe, 1996). Additionally, the high number of miners had low level of functional literacy in English and inadequate education and could not do anything to ensure their safety. Black workers were at the bottom of the organisational pyramid while white workers occupied high positions (Coupe, 1996). Hence, Eweje (2005:174) concluded that:

> "[…] (1) black workers had no legal recourse to higher officials to challenge the decisions of the white miners about safety in the workplace; (2) management policy was perceived as work first, report later and (3) refusal to work on account of perceived hazards was met by a disciplinary action".

Ever since the end of the apartheid era, mining companies have started training black miners to reduce distrust and the *Mine Health and Safety Act No. 29 of 1996* gave mine workers 'a say' regarding safety (RSA, 1996). The Minister of Mineral Resources Mr Gwede Mantashe (2019) opined that miners are still dying due to inadequate safety and a poor safety culture as most fatalities and injuries in 2019 were attributed to repeat accidents. In March 2021, NUM reported its concerns about the fall of ground and locomotive accidents which claimed two lives and one badly injured miner, which management wanted to keep as a secret. Laurence's study (2005) found that a large percentage of employees believe that rules should be broken to get the job done. Therefore, compliance in this study refers to the core activities that are carried out by management in accordance with the legislation to provide, ensure and maintain a safe working environment. Perceptions are beliefs or opinions often held by many people and based on how things seem (Griffin and Neal, 2000). Attitudes are feelings or opinions about something or someone or a way of behaving (Guldenmund, 2000).

The hazardous nature of mining exposes employees to injuries or death, especially if there are no safety controls in place. This negatively effects the financial performance of mining companies, as costs are incurred (Fernandez-Muniz, Montes-Peon & Vezquez-Ordas, 2009). These costs increase the production cost, resulting in a decrease in profitability (Ural & Demirkol, 2008). Cloete and Marimuthu (2019) define cost as a resource sacrificed to realise a specific objective. They noted that the production cost consists of three elements: direct material, direct labour and production overheads. Direct labour was defined as the cost incurred to convert raw materials into finished goods while direct material is the main ingredient of the product. Production overheads are costs incurred during production, but cannot be directly attributed to finished products, for example repairs.

Tang, Lee and Wong (1997) confirmed that the total cost of accidents depends on the application of safety controls. Good application results in lower costs while poor application results in higher costs. However, Muth, Karns, Wohlegenant and Anderson (2002) argued that safety legislation increases the production cost and has resulted in more businesses closing as the enactment resulted in increased unit cost due to lower quantities produced in small businesses compared to large businesses. This is because the cost can be allocated over many products. Hence controls are perceived to increase costs and negatively affect competitiveness (Heasman and Henson, 1997). However, Martinez, Fearne, Caswell and Henson (2007) opined that the future of organisations rests upon minimising hazards. Gupta, Hendershot and Mannan (2003) confirmed that organisations that started implementing safety controls are already realising the rewards in terms of profit as costs incurred in controlling hazards decreased considerably if not totally wiped out as the concepts of safer approaches were applied. This is consistent with Heinrich's Domino Theory (Figure 3).



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This theor… Loftus in 1974. The the… s, lack of control, person… , leading to fatalities or … ents can be avoided by re… ore evident that to ensure … nt and enforcement of the appl… fety … reveals that safety culture is determined by compliance, …itudes and …ptions … ult, safety culture determines safety performance of an organisation. The higher the safety culture, the lower the accident rates and therefore safety-related costs. The current study was thus based on the framework outlined in Figure 4 below.

