

**PSYCHOLOGICAL ABILITY AND THE RISK OF HUMAN ERROR IN
THE MINING INDUSTRY**

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MAGISTER ARTIUM

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COMMENTS

The reader is reminded of the following:

- The references as well as the editorial style as prescribed by the *Publication Manual* (6th edition) of the American Psychological Association (APA) were followed in this mini-dissertation.
- The mini-dissertation is submitted in the form of one research article.

DECLARATION

I, DOLLY EUNICE MOHLAMME, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously, in its entirety or in part, submitted it at any other university for a degree.

Signature:

A handwritten signature in black ink, appearing to read 'D. Mohlamme', followed by a period.

Date:

23 April 2014

TABLE OF CONTENTS

COMMENTS	i
DECLARATION.....	ii
TABLE OF CONTENTS	iii
ACKNOWLEDGEMENTS	v
SUMMARY	vi
CHAPTER 1 INTRODUCTION.....	1
1.1 Problem Statement.....	1
1.2 Expected Contribution of the Study	10
1.2.1 Contribution to the Organisation	10
1.2.2 Contribution to the Individual	11
1.2.3 Contribution to the Literature	11
1.3 RESEARCH OBJECTIVES.....	11
1.3.1 General Objectives	11
1.3.2 Specific Objectives	11
1.4 RESEARCH DESIGN.....	12
1.4.1 Research Approach.....	12
1.4.2 Research Method	12
1.4.2.1 Literature Review	12
1.4.2.2 Sample	13
1.4.2.3 Measuring Instrument.....	14
1.4.2.4 Research Procedure	14
1.4.2.5 Statitiscal Analysis	15
1.5 ETHICAL CONSIDERATIONS	22
1.6 CHAPTER DIVISION	16
1.7 CHAPTER SUMMARY	16
1.8 REFERENCES	17
CHAPTER 2 RESEARCH ARTICLE.....	23

CHAPTER 3 CONCLUSION, LIMITATIONS AND RECOMMENDATIONS	62
3.1 CONCLUSION	62
3.2. LIMITATIONS	64
3.3 RECOMMENDATIONS	65
3.3.1 Recommendation for the Industrial Psychological Centre of the Organisation	65
3.3.2 Recommendation for the Safety Department	65
3.3.3 Recommendation for Super-users of the Risk Profile (HR Community)	66
3.3.4 Recommendation for Future Research	66
4. REFERENCES	67

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SUMMARY

Title: Psychological ability and the risk of human error in the mining industry.

Key terms: Safety, accident-proneness, psychological assessments, operators, risk

The mining sector contributes immensely to the South African economy, and even though the industry was subjected to political issues in 2012 and 2013, it still remains one of the industries that contribute to the employment rate.

The industry is characterised by harsh realities, one being the fatalities of mine workers. Safety proves to be particularly concerning and challenging to the mining industry as the cost of human life is irreplaceable. Mines and other heavy operating machinery companies have employed all forms of safety measures, from safety specialists to the purchasing of heavy vehicles that require minimal manual operation, all in an attempt to reduce the number of incidents. However, the problem still persists, and thus the current study seeks to explore the concept of accident-proneness and its relation to accidents through the use of a psychological assessment tool known as the Dependability and Safety Instrument (DSI).

Companies have over the years turned to psychological assessments in an attempt to recruit the right candidates; in the case of most mining industries it is done in an effort to recruit the operator or miner who will work most safely. Instruments have been developed around certain personality questionnaires in an attempt to do that, the DSI being a result thereof. Much of the research on accident-proneness explores biographical variables, such as age and gender and its relation to accident-proneness to see if such variables do in anyway influence how accident-prone an employee is. The current study will also explore the same variables in relation to the DSI administered on the three sample groups.

The biggest assets for all mining companies are humans. Humans operate within a certain culture, a culture which is often crafted by the leaders in the organisation. Many safety initiatives fail as employees may feel that managers are imposing certain values and beliefs onto them; thus, specifically the culture and safety culture of an organisation

are important in ensuring that employees have a good understanding of what terms like “Zero Harm Culture” means in organisation, but most importantly, the role they play towards establishing such a culture.

A cross-sectional survey design was used in this study. A quantitative approach was followed by selecting a convenience sample (N=193) in a mine in the Northern Cape. Data were collected through standardised questionnaires. The measuring instrument that was used was the Dependability and Safety Instrument from SHL.

A significant correlation was observed between the DSI score and the Safety Incident group of participants with four or more years of experience; and not for participants with 0-3 years of experience. To conclude, this study suggested that employees who were more experienced or had more years of experience were likely to be involved in accidents as they might be more likely to take short-cuts and violate safety rules.

Recommendations were made to be applied in practice, as well as for future research.

CHAPTER 1

1. INTRODUCTION AND PROBLEM STATEMENT

Since the inception of South Africa's mining industry more than a century ago, the industry has established itself as the world's leading supplier of high quality mineral products and has played an authoritative role in directing the movement of the South African economy (Chamber of Mines, 2002). The quarterly employment statistics report (2012) indicates that the mining industry has had an annual increase of 1000 employees (+0.2%) in December 2012, as compared to the September 2011 period. This is particularly significant given the state of the industry regarding wild-cat strikes and even threats of cutting up to 6000 jobs in one of Anglo-America's operations in the North West Province. The report indicates that gross earnings paid to employees in the mining industry reflected an annual decrease of R875 million (-3.5%) for the quarter ending December 2012, compared to the quarter ending December 2011. However, this was still much higher than the quarter ending in September 2012 when there was an increase of R211 million (+0.9%) for the quarter ending December 2012 (Statistics S.A, 2012). In 2008, mining contributed 9.9% to the gross domestic product (GDP) and the sector provided 521 000 employment opportunities to a large number of South African employees in the fourth quarter of 2008, the sector contributing largely to the South African economy (Statistics S.A., 2011).

A major concern for every industrial business in the world is the prevention of accidents. Employee accidents threaten the integrity of the business as a result of personal injuries, lost production time, costly lawsuits, disability payments and damage to equipment (Hansen, 1988). According to Barling, Kelloway, and Iverson (2003), workplace accidents result in a perceived lack of influence on the part of the employee and a distrust of management. Both these factors predicted job dissatisfaction which, in turn, is negatively related to exit (turnover intention) and voice (perceptions of union instrumentality). This can be attributed to research findings on the influence of leadership or management on safety. Just as there is a relationship between leadership and organisational outcomes relating to productivity and profits, it can also be said that

“good safety is good business”, implying that productivity and safety could largely be influenced by similar leadership behaviour, yet this remains unproven (Bass, 1990; Yule, 2002).

Mining industries are no exception to the above mentioned as these organisations operate with a finite resource, often in remote locations; they require specialised skills with high capital intensity. This is an industry that is highly subject to political, social and environmental global issues (Hills, 2008). The industry is among the most technologically advanced of all heavy industries, yet relies highly on both employees and contractors. Needless to say, the industry faces a diverse range of challenges, including an aging population, lack of a diverse workforce, poor industry image and changing skills requirements (Ednies, 2004). The mining employees themselves experience harsh working conditions, especially considering that the most obvious aspects of mining are that it involves various job demands. These demands are unique and not commonly found in other industries. Mining employees are required to spend an excessive amount of hours working with heavy duty machines and with explosives for blasting purposes, in intense underground temperatures and with insufficient resources. Thus, employees in the mining industry have to face various demands and often unpleasant working conditions (Calitz, 2004).

Currently the mining industry is facing immense pressure from employees with outbreaks of unprotected strikes countrywide. These strikes attest to the notion that employees in the industry feel underpaid whilst working under such excruciating and unpleasant conditions. A recent incident at one of Anglo- American’s platinum mines with regard to poor wages, led to the killing of 34 mine workers on 16 August 2012. The low pay of mine workers is, according to the African Bank, a result of the inability of the mine workers to understand the implication of garnishee orders, resulting in money lenders and collector attorneys exploiting the employees to such an extent that some employees take home as little as R500, or at the most R1500 per month (Marikana Massacre Reports, 2012). The impact of garnishee orders and a taking home of less than 20% income will be explored in Chapter 2, as this was identified as one of the probable or most likely contributors to accident-proneness.

Many organisations, such as the organisation under study, work according to core business values that are central to their business and their operating model, one of these being safety. They thus strive to embed safety in all their processes, even going to the extent of building a safety culture that encourages employees to live safely at work and also in their private capacity.

Safety culture has been found to be important across a wide variety of organisations and industries and has been associated with employees' safety-related behaviour in industries such as manufacturing (Cooper & Phillips 2004; Griffin & Neal, 2000), shipping (Hetherington, Robbins, Herman, & Flin, 2006), and chemical processing (Hofmann & Stetzer, 1996). According to Clarke (1999), accidents in the organisation occur because of the existence of more than one safety culture; this thus brings forth the issue of defining safety climate and safety culture.

Various definitions of safety culture exist. According to Hofstede (1991), culture refers to a set of values learned which may take the form as interpreted in the organisation as rules and norms of behaviour. Safety culture is defined by Wiegmann, Zhang, Von Thaden, Sharma, and Mitchell (2002) as the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organisation. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organisational) behaviour based on lessons learned from mistakes and be rewarded in a manner consistent with these values (Wiegmann et al., 2002). Safety climate can be regarded as a subset of organisational climate. Organisational climate is very often a subjective perception of how employees view the organisation, influenced by various factors, is not consistent and may vary from time to time given the changes that occur in the organisation. Thus, safety climate is a sub-set of organisational climate implying that it is a subjective perception and evaluation of safety issues related to the organisation, its members, structures and processes, based on the experience of the organisational environment and social relationships in the organisation (Flin, Mearns, O'Connor, & Bryden, 2000).