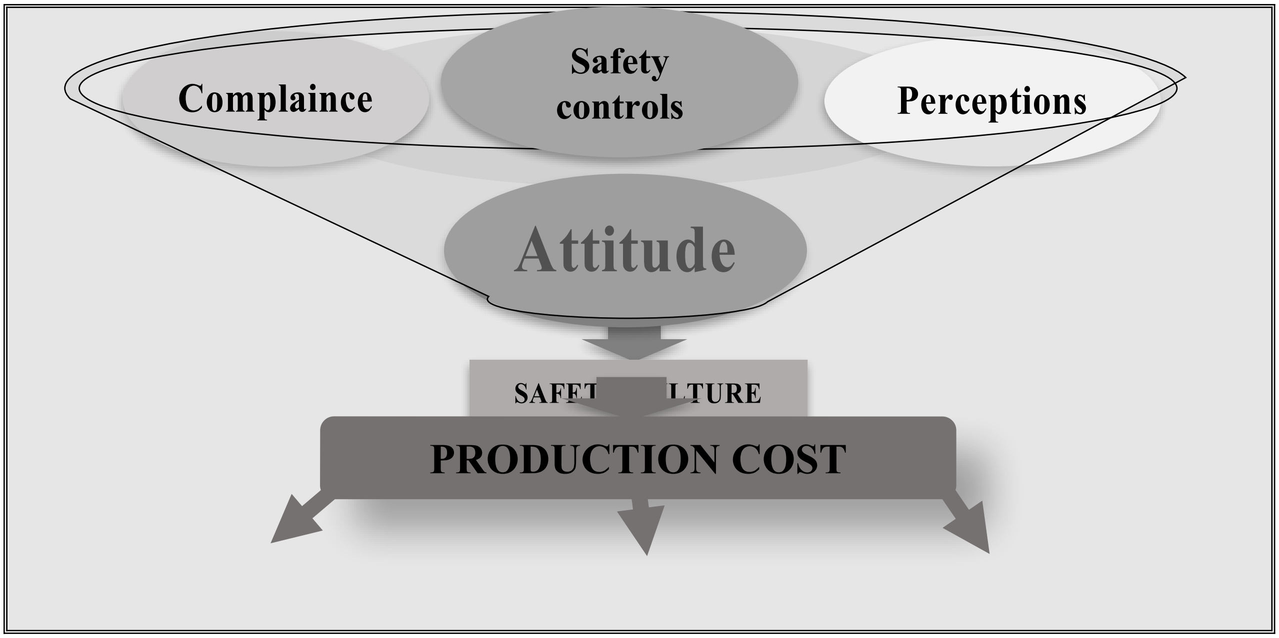

Figure 4: Conceptual framework below
Source: Authors' illustration

The aim of this study, therefore, is to assess safety culture at the colliery by determining the perceptions of employees regarding management's safety commitment and compliance with safety legislation and establishing employees' adherence and attitude towards the safety controls. Furthermore, the study intends to investigate the relationship between safety culture and production cost at the colliery. The study is guided by the following research question:

What is the relationship between safety culture and production cost at a selected South African Colliery?

To answer the above research question, the main objective of this study is to determine the safety culture at the mine and establish its influence on the production cost.

To achieve the above objective, the following empirical objectives are formulated:

(i) Determine whether management conforms to safety legislative requirements.

(ii) Assess whether the employees abide by the rules and apply the safety control procedures.

(iii) Investigate employees' perceptions and attitude towards the application of safety control procedures.

(iv) Analyse safety control mechanisms and production cost at the mine.

Based on the aforementioned, this study argues that the main cause of accidents, fatalities and crippling injuries in South Africa is poor safety culture. The absence of safety controls or failure to adhere to safety procedures put in place result in the loss of economic potential and productivity, owing to extended shutdowns of parts of the country's mining industry. Furthermore, mining companies may also incur far greater costs, such as property damage due to accidents and other indirect costs that are not captured by the accounting system. Hence poor safety culture is expected to increase the production cost at the selected colliery in the Free State Province, South Africa.