Safety climate is normally considered to be a predictor of work safety behaviour, meaning that if employees in the organisation somehow perceive the aspect of safety as not being positive, this is likely to manifest in their behaviour towards safety (Coyle, Sleeman, & Adams, 1995). Flin et al. (2000, p.178) referred to safety climate as a “snapshot of the state of safety, providing an indication of the underlying safety culture of a work group, plant or organization”. Glendon and Litherland (2001, p.160) refer to safety climate as “generally taken to comprise a summary of employee perceptions of a range of safety issues”. According to Cox and Flin (1998), safety climate reflects one’s attitudes, perception and beliefs regarding safety.

Nevertheless, mining organisations seek to attain both a safety climate and culture irrespective of which comes first. Many companies have dealt with this problem of safety by creating strong safety departments which have much influence in determining how the work should be carried out. McKenna (1983) and Reason (2000) acknowledged that 90% of all accidents could be attributed to human error. Research done by Stringfellow (2010) indicated that human and organisational factors are an important cause of accidents. In his study he stated that as the design of electro-mechanical equipment by safety engineers becomes more and more safe, the causes of accidents are more likely to be attributed to human and organisational factors; thus, the human error factor will become more prominent. The greatest concern of safety departments is to organise and design work so that accident probability is brought to a minimum; safety departments also largely emphasise the importance of training personnel in proper procedures and safety regulations (Denton, 1982). Why then do accidents still exist when organisations invest so much in safety initiatives? It thus brings forth the necessity of exploring the causes of accidents such as accident-proneness.

Kirschenbaum, Oigenblick, and Goldberg (2000) classified accident-proneness as a behavioural model, thus implying that accident-proneness is related to behaviour. The theory of accident-proneness implies that even if individuals are exposed to the same conditions, some individuals are more likely to have accidents than others, or that people differ fundamentally in their innate propensity for accidents (Shaw & Sichel, 1971). Visser, Pijl, Stolk, Neeleman, and Rosmalen (2007) regarded accident-proneness

as the tendency of an individual to experience more accidents than otherwise bio-identical individuals (in terms of basic personal characteristics such as age, gender and place of residence), due to stable personality characteristics. The concept of accident-proneness had already been explored by Greenwood and Woods (1919) and Newbold (1926) among factory hand workers, and upon their completion of the research they reached the conclusion that certain individuals had some sort of personality trait which rendered them more liable to have an accident. This trait (accident-proneness) seemed to be independent of the environment and constant for the individual from year to year. According to Hansen (1991), as well as Lawton and Parker (1998), it is widely acknowledged that the majority of workplace incidents are as a result of some form of human error and that some individuals are simply more likely than others to be involved in incidents, irrespective of how 'safe' the environment is; hence, accident-proneness is independent of the environment (Greenwood & Wood, 1919).

Even after the extensive research done by Greenwood on accident-proneness, the concept as a trait had been discredited (Knipling, 2004). Researchers have discovered that certain personal traits are related to the occurrence of accidents, but rather than use the term accident-proneness, some researchers prefer to use the term that reflects the empirical evidence known as differential crash risk; to the extent that this differential risk is enduring, reflecting constitutional or other long term personal traits (Knipling, 2004).

As a result, research shows that the safety metrics of companies that focus solely on the safety environment tends to plateau over time (Donald & Young, 1996; Neal, Griffin, & Hart, 2000). Once this plateau has been reached, continuing to focus on the environment is a classic example of the Law of Diminishing Marginal Returns, where increasingly large investments are needed yet with very minimal improvement in safety (Donald & Young, 1996; Neal, Griffin, & Hart, 2000). Naturally organisations tend to move towards the epidemiological model which focuses on multiple factors that result in accidents. The epidemiological model describes the three broad specific features of an accident in detail, namely the victim, the object which caused the injury, and the surrounding environment and how they are correlated to various accident types. These

three broad factors are also known as the host, agent and the environment (Goetsch, 2003). However, for organisations a safety initiative plateau is reached as they usually focus solely on the surrounding environment and not the holistic factors comprising the model. In exploring the features of the victim's biological and socio-economic factors such as age, gender and years of experience, these factors could influence accident-proneness. Hence, for the purpose of this study it is necessary to explore these factors and their impact on accident-proneness.

Rockwell's (1967) risk simulator serves as a good indicator of the effect of age on risk taking and, in turn, accident-proneness. The instrument indicated that younger workers take more risks than older workers and that males take more risks than females. Schuhfried (1996) discovered that as age increases, performance on the psychomotor test decreases. Research conducted by Martinussen (1996); Schmidt and Hunter (1998); Schmidt, Hunter, Outerbridge, and Golf (1988); and Shinar (1978), indicated that years of operating experience may potentially influence performance. It is thus deemed necessary in this study to explore the effect of age and years of experience on accident-proneness. Also, according to Reason, Manstead, Stradling, Campbell & Baxter (1990) violations may be the result of habits established after years of driving. De Winter and Dodou's (2010) research on the driver behaviour questionnaire as a predictor of accidents acknowledged the influence and impact that age, gender and experience might have. Their findings indicated that individuals' violation habits decreased with age or are minimised as individuals grow older, and that older individuals were more prone to errors than violations, perhaps because of reduced psychomotor ability gradually declining with age. Males, however, reported more violations and fewer errors than females. The relationship between work experience and errors was less consistent (De Winter & Dodou, 2010).

From the above research and findings it is thus necessary to include age, gender and experience as factors which may potentially influence accident-proneness. These factors will be assessed and included in the study to determine what their relation to the DSI is in relation to the three sample groups that will be used. The sample will be made up of employees who have been involved in some or other safety incident and this will be

referred to as the safety incidents group, then the employees who are classified as potential risk based on a risk data known as the risk profile which made up of various factors, this will be known as the high risk factors group and lastly the control group, which will be made up of employees who are neither on the safety incidents group nor the high risk group.

The distinction between errors and violations has been found cross-culturally by researchers such as Lajunen, Parker, and Summala (2004) as well as Özkan, Lajunen, Chliaoutakis, Parker, and Summala (2006). Previous research found it crucial to distinguish between errors and violations as contributing factors to accidents. According to Reason (1990), errors are statistically distinct from violations; errors reflect performance limits of drivers such as those related to perceptual, attention and information processing abilities. The proposed research focuses on a psychometric instrument that focuses mainly on violations. Violations represent the style in which the driver chooses to drive and the habits formed after years of driving. The DSI would then render service as a general screening tool that assesses candidates risk propensity.

A paradigm shift is therefore deemed necessary in enabling mining industries to shift from only focusing on creating conducive and safe environments, to focusing on selecting the right, “safe” working individuals. According to Hansen (1988), such individuals can be screened through the personnel selection approach. This approach or strategy seeks to identify those worker characteristics that differentiate between the employees involved in accidents and those that are not involved. The approach acknowledges that there are individual differences in knowledge, skills, abilities and other characteristics that workers bring to the job (Cartwright & Cooper 2008). Psychological assessments attempt to screen out the “good” candidates from the “bad” or the accident-prone individuals. In the last two decades, human resources departments have resorted to psychometric testing as there has been a significant increase in the use of psychometric testing for employee selection and development. This is supported by well-known research that has established a consistent relationship between personality and job suitability. Examples of such research are from Barrack and Mount, (1991);

Barrick, Mount, and Judge, (2001); Hogan and Holland, (2003); and Hertz and Donovan, (2000).

Psychometric assessments can accurately assess an individual's safety awareness on a range of factors that has been linked to safety behaviour and outcomes in the workplace. Together, these factors can provide a comprehensive understanding of individuals' overall safety risk. Psychometric tests are commonly employed as aids in occupational decisions. From the assembly line operator or filing clerk to top management, there is scarcely a type of job for which some kind of psychometric test has not proven helpful in such matters as hiring, job assignment, transfer, promotion, or termination (Anastasi & Urbina, 1997; 2007).

The cost of selecting the wrong candidates for positions in the South African work environment is evident, typically as can be seen in the provincial and municipal sectors where service delivery is poor, as officials are not able to cope with work pressure (Moerdyk, 2009). Selecting the wrong employee or an accident-prone employee in the mining industry might not only result in lost production time, but worse still fatalities that may compromise the integrity of the business. Tests are seen as an aid in the selection process and if used according to the prescribed standards and procedures, they supply invaluable information which is not easily gleaned in interviews (Kemp, 1999). According to Anastasi and Urbina (1997); Hunter and Hunter (1984); and Schmidt and Hunter (1981;1998), accurate predictions of applicants' performance on the job and subsequent selection of the most able candidates should translate into increases in productivity; which is directly opposed to losses experienced by companies as mentioned earlier by Hansen (1998).

According to Clark (2000), just as education and skills are important, an individual's personality trait might be his or her strongest suit for a job, irrespective of his or her qualifications; hence it is important to make use of psychometric tests. The purpose of this study is to explore, or examine, the effectiveness of the DSI in identifying accident prone employees amongst a group of mining operators.

Examining the concept of accident-proneness in South African mining industries is essential, as fatal accidents in the North West mining region of South Africa have increased significantly since 1999. During 2002, the North West region experienced the worst year ever in terms of fatalities, which is a direct indicator of safety performance. The fatality rate which is deaths per 1 000 employees, increased significantly from 0.61 in 2001 to 0.86 in 2002. In 2003 it decreased to 0.63, thus showing an inconsistent pattern in terms of the safety performance. The platinum industry which is predominantly located in the North West Province has been expanding drastically in the past few years. Due to its expansion, it is subsequently facing the risks associated with increased mining deaths (Jansen & Brent, 2005). An article titled “Mining Safety in South Africa” stated that in 2003 the South African mining sectors agreed to reduce fatalities by 20% as part of the annual safety targets. This was done in an effort to reach the levels of comparability of companies in Canada, Australia and even the USA. The death toll in 2003 from mining accidents was 270.

www.miningsafety.co.za/dynamiccontent/61/mining-safety-in-South-Africa).