3. Research Methodology

The study made use of a quantitative approach as numerical data were collected. This signifies evaluating objective data, to summarise, describe and to identify relationships and differences between and within groups (Wegner, 2012). A five-point likert scale structured questionnaire was used to examine employees' perceptions on the compliance of the colliery with safety legislation, employees' compliance and application of safety controls, employees' perceptions and attitude towards safety controls, and to analyse production cost and safety control mechanisms at the colliery and thereby establish the organisational safety culture. It was also used to establish the relationship between safety culture and production cost. Moreover, this approach was used to eliminate the possible subjectivity that is present in a qualitative paradigm. A quantitative approach is less costly as less time is spent to complete a questionnaire compared to interviews and there is less potential for bias. However, a questionnaire is prone to low response rate, provides less detail as it does not offer much insight into thoughts and behaviours and pre-set answers mask people's feelings. Nonetheless, it allows larger samples, as Lee and Harrison (2000) suggested that assessment of safety culture must involve all employees within the organisation. However, due to the constraints of time and resources, a census was not feasible.

Section A comprised questions on the demographic profile of the respondents. Section B encompassed questions relating to the compliance of the colliery with the safety legislation.

Section C solicited information on the employees' compliance regarding the application of safety control measures. Section D consisted of questions on employees' perceptions and attitudes towards safety controls while Section E included questions on safety controls and production costs at the Mine. Sections B, C and D contained modified questions adapted from the *Safety Climate Questionnaire* by Zohar in 1980 (SCQ) (Glendon and Litherland 2001) and used by Laurence (2005) to seek the opinions of mine workers on safety rules and regulations. Cox and Cheyne (2000) and Mason, Lawton, Travers, Rycraft, Acroyd, and Collier (1995) used the same questionnaire to assess safety culture in offshore environments (2000). The *Safety Attitude Questionnaire* (SAQ) by Donald and Canter (1993) was also used in the study. The rest of the questions under Section A and E were developed by the researcher.

Content and construct validity of the questionnaire were established by experts in the fields of Accounting and Safety to ensure that all aspects that make up the concept were covered. Individual questions under the four sections were measured to determine consistency as shown in Table 2 using Cronbach's alpha coefficient (Goddard and Melville, 2009).

Table 2: Reliability of the questionnaire

Sections of the questionnaire	**Cronbach's alpha**
Section B	0.87
Section C	0.80
Section D	0.77
Section E	0.86

The instrument used was reliable as the scale achieved the scores ranging between 0.77 (77 %) and 0.87 (87%) as all the sections scored above the benchmark level of 0.70 (Zikmund and Babin 2007). The questionnaire was pre-tested and piloted with 50 respondents to identify limitations and errors before the questionnaire was applied on a larger scale (Andres, 2012).

The study was conducted at one colliery in Free State province and is therefore a single case study design. Case studies enable intensive study of a unit and could give insight into the phenomena. However, data collected cannot be generalised and case studies are prone to researcher bias. The target population for this study was restricted to 1 023 employees including top management according to the database provided by the Human Resources department at the colliery. Manoharan (2010) concurred that the sample should be large as large samples can reflect the characteristics of the whole population. However, the larger the sample, the more it costs to analyse the data and to administer the survey. Hence, cost and the constraint of time were a major consideration for determining the ultimate sample size. Flin, Mearns, O'Connor and Bryden (2000), after reviewing 18 published reports on safety culture, were of the view that the sample size should be greater than 100. Based on the aforesaid, the study used a total of 205 employees, which was equal to 20% of the employees at the colliery. The sample used was far more than 100 to allow for non-response and to ensure the accuracy of data analysis. Furthermore, larger samples are more likely to be more representative of the target population (Daniel, 2012). A total of 151 usable questionnaires were received, which constituted the sample size resulting in the response rate of 73.7%.

Stratified sampling, a probability sampling technique, was used in selecting the sample. Probability sampling has less potential for bias as it ensures that all the elements of the population have the opportunity of being selected to participate in the study while in non-probability sampling the selection of the sample depends on the personal judgement of the researcher (Churchill, Brown, & Suter, 2010). Stratified sampling ensures that each group within the target population is represented. However, it is tedious and time consuming when creating large samples. The target population was divided into strata based on the employees' relationship with risk. This is because the employees in the Human Resources Department have a different relationship with risk compared to the employees in the mining department, and plant and engineering department. Therefore, these employees could not be in the same sample batch as the others because the work experiences are not the same and the exposure to hazards is different. The departments were thus grouped into Administration, Mining and Plant as well as Engineering and Technical services.