The year 2012 saw the lowest registration number of fatalities. According to the report from the Mine Health and Safety, 112 miners died compared with the 123 from 2011, the number of fall-of-ground accidents also dropped to 26 from 40 in 2011. From the 112, 51 of the fatalities were from the gold mines, 28 from the platinum mines and 11 from the coal mines (www.bdlive.co.za/business/mining/2013/09/27/safety-improving-at-south-africans-mines).

The efforts from the sector might have yielded positive results as the total fatality figure for legal mine workers amounted to 221 in 2007. Even though the total fatality figure in 2008 amounted to 168 workers, a safety audit revealed that the safety compliance in South African mines was below target at 66%; in 2009 the total fatality figure was 169 workers. Figures released by the Department of Mineral Resources indicated that a total of 128 people died in South African mines in 2010; thus; 2010 was regarded as the best safety year by the CEO of the Chamber of Mines, Bheki Sibiyi. These figures were representative of 80% of all mining companies in South Africa. The

reduction of 24% has been the biggest year-on-year decrease since the 2004 agreement (www.miningsafety.co.za/dynamiccontent/61/mining-safety-in-South-Africa).

In 2011 the total numbers of 123 mine workers were reported dead as compared to 128 in 2010, this translates to about 3% improvement on the actual numbers on the actual numbers of mine workers that dies year on year

(<https://www.google.co.uk/search?hl=enGB&source=hp&q=department+of+mineral+resources+report+of+fatalities+in+2011+and+2012+in+mining+sector&gbv=2&oq=department+of+mineral+resources+report>)

The following research questions can be drawn from the above:

- Is the DSI able to identify accident-prone individuals?
- Is there a relationship between the DSI and the safety incident and high risk factors group?
- Do biographical variables (age, gender and years of experience in being an operator) have a relationship with the DSI score, the safety incidents, and the risk factors sample group?
- Does the DSI have the ability to differentiate between the risk factors, safety incidents and control groups?

1.2 EXPECTED CONTRIBUTION OF THE STUDY

1.2.1 Contribution to the Organisation

Since safety in mines is a major concern, the study will assist in determining whether the current measures employed for the selection of operators have predictive capacity towards identifying accident-prone employees. Thus, this could assist the mine in developing more reliable measures for identifying risk candidates and will assist in managing their safety initiatives from an individual perspective rather than only from a generalised company or environmental perspective. The organisations will have reduced overall costs, especially pertaining to accidents and lost time injuries.

1.2.2 Expected Contribution to the Individual

Individuals can be placed in more suitable or low risk occupations based on their accident-proneness. Individuals with high accident-proneness will thus be involved in fewer accidents and the work place can be safer as organisational

1.2.3 Expected Contribution to Literature

The current study will add to literature in the research of accidents, accident-proneness and safety in the mining industry by introducing literature less commonly explored and researched assessments such as the DSI, which will pave the way for further research topics in this particular field. Since the earlier days of research, the concept of accident was ridiculed. This research provides the opportunity to explore the concept of accident-proneness from a different angle and perspective through the use of different and reliable tests that will eventually enable literature to acknowledge accident-proneness as a real and solid existing concept.

1.3. RESEARCH OBJECTIVE

The research objectives are divided into a general objective and specific objectives:

1.3.1 General Objective

The general objective of the study is to determine whether the DSI is able to determine accident-proneness.

1.3.2 Specific Objectives

The specific objectives of this study are to:

- Establish if the DSI is able to identify accident-prone individuals.
- Establish if there is a relationship between the DSI score and the safety incident and risk profile group.
- Determine if biographical variables (age, gender and years of experience in being an operator) have a relationship with the DSI score, the safety incidents, and the risk factors sample group.

- Determine if the DSI has the ability to differentiate between the risk profile, safety violations- and control groups.

1.4. RESEARCH DESIGN

1.4.1 Research Approach

A quantitative research design will be used in this study in order to obtain information from the sample. According to Struwig and Stead (2001), quantitative research is a form of conclusive research involving large representative samples and a rather structured data collection process. A cross-sectional survey will be used to collect and analyse the data. The DSI questionnaire will be used to collect data.

1.4.2 Research Method

The research method consists of a literature review and empirical study.

1.4.2.1 Literature Review

The literature review will focus on psychometric tests, specifically the DSI in predicting workplace safety and accident-proneness. Literature on psychometric assessment in general and the safety environment in the mining industry will also be taken into account. The sources that will be used include:

- Article databases, which include EBSCOHOST, Science Direct, Emerald, Sabinet Online and SAe Publications, JSTOR.
- Relevant text books.
- Internet-based search engines such as Google Scholar and Google.
- Journal articles from various publications such as: *Personnel Psychology*; *International Journal of Selection and Assessment*; *Industrial and Organisational Psychology*; *Research in Personnel and Human Resources Management*; *Journal of Applied Psychology*; *Leadership & Organization Development Journal*; *Professional Safety*, *Journal of Prevention & Intervention in the Community*; *Safety Science*; *Journal of Safety Research*.

1.4.2.2 Sampling

A stratified sampling method will be used; stratified sampling is obtained by independently selecting a separate simple random sample from each population stratum. A population which can be divided into different groups is called strata, and the probability sampling conducted independently within each strata may be based on some characteristic or variable such as income or education (Ross, 2005). In the case of the current study, it is the occurrence of incidents, risk factors or the absence thereof. The sample will be made up of three varying groups: the first being employees in the mine who have been involved in accidents ranging from lost time injuries (LTI), medical treatment cases (MTC) and first aid cases (FAC). Lost time injuries are injuries where the injured is required to consult with the medical doctor and is booked off, either from a shift, or for a day or longer. However, in order for it to be classified as a LTI, there ought to be shift or time loss. A medical treatment case is where the employee is required to see the medical doctor or a nurse and is treated for the injury. However, the employee is not booked off from a shift or even for a day and is thus required to return to work. First aid cases are injuries that require mere first aid treatment by the appointed Safety Health Environment and Quality representative of the area or department.

The second sample group will be employees identified as potential risk from the risk profile data base of the mine who will also undergo the assessment. The employees are identified through various factors that collectively make up a risk profile. These factors include disciplinary measures taken, sick leave out of control, and having a take home salary of less than 20%. The last sample group will be made up of employees who have never been involved in work accidents and who neither appear on the risk profile. Various statistical analyses will be done on the three sample groups to try and establish their risk propensity. A sample of 60 from each sample group will be selected, comprising both males and females with work experience ranging from a minimum of 0-3 and 4+ years. The age groups will range between 22-34 years and these will be defined as the younger employees or participants in the study, while the 35-59 year olds will be the older participants in the age group. The participants will be mining operators who operate on haul trucks.

1.4.2.3 Measuring Instruments

The DSI questionnaire will be used to determine the risk-scale of individuals.

Table 1: *Example of items from the DSI Questionnaire*

I think that time should be spent on planning	Most like me	Neither	Most like me	I normally try to fix things when they are broken
I enjoy making things	Most like me	Neither	Most like me	I take time to check my work thoroughly
I work better on my own	Most like me	Neither	Most like me	I tend to be cautious when making decisions

The focus of the DSI will be on violation behaviour. The DSI determines the risk probability of the individual. The revised version 1.1 contains 18 pairs of work-related statements. Candidates are asked to select from two statements the one that is most like them at work. The output score indicates the likelihood that a candidate will be a safe, reliable and productive employee on a scale of “very high risk” to “low risk” (Burke, Vauhan, & Ablitt, 2010).

The DSI will be administered on a sample of three groups namely the safety incident group, this being employees who have previously been involved in accidents; the risk profile group employees, this is a profile that seeks to identify employees who might be involved in accidents due to various reasons often classified as factors which could be seen to potentially bring them distress; and lastly, the control group which would be employees who are neither on the risk profile or have had any safety incidents.

1.4.2.4 Research Procedure

A written letter of consent will be attached to the DSI questionnaire describing the research goals, purpose and implications of the tests. The DSI test will be administered in groups of 10. The research will be conducted on the premises of the selected mine and will adhere to the required conditions suitable for psychometric testing, including the following:

Confidentiality: Psychological assessments are subject to regulation by law due to the fact that assessments are highly confidential. This means that psychologists must adhere to the confidentiality clause in the administration of the test (Foxcroft & Roodt, 2005; 2009). The participants' results will be treated confidentially by the researcher and a registered industrial psychologist at the particular mine involved in the study.

Physical Conditions: This entails ensuring that seating, lighting, ventilation, temperature and noise levels in the testing venue and surrounding areas are appropriate.

Informed Consent: Prior to participation, the researcher and the participants should enter into an agreement that clarifies the obligation and responsibilities (Kerlinger & Lee, 2000). The test takers will be informed well in advance about what and where the assessment measure will be administered, what sort of material it contains and the purpose it serves. Tests takers deserve an opportunity to prepare themselves intellectually, emotionally and physically for the assessment; this is done by ensuring that they are all in the right emotional state and physical condition to participate in the assessment. Sufficient information should also be provided about the assessment, to enable the candidates to be in a better position to judge whether they want to consent to being assessed (Foxcroft & Roodt, 2005; 2009).

1.4.2.5 Statistical Analysis

Statistical analysis will be conducted using the SPSS version IBM SPSS Statistics 20 to analyse the data. Chi-squares and t-tests will be used to determine whether age, gender and experience influence accident-proneness. ANOVAs will be used to determine the differences between the DSI score of the three groups; in addition Cohen's (1988) d statistics will be used to investigate practical significance between the three sample groups. Correlations will also be used to determine the relationship between the psychological assessments and human error.