The appropriate number was randomly selected from each stratum to ensure that the sample reflects each group in different proportions. That is, the larger samples were drawn from larger strata and smaller samples from smaller strata (Table 3). This is referred to as proportionate stratification (Andres, 2012).

Table 3: Number of employees in different departments and proportional sample sizes

Department	Number of employees	Sample size

Engineering and Technical Services	254	254 * 20% = 51
Mining and Plant	686	686 * 20% = 137
Administration	83	83 * 20% = 17
Total	1023	205

The objectives of the study were achieved using descriptive statistics, regression and correlation analyses. Descriptive statistics were utilized to determine the compliance of the colliery with the legislation, revealed employee commitment and application of safety controls, highlighted the perceptions and attitudes of employees towards safety controls and thereby expose the safety culture at the colliery. To achieve the fifth objective, correlation and regression analyses were employed.

The study was carried out with high ethical standards. Permission was obtained from the mine to conduct the research. The respondents were notified of the right to abstain, and each respondent gave their consent to participation. The right of participants to privacy was respected and all participants were respected as individuals. Therefore, the identity of all participants remained anonymous. The data collected as well as the mine records which were used in this study were treated as highly confidential.

3.1 Ethics

The study was conducted with high ethical considerations; hence the approval was obtained from the Free State mining company concerned. Participants were also informed that their responses would be kept confidential and that no names would be used in the data analysis.

4. Results and discussion

4.1. Descriptive analysis

The first column in Table 4 labelled Section indicates the sections of the questionnaire. The second column depicts the number of participants and the third to the fifth column show the mean scores for each section, standard deviation, skewness and kurtosis respectively. Mean scores shown below are fractions; therefore, the Mean scores of 4+ indicate ‘strongly agree’;

scores between 4 and 3 indicate ‘agree’; scores between 3 and 2 indicate ‘disagree’ while less than 2 indicate ‘strongly disagree’.

Table 4: Measures of central location, dispersion, shape and ‘peakedness’

Section	N	Mean	Std Deviation	Skewness	Kurtosis
B	151	4.17	0.53	-0.58	0.81
C	151	2.67	0.69	0.58	0.44
D	151	2.56	0.69	0.89	0.35
E	151	3.41	0.54	0.36	-0.49

Section B ranked the highest with the mean score of ($\overline{x}$ = 4.17; σ = 0.53), indicating that the majority of employees strongly agreed that the colliery is compliant with the relevant safety legislations. The standard deviation is within the acceptable range of ±2 from the mean, showing that the results are near the mean (Manoharan, 2010). Under Section C ($\overline{x}$ = 2.67; σ = 0.69). The results indicate the employees’ disagreement with the negative statements about employees’ compliance with and application of safety controls. Employees further disagreed with negative statements under Section D ($\overline{x}$ = 2.56; σ = 0.69) and therefore showed a positive attitude towards safety controls, while in Section E employees were in agreement that safety controls reduce costs. However, there are safety related costs that are still incurred by the Colliery ($\overline{x}$ = 3.41; σ = 0.54).

Column five shows skewness, which measures the degree of departure from the symmetry within the data while kurtosis in column six measures the degree of peakedness of the distribution. The values of skewness and kurtosis should be zero when the data is normally distributed. Wegner (2012) concurs that the rule of thumb for skewness states that a coefficient below -1 or above +1 indicates excessive skewness due to extreme outliers within the data. Skewness results range from -0.58 to + 0.89 which are within -1 and +1. This shows moderate skewness and it can therefore be inferred that the data tend to be approximately evenly spread about the mean score. The outcomes of kurtosis in column six range between -0.49 and + 0.81, which are also within the range of -1 and +1 and as a result establish a moderate concentration of data around the mean (Van der vaart, Linde, & Cokeranet, 2013).