1.5 ETHICAL CONSIDERATIONS

All the ethical issues pertaining specifically to psychometric testing as well as conducting research will be taken into account. One of the biggest ethical concerns for the purpose of this study is to assure the participants that the results and names will remain confidential and that these results, at no point, will jeopardise their jobs. Another issue regarding ethics will be for the researcher, who is not a registered psychometrist, to work under the strict supervision of a registered industrial psychologist on the premises of the mine, in order to ensure that there is no misuse of the tests and results.

1.6 CHAPTER DIVISION

The chapters will be presented as follows:

Chapter 1: Introduction

Chapter 2: Research Article

Chapter 3: Conclusion, Limitations and Recommendations

1.7 CHAPTER SUMMARY

Chapter 1 primarily focused on providing an overview of the research problem and research objectives. A detailed explanation of the research method, research instruments and research participants was provided.

Chapter 2 will focus on a discussion of the empirical study.

The conclusion, limitations and recommendations will be discussed in Chapter 3.

1.8 REFERENCES

- Anastasi, A., & Urbina, S. (1997). *Psychological testing* (7th ed). Massachusetts, MA: Allyn & Bacon.
- Anastasi, A., & Urbina, S. (2007). *Psychological testing* (2nd impression). Delhi, India: Pearson Education and Dorling Kindersley (India) Publishing.
- Bass, B. (1990). *Bass and Stogdill's handbook of leadership*. New York, NY: Free Press.
- Barrick, M. R., & Mount, M. K. (1991). The Big Five personality dimensions and job performance: A meta-analysis. *Personnel Psychology*, *44*, 1–26.
- Barrick, M. R., Mount, M. K., & Judge, T. A. (2001). Personality and performance at the beginning of the new millennium. What do we know and where do we go next? *International Journal of Selection & Assessment*, *9*, 9–30.
- Barling, J., Kelloway, E. K., & Iverson, R. D. (2003). Accidental outcomes: Attitudinal consequences of workplace injuries. *Journal of Occupational Health Psychology*, *8*(1), 74–85.
- Brough, P. (2003). The influence of perceived control, social support and inter-domain conflict upon psychological wellbeing: A longitudinal investigation. *Australian Journal of Psychology*, *55*, 117.
- Burke, E., Vaughan, C., & Ablitt, H. (2010). Dependability and Safety Instrument (DSI) Version 1.1 Technical manual.
- Calitz, P. L. (2004). The experience of women in the platinum mining industry. (Unpublished Master's dissertation). North-West University, Potchefstroom.
- Cartwright, S., & Cooper. (2008). *The Oxford Handbook of Personnel Psychology*. United States: New York. Oxford University Press Inc.
- Cellar, D. F., Nelson, Z. C., York, C. M., & Bauer, C. (2001). The Five Factor model and safety in the workplace: Investigating the relationship between personality and accident involvement. *Journal of prevention & Intervention in the Community*, *22*, 43–52.
- Clarke, S. (1999). Perceptions of organizational safety: Implication for development of safety culture. *Journal of Organisational Behaviour*, *20*(2), 185–198.
- Clarke, S. (2006). Contrasting perceptual, attitudinal and dispositional approaches to accident involvement in the workplace. *Safety Science*, *44*, 537–550.

- Coyle, I. R., Sleeman, S. D., & Adams, N. (1995). Safety climate. *Journal of Safety Research*, 26(4), 247–254.
- Cox, S., & Flin, R. (1998). Safety culture: Philosophers stone or man of straw? *Work & Stress*, 12(3), 189–201.
- Cooper, M., & Phillips, R. (2004). Exploratory analysis of the safety climate and safety behaviour relationship. *Journal of Safety Research*, 35(5), 497–512.
- Department of Mineral Resources. Annual Report 2011/2012. Retrieved from (<https://www.google.co.uk/search?hl=enGB&source=hp&q=department+of+mineral+resources+report+of+fatalities+in+2011+and+2012+in+mining+sector&gbv=2&oq=department+of+mineral+resources+report>)
- Denton, K. (1982). *Safety management: Improving performance*. New York, NY: McGraw-Hill.
- De Winter, J. C. F., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research*, 41, 463–470.
- Donald, I., & Young, S. (1996). Managing safety: and attitudinal-based approach to improving safety in organizations. *Leadership & Organisation development Journal*, 17(4), 13–20.
- Ednies, H. (2004). “Innovative solutions for mining’s human resource challenges”. *CIM Bulletin*, 97(1076), 9.
- Flin, R., Mearns, K., O’Connor, P., & Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety Science*, 34(1–3), 177–192.
- Foxcroft, C., & Roodt, G. (2005). An introduction to psychological assessment in South African context (2nd ed). South Africa, Cape Town: Oxford University Press.
- Foxcroft, C., & Roodt, G. (2009). An introduction to psychological assessment in South African context (3rd ed.). South Africa, Cape Town: Oxford University Press.
- Glendon, A. I., & Litherland, D. K. (2001). Safety climate factors, group differences and safety behaviour in road construction. *Safety Science*, 39, 157–188.
- Goetsch, D. L. (2003). *Construction safety and health*. New York, NY: Upper Saddle River, Prentice Hall.
- Greenwood, M., & Woods, H. M. (1919). *The incidence of industrial accidents upon individuals, with special reference to multiple accidents*. Industrial, Fatigue Research. Board, Report No.4. H.M.S.O: London.

- Greenhaus, J. H., & Beutell, N. (1985). Sources of conflict between work and family roles. *Academy of Management Review*, *10*(1), 76–88.
- Griffin, M. A., Hart, P. M., & Neal, A. (2000). The impact of organisational climate on safety climate and individual behaviour. *Safety Science*, *34*, 99–109.
- Hensen, C. P. (1991). Personality characteristics of accident-involved employees. In J. Jones, J. Steffy., & D. Brav. (Eds). *Applying psychology in business*. New York, NY: Lexington Books.
- Hansen, C. P. (1988). Personality characteristics of the accident involved employee. *Journal of Business and Psychology*, *2* (4), 346–365.
- Hetherington, C. J., Robbins, J., Herman, J., & Flin, R. (2006). *Personal values and the safety climate-safety behaviour relationship*. Paper presented at the Society for Industrial Organizational Psychology, Dallas, TX.
- Hills, J. (2008). “Need to know: Internal influences”, *Personnel Today*. 868–879.
- Hoffman, D. A., & Stetzer, A. (1996). A cross-level investigation of factors influencing unsafe behaviour and accidents. *Personnel Psychology*, *49*(2), 307–339.
- Hofstede, G. (1991). *Cultures and organisations: Software of the mind*. New York, NY: Harper Collins.
- Hogan, J., & Holland, B. (2003). Using theory to evaluate personality and job-performance relations: A socioanalytic perspective. *Journal of Applied Psychology*, *88*, 100–112.
- Hunter, J. E., & Hunter, R. F. (1984). Validity and utility of alternative predictors of job performance. *Psychological Bulletin*, *96*, 72–98.
- Hurtz, G. M., & Donovan, J. J., (2000). Personality and job performance: The Big Five revisited. *Journal of Applied Psychology*, *85*, 869–879.
- Jansen, J. C., & Brent, A. C. (2005). *The South African institute of mining and metallurgy, SA ISSN 0038–223X/3.00 + 0.00. Paper received Jan. 2005; revised paper received Sep. 2005.*
- Kamp, J., & Krause, T. R. (1997). Selecting safe employees: A behavioural science perspective. *Professional Safety*, *42*, 24–28.
- Kemp, N. (1999). Psychometric testing is not dead. *People Dynamics*, *17*(3), 14–17.

- Kirschenbaum, A., Oigenblick, L., & Goldberg, A .I. (2000). Well-being, work environment and work accidents. *Social Science and Medicine Pergamon*, 50, 631–639.
- Knipling, R. R. (2004). Individual differences and “high risk” commercial driver. A Synthesis of Safety Practise .*Transportation Research Board of the National Academies*.
- Lajunen, T., Parker, D., & Summala, H. (2004). The Manchester Driver Behaviour Questionnaire: A cross-cultural study. *Accident Analysis and Prevention*, 36, 231–238.
- Lawton, R., & Parker, D. (1998). Individual differences in accident liability: Review and integrative approach. *Human Factor*, 40(4), 655–671.
- Li, R.Y.M., & Poon, S.W. (2013). Why do accidents exist? A critical review on the evolution of construction accident causation models. *Construction Safety*. ISBN: 987-3-642-35045-0.
- Marikana Massacre Report (2012). Retrieved from <http://www.moneyweb.co.za/moneyweb-special-investigations/financially-illiterate-miners-debt-shockers-fraud-a>
- Martinussen, M. (1996). Psychological measures as predictors of pilot performance: A meta-analysis. *International Journal of Aviation Psychology*, 6(1), 1–20.
- McKenna, F. P. (1983). Accident-proneness: A conceptual analysis. *Accident Analysis and Prevention*, 15, 65–71.
- Mining Safety in South Africa (2013) Retrieved from www.miningsafety.co.za/dynamiccontent/61/mining-safety-in-South-Africa
- Newbold, E. M. (1926). A contribution to the study of the human factor in the causation of accidents. Industrial Fatigue Research. Board Report No, 34. H.M.SO
- Özkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., & Summala, H. (2006). Cross-cultural differences in driving behaviours: A comparison of six countries. *Transportation Research Part F*, 9, 227–242.
- Paul, V. (2013). Safety improving at South Africa’s mines. Retrieved from www.bdlive.co.za/business/mining/2013/09/27/safety-improving-at-south-africans-mines

- Reason, J., Manstead, A., Stradling, S., Campbell, K., & Baxter, J. (1990). Errors and violations on the roads: A real distinction. *Ergonomics*, 33, 1315–1332.
- Reason, J. (2000). Human error: Models and management. *British Medical Journal*, 320, 768–770.
- Rockwell, T. H. (1967). Some exploratory research on risk acceptance in man/machine settings. *Journal of American Society of Safety Engineering*, 13, 6–19.
- Ross, K. N. (2005). Quantitative research methods in educational planning. Sample design for educational research. International Institute for Educational Planning. UNESCO, Paris: IIEP.
- Schmidt, F. L. & Hunter, J. E. (1981). Employment testing: Old theories and new research findings. *American Psychologist*, 36, 1128–1137.
- Schmidt, F. L., Hunter, J. E., Outerbridge, A. N., & Golf, S. (1988). The joint relation of experience and ability with job performance: A test of three hypotheses. *Journal of Applied Psychology*, 73, 46–57.
- Schmidt, F. L. & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology. *Psychological Bulletin*, 124(2), 262–274.
- Shaw, L., & Sichel, H. S. (1971). *Accident-proneness*. Oxford, United Kingdom: Pergamon Press.
- Smith, G .S., Huang, Y. H., Ho, M., & Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: the need to adjust for injury hazards. *Accident Analysis and Prevention*, 38, 556–562.
- Stringfellow, M. V. (2010). Accident analysis and hazard analysis for human and organizational factors.
- Statistics South Africa. (2011). Mineral accounts for S.A. Retrieved from <http://www.statssa.gov.za/publications/D04052/D04>
- Statistics South Africa (2012). Quarterly employment statistic. Retrieved from www.sanews.gov.za/south-africa/employment-2012-fourth-quarter
- Strazdins, L., & Broom, D. H. (2003). Servicing emotions at work and at home: Implications for stress and wellbeing. *Australian Journal of Psychology*, 55, 145-145.
- Struwig, F. W., & Stead, G. B. (2001). *Planning, designing and reporting research*. South Africa, Cape Town: Pearson Education.

- Wiegmann, D. A., Zhang, H. T. L., Von Thaden Sharma, G., & Mitchell, A. A. (2002). A synthesis of safety culture and safety climate research. University of Illinois Aviation Research Lab Technical Report ARL-02-03/FAA-02-2.
- Visser, E., Pijl, Y. J., Stolk, R. P., Neeleman, J., & Rosmalen, J. G. M. (2007). Accident-proneness, does it exist? A review and meta-analysis. *Accident analysis and Prevention*, 39, 556–564.
- Yule, G. (2002). *Leadership in organisations* (5th ed). New York, NY: Prentice Hall.

CHAPTER 2

ARTICLE

Psychological ability and the risk of human error in the mining industry

Abstract

The objective of this study was to determine the accident-proneness of mine operators in a mine situated in the Northern Cape by making use of an assessment instrument known as the Dependability and Safety Instrument (DSI). A cross-sectional survey design was used, where a convenience sample ($N = 193$) of operators was selected. The sample group was split into three groups for comparison purposes, namely employees who have been involved in incidents referred to as the safety incidents group ($N=35$); employees who could potentially be involved in incidents classified on the risk profile referred to as the risk factors group ($N = 38$); and the control group ($N = 120$). The results demonstrated that the DSI score and safety incidents group as well as the risk factor group were negatively correlated; yet for the risk profile the correlation was not significant. Variables such as age and years of experience were explored in relation to the three sample groups. A positive and significant relationship between age and years of experience was found, which was practically significant with a large effect size. A significant correlation was observed between the DSI score and the safety incident group of participants with four or more years of experience, and not for participants with 0-3 years of experience, although the practical significance effect is small. Furthermore, the safety incident group obtained the lowest DSI score which indicates a higher risk probability.

Key terms: Safety, accident proneness, risk, mining industry, accidents, psychological assessments, operators.

INTRODUCTION

According to Cummings and Saleh (2011), mining is still one of the most dangerous and hazardous occupations with higher accident rates globally. These accidents not only negatively affect the respective mine where they occur, but they have a broader negative impact on the country's economy as accidents result in wasted domestic resources, causing losses for the labour force and of working days (Kasap, 2011).

South Africa, amongst countries such as China, United States and Ukraine, has recently seen fatalities which were widely reported in various forms of the media as a result of growing public awareness of the dangers that mine workers are subject to on a daily basis (Cummings & Saleh, 2011). Workplace accidents do not only impact on business profits in terms of the pensions that need to be paid out due to incapacity and treatment costs, but largely affect businesses in terms of loss of production time, disruption in production schedule and damage to machinery or equipment (Kasap, 2011).

In many other mines as well as the mine under study, the injured employee may be put on bed rest if the injury was particularly serious. This would be termed as a lost time injury case, resulting in work delays as the employee is booked off. Even if the employee merely takes off a couple of hours to get treatment for the injury, the industry loses profits. According to the International Labour Organisation's (ILO) regulations, total working days lost are the number of days beginning from the day of the incident (with temporary or permanent incapacity for work) until the day when the recovery period ends. Working days lost are calculated in the following way, namely if the injured worker has an official recovery period on the actual day and/or on the day following the incident, and if he/she starts to work on the third day following the incident, the first two working days are not taken into consideration. However, if the deadline for the recovery period is the third working day or later and if the worker starts work then, the number of working days lost prior is recorded (Kasap, 2011).

For the mine under study the concept of lost time injury is applied by taking into account the total number of calendar days (not working days), from the day following that of the injury to the day on which the injured person is able to resume all the routine

functions of his/her job. Days lost are calendar days, regardless of whether the injured was due to report at work or not on any of those days, and includes scheduled time off, weekends and public holidays. Restricted work (or light duty) is counted as a lost-time injury. In the USA a fatal work accident is counted as a total of 6 000 lost working days. However, human life is an asset which cannot be substituted; the same goes for the pain suffered by family members who have lost a loved one (Kasap, 2011).

Coal mining is the most dangerous occupation in the United States, with the injury frequency and severity rates several times higher than the average for all industries. Although there was a slight improvement in the 1970s, some trends indicate an increase in the severity of the accidents even though other trends indicate a small decrease in accidents and injuries (Bennet & Passmore, 1984).

The death rate of mine workers in the US mining industry took on various trends over the years. In the 1990s, the total fatalities in the mining industry were 90 and decreased to 53 by 2008. The decrease should not be seen as a result of improved safety interventions over the years or in this particular industry, as a decrease in fatalities is likely to invite a decrease in safety vigilance as complacency in the mining industry will compromise safety (Bennet & Passmore, 1984).

Just as trends can be drawn regarding safety in the US mining industry, South African mines particularly the platinum mines have also established certain trends. The Platinum mining industry indicated that 70% of deaths were related to compliance issues or lack thereof (Jansen & Brent, 2005). Thus, in addition to the already existing safety management systems that are traditionally used, the industry implemented behaviour-based safety programmes. Yet even with such technology and greater emphasis and focus on safety accidents in the mine, accidents still occur with unacceptable frequency (Lim, Murray, Dowdeswell, Glynn, & Sonnenberg, 2011).

Data from the South African Department of Mineral Resources show a significant decline in platinum mine occupational fatalities from 49/100 000 workers in 1992 to 19/100 000 workers in 2008. Gold mine occupational fatalities went from 113/ 100 000

workers in 1992 to 55/100 000 workers in 2008, and occupational fatalities in the South African mining industry as a whole from 94/100 000 workers in 1992 to 35/100 000 workers in 2008 (Statistics South Africa, 2010). Yet the industry remains significantly important to the global economy as it provides some form of employment for many communities (Cummings & Saleh, 2011).

The overall effect of mortality in the South African platinum mines could have been as a result of the hazards and migration of work, in addition to the unnatural causes of deaths that are very common. Over a 17-year period unnatural deaths totalled 808. The pre-mature death of mine workers and the loss of income have a broader implication for their families and communities (Lim et al., 2011).

Accident-proneness

The early work done by Greenwood and Wood (1919) concluded that some people are clumsy, or risk-seeking, and therefore cause more damage to themselves and their surroundings than their more safety-minded peers.

The concept of accident-proneness which is defined as some people having the tendency of being involved in accidents more than others (Greenwood & Woods, 1919) was discredited in the twentieth century and research focused more on the design of work environments and on putting safety systems in place, however as discussed in Chapter 1, such a focus tends to result in a safety performance plateau overtime (Donald & Young, 1996; Neal, Griffin, & Hart, 2000).

Cummings and Saleh (2011) described factors that can be controlled by human decisions which can influence safety as safety levers. These factors can vary in nature such as technical, managerial or organisational and regulatory factors. Managerial and regulatory factors typically entail defining and laying out safety procedures and standards to workers; their ability to influence safety is limited to workers' decisions to either adhere to the standards or not. The regulatory lever which has been a resort for most companies entails actions such as mandating, inspecting and enforcing certain regulations.

The concept of accident-proneness was also introduced by Farmer and Chamber (1926) as a natural tendency to be involved in an accident; this is opposed to and very distinct from accident liability as liability implies that there has been some degree of exposure to or likelihood of suffering from all factors determining the accident rate. If environmental exposure was the same for each person, then liability should measure proneness; assuming that consequences of liability such as absence and injury are closely related.

One of the most common hypotheses relating to the concept of accident-proneness is that accidents are not random events for workers, but occur as a result of a stable individual difference in their behaviour (Af Wahlberg & Dorn, 2007). Contradictory to this is the work of Greenwood and Woods (1919), and Greenwood and Yule (1920) as cited by Froggat and Smiley (1963) in their article titled “The concept of accident-proneness: A review”. One of the hypotheses that Greenwood postulated in his study related to certain laws of probability. He explored the distribution of accidents by making use of a sample of female workers, where he concluded that accidents in their real and strictest sense were accidents; their distribution or allocation to human beings in an unchanging environment was truly random and due to equal chance (Froggatt & Smiley, 1963). In this event the frequency distribution of accidents among individuals would conform to a type of 'pure chance' distribution, similar to the 'Poisson distribution' which emerged in 1837. Poisson distribution is discrete probability distribution that expresses the probability of a given number of events that occur at a fixed interval of time (<http://ww.stat.washington.edu/peter/341/Group%205.pdf>).