4.2. Regression analysis

A regression model was built with production cost as a dependent variable and employee perceptions and attitude towards safety controls, employee compliance regarding the application of safety control measures, adherence or compliance of the Colliery to safety legislation and safety control measures as independent variables to establish whether these are good predictors of production cost. The model summary in Table 5 indicates that 40% of variance in the production cost can be explained by variables.

Table 5: Model summary showing the contribution of variables on the production cost

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.646	0.418	0.399	0.50921	0.418	22.619	4	126	0.000**

**. Significant at the 0.05 level.

ANOVA found the model to be significant and the variables to be good predictors of production cost model (Table 6), with F (1,126) = 22.619, P<.001, R^2 = 0.399.

Table 6: ANOVA highlighting the significance of the contribution

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.460	4	5.865	22.619	0.000**
	Residual	32.671	126	0.259		
	Total	56.131	130			

**. Significant at the 0.05 level

Table 7: Regression analysis of all independent variables with production cost

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.355	0.567		2.390	0.018
	Adherence or compliance	0.002	0.099	0.002	0.024	0.981
	Employees' compliance	0.005	0.070	0.006	0.077	0.939
	Employees' perceptions and attitude	-0.127	0.078	-0.126	-1.629	0.106
	Safety control measures	0.749	0.080	0.660	9.376	0.000**

**. Significant at the 0.05 level

There is no correlation between production cost and all the variables listed in Table 7 above. A significant positive relationship was found between production cost and safety control measures (P=0.000; β = +0.660). This suggests that safety control measures predict production cost at the Colliery. This is consistent with Ural and Demikol (2008) who declared that in 2000, the USA saw a decline in fatalities due to the strengthening of the safety legislations and enforcements.

4.3. Correlation analysis

Table 8: Correlations between variables

		Adherence	Employees' compliance	Employee perceptions' and attitude	Safety control measures	Production cost
Adherence	Correlation Coefficient	1.000				
	Sig. (2-tailed)	0.000				
	N	147				
Employees' compliance	Correlation Coefficient	-0.342**	1.000			
	Sig. (2-tailed)	0.000**	.			
	N	146	151			
Employees' perceptions and attitude	Correlation Coefficient	-0.416**	0.453**	1.000		
	Sig. (2-tailed)	0.000**	0.000**	.		
	N	140	143	144		
Safety control measures	Correlation Coefficient	0.044	-0.047	0.166	1.000	
	Sig. (2-tailed)	0.611	0.584	0.053	.	
	N	138	140	136	141	
Production cost	Correlation Coefficient	0.073	-0.089	0.029	0.652**	1.000
	Sig. (2-tailed)	0.385	0.285	0.734	0.000**	.
	N	142	145	139	139	146

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

There is no correlation exposed between constructs listed in Table 8 above except a moderate negative correlation found when adherence to safety legislation was compared with employee compliance and application of safety controls and employee perceptions and attitude towards safety control measures, with rs (146) = -0.342, $p<0.001$ and rs (140) =-0.416, $p<0.001$ respectively. A moderate positive correlation was established between employee perceptions and attitudes towards safety controls and employee compliance with and application of safety controls, with rs (143) =0.453, $p<0.001$ while a strong positive relationship was established between safety control measures and production cost, with rs (139) =0.652, $p<0.001$.

The results indicated that the Colliery adheres to the relevant legislation, made sure that employees understand the importance and the need for safety control measures and enforces the application of these measures. Hence the display of a positive attitude and perceptions of employees towards safety controls at the Colliery. The results therefore reflect a positive safety culture at the Colliery. This contradicts the conclusion by the Minister of Mineral Resources, Gwede Mantashe that poor safety culture in the South African mining industry is the main cause of mine fatalities and injuries. There are mining companies that are doing their best to ensure the safety of their employees. Other mines refused the author permission for that reason, it was not possible to establish whether the mine under study is an outlier or not. It is therefore recommended that not all mining companies should be painted with the same brush. Thorough investigations should be conducted, especially at the mines with fatalities and injuries to determine their safety culture with Northam Platinum Mine in Limpopo province as a starting point to find out the reasons why management wanted to keep the two fatalities as a secret as highlighted in the introduction section (NUM, 2021). However, there are still gaps with regard to safety control measures (Section C, $\overline{x} = 2.67$), as well as perceptions and attitudes of employees towards the application of safety controls (Section D = 2.56), which was revealed by lower means in these sections which indicate that there are employees who still deviate from safety rules, believe they have found better ways of doing their jobs and that rules are only for inexperienced workers.