In practice the Poisson distribution failed to 'fit' the observed frequency distributions in the original series. Greenwood thus adapted the hypothesis of random distribution by further hypothesizing that once an individual has incurred an accident, the individual subsequently becomes more likely or even less likely to incur another accident. Greenwood explained that the accident probability is firstly distributed evenly or randomly across individuals or happens by pure chance; however, the probability changes after the first accident.

Froggat and Smiley (1963) argued differently stating that it is impossible to obtain a group of people in which each member is exposed to equally or to exactly similar risk

of incurring an accident. Greenwood's last hypothesis which seems to be closer to the common understood definition of accident-proneness is that some individuals are inherently more likely to incur accidents than other; thus, disregarding the above two stated hypotheses that the probability is random or evenly distributed.

Research done by Broadbent, Cooper, Fitzgerald, and Parkes (1982) which entailed making use of the Cognitive Failure Questionnaire (CFQ), showed that cognitive lapses and slips predict safety behaviour. The CFQ measures an individual's discernment of his or her perception, action and memory capabilities (Schmidt, Neubach, & Heuer, 2007). The day-to-day failures that are measured by this instrument are the typical characteristics used by safety researchers to classify human error, including omission, commission and even psychomotor errors. The results produced by the CFQ are strongly supported by other research, demonstrating that accidents are usually a result of distractibility, mental error and poor selective attention.

According to Day, Brasher, and Bridger (2012), people who are under stress are more susceptible to accidents as they are more prone to cognitive failures and these lapses result in their causing accidents. Research by Maritime Coastguard Agency (2007) indicated that one of the effects of job stress is fatigue resulting in errors due to lapses in attention, memory problems and slower reaction time. This notion can be supported by the discussion around the work conditions of mine workers which are often harsh and could easily be a source of stress for the employees. Lack of money usually sees mine workers increasing their work time to compensate for the shortage of income through overtime payment; this has an adverse effect as they often experience fatigue which could ultimately result in their being more susceptible to incurring accidents.

This can be further supported by research done by Bridger, Brasher, Dew, and Kilminster (2008) who indicated that workplace psychosocial stressors are associated with stress, such as effort-reward imbalances and dissatisfaction with the work environment. All these were the main causes of the second quarter 2012 outbreaks of strikes in the mining industry. An article by TCEToday (2012) indicated that the average wage for a South African miner is ZAR13 500 (according to the figures from the UN's International Labour Organisation). Furthermore, it was established that there

is a large wealth inequality in South Africa and over the years the gap between the poor and overly wealthy seems to be becoming bigger. The mine under study has over the years put in place various non-mechanical or technical interventions in an effort to remedy the situation of employees experiencing fatigue due to working overtime in order to compensate for low income as a result of debt such as garnishee orders. The mine established that there were employees who were taking home a monthly income of less than 20%, due to various garnishes set against their names. Other factors were also taken into account which at the end could psychologically hinder an employee's ability to function optimally in the work place; thus, resulting in accidents.

The latter further more supports the hypothesis under study, namely that the psychological instrument being used to assess accident-prone employees will be able to detect risk prone employees from the data base of the mine under study through a risk profile, which takes into account various factors as previously explained.

According to Permana (2012), taking account of human failure is a significant point of departure to address the issue of accidents in the mines. Human failures constitute things such as not following work instructions or procedures properly, violating rules, and a lack of knowledge and skill. Furthermore, Permana (2012) stated that all accidents are preventable, and that no accident can occur without a cause; thus, it is important to identify, manage and control these causes. He stated that accidents typically happen as a result of an unsafe act committed by people.

The assessment instrument used, namely DSI, was largely developed around the concept of dependability by defining what dependability is, according to SHL (2010) dependability can be defined as a set of behaviours related to time keeping, meeting expectations for how to behave in the workplace (e.g. compliance with procedures and organisational policies), getting along with and supporting work colleagues, and coping with the day-to-day challenges that normally occur in the workplace., as well as workplace behaviours that are associated with dependability. The two concepts commonly used in the DSI are organisational citizenship behaviour (OCB) and counterproductive work behaviour (CWB). OCB refers to behaviours that contribute to social functioning, such as courtesy and civic virtue. A parallel line of research has focused on CWB that is defined as any behaviour from the members of the organisation

that is viewed by the organisation to be contrary to its legitimate interest, and may include behaviours such as absenteeism from work (Ablitt et al., 2010).

When making reference to the concept of accident-proneness in relation to Permana's (2012) hypothesis of what an accident is, in terms of human failure and what causes it, it would be fair to state the view of the theory of accident distribution that individuals will respectively be exposed to the same amount of risk at random. Yet because of the trait of accident-proneness one or more of the individuals will incur an accident due to an unsafe act or violation which in Permana's words would be termed as human failure.

In Permana's study of mine accidents in Indonesia between 2003 and 2012, he established that mining areas such as hauling roads which are made up of haul truck operators, who predominantly comprised the sample size in the current study, had a medium risk level with a moderate probability that accidents would occur and a low severity level (Permana, 2012).

A different definition of accident is shared by Arbous and Kerrich (1951) who regarded an accident as a chain of events, each of which is planned and controlled. However, the unplanned event occurs which is the result of some non-adjustive act on the part of the individual.

The research under way seeks to take into account various factors which may influence accident-proneness, including age, gender and experience which are dealt with in the literature to follow. Explored in the literature review are also psychological factors such as personality as well as some factors which make up the risk profile of the mine under study.

FACTORS INFLUENCING THE CONCEPT OF ACCIDENT-PRONENESS

The relationship between age, gender and experience in accident-proneness

According to Williamson (2003), evidence exists from accident statistics that younger drivers tend to be at a higher risk of being involved in an accident than older drivers. Although Williamson strongly focused on motor vehicle accidents in his evidence, the

belief that younger drivers tend to engage in more risky behaviour than older drivers can easily be adopted into the mining industry, since the age demographics in the industry are vast. This belief elicits a discussion around a concept known as accident or risk propensity. Rohrmann (2004) defined accident propensity as a positive attitude towards taking recognised risks. The word recognised suggests that the individual acknowledges and is fully aware of the risk involved in his or her actions. In contrast, Catchpole (2005) argued that young drivers may engage in risky behaviour because of their unawareness of the risk involved in their behaviour. This may be as a result of inexperience and error; however, inexperience does not account for all the variance in their risky driving.

According to Fernades and Hatfield (2007), the classification and differentiation between perceived benefits and costs are essential elements to be explored in younger drivers. This differentiation or ratio is referred to as risk-perception. Young drivers may choose to adopt behaviour that they recognise as being risky when the perceived benefits of their behaviour outweigh the perceived costs, namely penalty and being involved in crashes which can be defined as risk-perception.

The perceived riskiness of behaviour may be considered as neither a cost nor a benefit, depending largely on the individual's attitude towards taking risks. Research into the inter-relationship between risky driving and risk perception, and attitudes towards risk-taking has been hampered by the ability to gain conceptual clarity as well as the lack of appropriate measuring instruments for the different concepts. Discussion around the motivation for risk driving has combined perceived benefits of the risk with perceived costs of the behaviour, which are independent of the risk (Beirness, 1993; Johan, 1986).

Although there is still a significant gap in literature into the relationship of risk-propensity and the motives for valuing risks positively with risk driving and with age, Johan and Dawson (1987) found that younger drivers had less regard for safety features when buying a car than older drivers. The study undertaken by Rohrmann (2004) undertook to compare younger drivers and older drivers in terms of risk propensity, risk-aversion and the motives for positive attitude towards risky driving. Rohrmann employed various assessment questionnaires ranging from his own self-developed,

modified Risk Motivation Questionnaire which measures risk motivation to Marlow-Crowne's Social Desirability Scale and Risk-Perception assessment.

Findings from Rohramann's study (2004) were that social desirability showed significant correlations only to the getting-there-faster motivation for speeding ($r = -2.14$). In the older sample, social desirability demonstrated a significant correlation with getting-there-faster, motivation for speeding ($r = -2.10$); meaning that older people also have the desirability to speed, yet solely motivated by the need to get somewhere faster.

An interaction with gender was also observed in certain factors and as a result of the interaction found, the sample was tested separately for males and females primarily by using t-tests or univariate general linear models when a social desirability score was needed (Rohrman 2004).

Younger drivers demonstrated lower risk-aversion than older drivers across both male and female groups; and a greater propensity for physical accident risk, sensation-seeking and prestige-seeking were found to be applicable to the female driver only, while the irrelevance of risk was found applicable to males only. Younger drivers also had stronger motives for speeding which was strongly motivated by experience-seeking, excitement, social influence and letting steam off. This was generally found in both the male and female group (Rohrman 2004).

According to Shinar and Compton (2004), males tend to display more aggressive driving behaviour such as road-rage, risk taking and violations. However, it is believed that women also demonstrate some negative driving styles such as being overly stressed, which can result in accidents. Other research suggests that there is a negative relationship between driver age and accident risk. Kweon and Kockelman (2003) did an extensive study on the accident rate per vehicle mile driven and there were very few differences between young men and women. This may suggest that young men's higher risk may simply be due to the fact that they tend to drive more than their female counterparts; however, their higher driving experience does not necessarily mean that they are less susceptible when it comes to accidents.

In the platinum mines situated in the North West province, it was found that occupational injuries' mortality rate increased with age. This is in contrast with previous

research done in South African gold mines which found a decrease in work-related injuries in those aged 50 years (Murray, Sonnenberg, Nelson, Bester, & Shearer, 2007). Older and more experienced drivers tend to be more involved in accidents than errors; one theory being that with growing age one's psychomotoric ability and performance naturally tend to decline, resulting in accidents (De Winter & Dodou, 2010).

The above result suggests that there are differences in the way that generations view risk, these differences also exist even between males and females. Since the workforce is made up of various demographics, it is important to take into account such finding in managing risky employees as well as safety in the workplace.

The relationship between work experience and the number of workers who died in equipment-related incidents was examined and it was noted that workers with less than 5 years of proper mining experience constituted 44% of all fatalities - the sample mainly comprised haul truck workers (Kecojevic, Komljenovic, Groves, & Radmosky, 2007).

Conflicting and contradictory evidence is found in literature regarding experienced versus younger less experienced workers, such as a recent study that found much higher disabling injury rates among younger miners than older miners (Kecojevic et al., 2007). Yet, according to De Winter & Dodou (2010), experienced workers are more susceptible to accidents. The use of words such as the "younger less experienced" to some extent implies that with age comes more experience and that often the younger people are less experienced in comparison to the older people. It may be difficult to establish a concrete and solid notion pertaining to this, as studies of the relationships between accidents and injuries and the effectiveness of safety training, the number of shifts each day at a mine site, and the time elapsed during a shift until an accident occurs have produced ambiguous results, often as a result of analysis of inadequate data (Bennet & Passmore, 1984).

Experienced miners have lower risks of fatal injuries than inexperienced miners. Various factors were explored by Bennet and Passmore (1984) in an attempt to establish if there are correlations between factors such as size of mine, and engineering methods employed by the mine to accidents or injury. The size of the mine seems to also be a contributing factor in accidents experienced at the particular mine, as employees in

smaller mines are more likely to receive fatal injuries than those in large mines. The various engineering methods of extracting coal from its natural deposit do not produce different fatality rates. The thickness of the coal seam mined is not related to the incidence of fatalities (Bennet & Passmore, 1984).

According to Holland, Geraghty, and Shah (2010) experience does not have a positive relation or effect for young men as it does for young women. As a result of the small representation of females in the sample, gender could not be explored as a variable in the DSI score of the current study.

In a study done by Holland et al. (2010), they explored driving experience in relation to various driving styles between male and female, taking into account age differences as well. The driving styles refer to the way the driver chooses to drive, or habitually drives including speed, attitude towards other road users and to rules and general attentiveness. Driving styles can be influenced by beliefs or the perception that one holds about one's own driving ability. This relates to what was previously discussed regarding risk-perception that individuals hold of the cost versus the benefit of engaging in risky behaviour.

The extent to which driving skills benefit from experience seems to be more complex, as it is closely related to gender, personality and driving style. In relation to driver experience and its influence on accident-proneness, Holland et al. (2010) explored the following hypothesis: Firstly, driving experience, that is the duration and the amount of driving, will influence the driving style; secondly, locus of control will have an effect on the driver's style; and lastly, locus of control will account for gender differences in driving styles.

The finding revealed that there was a significant negative relationship between duration of driving experience and dissociative and anxious driving styles. Thus, the more experience a driver has, the less dissociative and anxious his or her driving style is. This was replicated in the relationship with amount of driving. This measure also correlated negatively with patient driving; the more a participant drives, the less patient his/her driving style becomes. In contrast, these measures were correlated positively with high velocity driving: the more a person drove, the higher they scored on this style.

Experience was shown to have a generally positive influence on anxious and dissociative driving styles (the “stress” styles), but amount of driving was the more important experience variable for women, who appeared to be more prone to stress styles than men (Holland et al., 2010).

RISK PROFILE AND ITS ASSOCIATION WITH ACCIDENTS

The current study assesses a group of employees classified as being risk employees due to the fact that they appear on the risk profile. This is a report profile that the mine under study generates on a monthly basis to see which employees are in the profile, based on the following factors that make up the risk profile:

- Accidents or Incidents,
- Less than 20% take home income
- Uncertified sick leave
- Unpaid Sick leave
- Unpaid leave
- Unpaid suspension
- Garnishees with more than 30 hours overtime
- Excessive Overtime
- Disciplinary cases

The main hypothesis around the risk profile is that employees who are not in the best financial position or health condition are likely to have higher levels of stress, either as a result of their finances or the illness which could be a direct cause of stress. Stress is thus seen as having the ability to not only affect them cognitively, but also physically. This can be observed in their proneness to absence from work due to illness. The stress incurred either due to finances, illness, work or private life can render the employee to be easily susceptible to accidents. Such employees are considered to be high risk to the business in terms of being involved in accidents. Hence, it is important to identify such employees and manage their risk probability.

Research done in the Royal Navy in 2010 supports the above hypothesis (Bridger et al., 2010). The General Health Questionnaire (GHQ) which is a 12-item questionnaire

measuring the current levels of psychological stress (anxiety and depression) in staff, with a total score range of 0-36 for each item, was used in the Royal Navy research (Goldberg & William,1988). In making use of this assessment, a sample of accident-case employees versus matched-control employees was used. The stress levels were significantly different between the two groups. Individuals in the accident group had significantly higher levels of stress than the matched-control group. The accident group's correlation was statistically significant at 0.46 with the matched-control group at 0.26. This means that the accident group experienced higher stress levels than the control group. The present findings suggest that occupational stress may have an implication on safety via accidents in the workplace (Day et al., 2012).

The study of the gold mines in South Africa also found that HIV (Murray et al., 2007) was positively associated with an increase in work-related injuries, not necessarily fatalities. This thus relates to the issue of sick leave. The mine under study has experienced a significant rise in employees constantly being off sick over the years and therefore incorporated a term known as 'sick leave out of control' in their sick leave policy, which can be defined as a person taking excessive time off work due to being sick within a specified period of time from the inception of employment. It is thus important to note that illness can stem from various factors such as financial instability, personal illness or illness of a family member that results in employees being stressed and staying away from work. Employees who have been employed for 6 months and within the 6-month period of employment have been off work three times or more are deemed to qualify for sick leave that is out of control. The same applies to employees who had been employed for 12 months and who had been off work for sick leave six times within that 12-month period. Sick leave is also a factor which is taken into account in the risk profile

Illness as a factor from the risk profile

According to Ferguson (1972), there are various problems or factors that are inherent in the concept of accident-proneness, such as absence, illness or sickness proneness. Absence in the workplace can be as a result of various reasons or factors, only one or none being medically-related. Blumberg and Coffin (1956) stated that non-medical personal, social, industrial and organisational factors may impact and influence the

desire of employees to come to work. In the context of the mining industry, the harsh working conditions and low pay that have seen employees march to the streets can be regarded as possible reasons or factors that contribute to reduced employee morale or engagement in their work. This type of behaviour, therefore, is manifested through high absenteeism rates in the mine under study.

Fertuin (1955) classified absent repeaters into three groups. First, the chance repeaters: these are people with an increased number of absenteeism, often with unrelated and varied illnesses, presumably as a result of chance. Second, the recurrent repeaters: these are people certified as suffering from a disease or diseases involving recurrent disability. Third, the symptomatic repeaters: these are people whose certified diagnoses of sickness absence were usually vague or symptomatic or otherwise gave rise to doubt as to the medical reason for the absence.

Ferguson (1955) made reference to another factor that is included in the risk profile which is usually associated with fatigue, namely working overtime. Some symptomatic repeaters have second jobs, yet he found that working overtime does not necessarily have a positive relationship with repeated absence. It can be argued that if an individual works excessive overtime, he or she is more likely to be absent more often as he/she develops a pattern of recuperating between days of working overtime. Thus, these types of people can be classified as symptomatic repeaters as their reasons for absence will often be vague, creating doubt as to whether there is a medical reason for their absence.

According to Saleh and Cummings (2011), very often in the mining industry safety issues are addressed as separate issues from health issues. It is thus important to see the two in conjunction when taking into account the following statistics. In the US 10 406 miners died as a result of pneumoconiosis between 1995 and 2004 (Work-related Lung Disease Surveillance Report, 2007); this is more than the number of US mining fatalities due to accidents (safety issues).

Looking at the two issues in conjunction will also assist in creating an understanding of the differences in time scales effect of hazardous sources, for example, an explosion will result in an immediate injury or fatality and often the source of the explosion will be investigated as either being a human error or unsafe work condition. However,

prolonged exposure to coal or silica dust can result in debilitating fatality in the long run in the form of lung diseases. Thus, when considering sickness-proneness it is important to take the latter into account, especially before classifying an individual's absence into one of the previously discussed absence categories.

PREDICTING WORKPLACE ACCIDENTS THROUGH PSYCHOLOGICAL ASSESSMENTS

Psychological assessments are widely used in industries today for various reasons; one of the main reasons being recruitment purposes. Yet, they are still used in conjunction with interviews and other recruitment methods. This is because as much as they offer the recruiter the psychological knowledge of an individual, it is only fair to still see potential employees one on one as they provide an in-depth picture of a person's psychological capability.

The idea that person factors, such as attitude and personality determine unintentional injury, have been explored in literature will often drive consultants to employ a new recruitment tool to identify such factors in the process of recruitment. Several consulting companies across the world have developed and implemented personality-based measures for selection of employees who possess characteristics believed to be important in occupational safety. A valid selection tool can enable an organisation to identify applicants who possess personality characteristics linked to careful decision making and ability to cope under stress and reduce the chances of accidents (Geller & Wiegand, 2005).

To bring the above in the context of the current study, establishing such factors about an employee would be important, given the immense pressure that mine workers are at times faced with in meeting production targets.