Employees also complained that there were too many rules and that they did not understand which rules to apply and felt some of these rules were impossible to apply. Hence employees concluded that it is necessary to break the rules to get the job done. This is consistent with the regression analysis results, which show a negative correlation when adherence and compliance to safety legislation was compared to employee compliance and perceptions and attitude towards safety controls. This was also confirmed by a positive correlation between employee compliance and the application of safety controls and employee perceptions and attitudes, indicating that perceptions and attitude influence compliance. This could pose a challenge as the employees may choose not to apply safety controls or apply incorrect safety procedures, which may result in accidents as reflected in Heinrich's Domino Theory in 1931 (Sabet, et al., 2013).

It is therefore suggested that illustrations should be given during safety training to ensure that the employees understand what is expected of them. The colliery should make the rules flexible, up to date, let them be simple, brief, understandable, practical and authentic. The production of more rules and procedures to cover all the aspects of the mine should be avoided as these will not be read or comprehended but the provision of fewer rules of high quality is recommended to avoid confusion. This could result in brief and effective mining rules and procedures for the Colliery. It is also important that the rules are readily available to all employees. Furthermore, the importance of safety measures should be emphasised.

A positive correlation between safety controls and production cost was established. Section E contained statements indicating that safety controls reduce safety related costs. A positive correlation thus indicates that the application of safety controls reduces production cost, which was also confirmed by the mean score of 3.41 under Section E. This is consistent with the findings of Gupta, et al. (2003), who confirmed that organisations that started implementing safety controls were already realising the rewards in terms of profit as costs incurred in controlling hazards decreased considerably if not totally wiped out. However, in the current study, safety culture was found not to have any influence on the production cost.

5. Summary and conclusion

From the findings of this study, it can be concluded that there is a positive safety culture at the colliery as the mine and its employees are complaint with the safety regulations. Nonetheless, safety culture was not found to have influence on the production cost. There are aspects of safety culture components, however that must be addressed like, employee compliance and application of safety controls as well as perceptions and attitude towards safety controls as some employees are still deviating from safety rules, those who believe they have found better ways of doing their jobs and that safety is not their role. Only one component of safety culture; safety control measures were found to have an influence on the production cost. The South African mining industry (similarly to China) which is considered to be production and profit-orientated, should consider safety control measures from a different perspective. Companies are convinced that implementation of safety controls is burdensome and costly; however, the current study revealed that safety control measures reduce production cost. Therefore, for mining companies to be sustainable, investment in safety controls is crucial to reduce safety-related costs and thereby increase profitability in the long run. This consideration was also emphasised by studies in the Chinese mining industry.

It is recognised that the findings of this study have limited generalisability to the broader South African mining industry as it was conducted at one colliery. However, it provides avenues for future research. The results of the study indicate a positive culture which contradicts the Minister Gwede Mantashe. Perhaps the colliery under study is an outlier, hence the study can be replicated and conducted at other mines to establish safety culture at other mines, to identify gaps in safety measures and enable generalisation of findings. Because of very complex and hazardous environment of underground mines which continue to contribute significantly to occupational fatalities and injuries, most mine operators are deploying the wireless sensor network (WSN) technology to improve safety and health monitoring. However, the application of WSN in the industry is not fully understood and current research themes in this area are fragmented. A further study could be conducted to review the existing trends and applications of WSNs technology to evaluate costs towards the underground mining industry.

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