Day et al. (2012) used certain assessments to see if they could predict employees who would be prone to being involved in accidents at work. A Pearson correlation analysis was done between the predictors of accidents as defined under the heading of risk profile; these being stress and cognitive failures which were also discussed in the

literature review. Through the logistic regression that was done, it was established that GHQ was a significant predictor of whether an individual had an accident or not. Individuals scoring high on the GHQ were more likely to have had an accident. In the second step cognitive failure was used as a mediator and was found to be a significant predictor of whether or not an individual has had an accident; thus, individuals scoring high on CFQ were more likely to have had an accident.

The mediation of the stress-accident relationship by the CFQ may be related to the current ability of individuals to regulate their thoughts and attentional processes when stressed which, in turn, might lead to accidents. In simpler terms it means that people who are stressed have difficulty regulating their focus, memory and psychomotor processes (McEwen, 2006).

Past research has focused on identifying the psychological and personality factors associated with accidents and physical injuries; several studies have been able to show how psychological states and traits are related to increased probability of persons becoming victim to physical injury (Quinlan & Bohle, 1991).

According to Ormel, VonKorff, Ustun, Pini, and Korten (1994), physical disability was more closely related or associated with psychological factors than with medical diagnosis. The important task is the identification of the basic personality structure that underlies injury-proneness. Empirical research has shown that factors such as emotional dissatisfaction, impulsiveness, extraversion, external locus of control and anti-social attitudes are all connected to accident-prone behaviour (Vavrik, 1999).

Although the current research does not account for personality traits, it is inevitable in literature that personality plays a major role in accident-proneness and the general safety climate or culture that organisations seek to establish. According to Geller and Wiegand (2005), there are three basic factors that need to be considered in an attempt to establish an injury-free workplace. These include: the environment (this will be made up of tools, equipment and the climate of the work setting); the person which is the employee and this includes the person's attitude, beliefs and personality; and the behaviour including safe and at-risk work practices. The factors mentioned are interactive by nature and a disruption of one factor will have an impact on the next.

Holland et al. (2010) explored the personality trait of locus of control between male and female in varying age groups and the relation thereof to accident-proneness. The notion of locus of control in relation to accidents suggests that drivers who believe that outcomes are controlled purely by external factors such as fate and not by self, will be less likely to change behaviour in response to outcomes (Walker, Stanton, & Young, 2008), compared to those who have an internal locus of control. These would be drivers who perceive outcomes to be dependent on their own skills, efforts and behaviours. Furthermore, research suggests that drivers who have an external locus of control are more likely to be involved in accidents than those with an internal locus of control, as they would take less precautionary measures to steer away from accidents believing that these are due to fate and beyond their control.

A key design aim in developing the DSI used in this study, was to construct items made up of statement pairs, using the following logic and reflecting the following features: Each pair to contain one statement keyed as either a positive or a negative predictor of dependability; each pair to contain one statement operating as a distractor (i.e. not hypothesised as a predictor of dependability); both statements in each pair to be matched in terms of attractiveness, (i.e. seen as a desirable characteristic of people by those completing the DSI); and a simple response format where the respondent indicates which statement (from options A and B) is 'most like' them, or indicates that neither statement applies to them, or that both statements are equally applicable (Ablitt, Burke, & Vaughan, 2010).

In developing the DSI, the Corporate Executive Board made use of various other assessments such as the Occupational Personality Questionnaire (OPQ), and the Big Five personality constructs; these assessments were used as guides and a basis for constructing the statement pairs to tap into facets of personality-related dependability.

The DSI was also placed in the broader context of its relation to these personality instruments. Data was available for DSI Version 1.1 and OPQ32 with all instruments administered in English. OPQ32 scores were transformed into Big Five indicators using equations developed by Bartram and Brown (2005), based on structural equation modelling of OPQ32 and Big Five reference questionnaires. DSI scores were regressed

on the OPQ32 Big Five scores, yielding a Multiple R of 0.41 significant at the 0.0001 level. Adjusting for the average reliability of all scales in the regression including DSI, the correlation between DSI scores and a composite of Big Five scores as weighted by the results of the regression model, the corrected correlation is estimated to be 0.54. It was found that DSI scores are positively (and significantly) related to conscientiousness, agreeableness and emotional stability, but negatively (and significantly) related to openness-to-experience. These results confirm the validities reported by Clarke and Robertson (2009) for Big Five constructs in predicting accidents (Ablitt et al., 2010).

SAFETY CULTURE

Safety culture is a sub-component of the general organisational culture or corporate culture, which alludes to individual, job and organisational features that affect and influence health and safety. Safety culture can be defined as the corporate atmosphere or culture in which safety is understood to be, and is accepted as one priority (Cullen, 1990). Thus, any negative factors such as restructuring and organisational downsizing will influence and have an impact on the safety culture. This indicates that safety culture is not an independent culture; it affects and is in turn affected by various factors, such as operational processes, organisational systems and/or social events.

Most organisations very narrowly focus on economic factors and the impact they have on production. Very often companies focus on measures of downsizing, and mergers for economic sustainability of the companies, yet seldom remembering that 50% increase in safety can result in 12% increase in productivity. Ironically the factors they choose to focus on often result in inadvertent introduction of accidents, causing pathogens into the organisation, resulting in increased accidents and incidents which ultimately result in lost production and increased costs of various forms of pay-out that need to be done to the injured (Stewards & Townsend, 2000).

Cooper (2002) explored Heinrich Domino's model that is very specific to unsafe acts. Weavers' (1971) main focus was on symptoms of operational error that influence or

interact with unsafe acts; Adam (1976) focused more on management structures, objectives and synchronizing these into the workflows. The above authors together with John Wreathall (1995) aligned Heinrich's model with a five element production model and identified how latent and active safety failures could be incorporated into organisational systems. The model emphasises that individuals, in terms of psychological or behavioural factors, are the triggers to the active failures. Didla et al. (2009) explored the concept of safety citizenship behaviour (SCB) emphasising that organisations must move towards a safety culture that embeds the concept of SCB. According to Didla et al. (2009), SCB can be defined as a culture where employees are proactive in participating and initiating safety; further identifying a positive safety culture to be key and influential in encouraging employees to SCB.

From the literature, the following hypotheses can be formulated:

Hypothesis 1: The DSI is able to identify accident-prone individuals.

Hypothesis 2: There is a relationship between the DSI score and the, safety incident and risk profile group.

Hypothesis 3: Biographical variables (age, gender and years of experience in being an operator) have a relationship with the DSI score, the safety incidentst, and the risk factors sample group.

Hypothesis 4: The DSI has the ability to differentiate between the safety incidents group, the risk factors and the control group.

RESEARCH DESIGN

Research Approach

A quantitative research design was utilised in this study in order to obtain information from the sample. According to Struwig and Stead (2001), quantitative research is a form of conclusive research involving large representative samples and a rather structured data collection process. A cross-sectional survey was used to collect the data. The

Dependability and Safety Instrument and a biographical questionnaire were used as measuring instruments.

RESEARCH METHOD

Participants and Procedure

Mining operators in the Northern Cape Province were used across the four shifts A-D. The sample was then grouped in terms of employees on the risk profile termed as high risk employees; employees on the safety data termed as safety violation; and the remaining sample was used as a control group. The questionnaire and the purpose it serves were explained to the employees, where after they were asked to complete the survey. The relevant authorisation was obtained via the union representatives from the foreman. The confidentiality of employees' participation was maintained. The questionnaire was administered to a total of 497 people, of which a total of 70 either did not complete the survey or completed it incorrectly and thus had to be excluded. Participants with no Grade 12 qualification were also excluded as the minimum requirement for the DSI is a Grade 12; another requirement was competency in understanding English as the questionnaire was in English. The final sample comprised a total of 193 participants which gave a response rate of 39%.

Descriptive information of the sample is given in Table 1.

Table 1

Characteristics of Participants

Item	Category	Frequency	Percentage
Racial Group	African	143	74.1
	Coloured	39	20.2
	White	11	5.7
	Total	193	100
Language	Afrikaans	43	22.3
	English	15	7.8
	Ndebele	1	0.5
	North Sesotho	2	1.0
	South Sesotho	3	1.6
	Tswana	124	64.2
	Xhosa	4	2.1
	Zulu	1	0.5
	Total	193	100
Age	22-34 years	103	53.4
	35-59 years	89	46.1
	Missing values	1	0.5
	Total	193	100
Gender	Male	174	90.2
	Female	18	9.3
	Total	193	100
Qualification	Grade 12	193	100
Years of Experience	0-3 years	83	43.0
	4+ years	110	57.0
	Total	193	100

According to Table 1 the sample was predominately made up of male participants (90.2%), with 74% of the participants being African as indicated in the table. The vast majority of 64.2% participants were Tswana-speaking. All participants were in possession of a Grade 12 certificate; 53.4% of the participants were between 22-34 years old; and 57% of the participants had 4 or more years of experience with only 43% having 3 or less.

Measuring Instruments

The DSI questionnaire was used to measure accident-proneness across the three sample groups as well as the characteristics of participants. Participants were requested to indicate on the questionnaire the years of experience in their current position.

The focus of designing the DSI was to provide an instrument that was short, fake resistant and could be used as an efficient screening tool or as an assessment in conjunction with other assessments during the selection of operational personnel (Ablitt, Burke, & Vaughan, 2010).

Various studies tested the validity and reliability of the DSI. Reliability estimates provide information on the consistency and accuracy of scores obtained from a test. The reliability of the DSI can be determined through the stability coefficient which answers the question of how consistent scores are over time. It thus reports the proportion of variation in applicants ranking on test scores across two or more administrations at different times. The reliability of the DSI was established through a test-retest and was found to be 0.72.

The revised DSI version consists of 18 statements and not 22 as with version 1.0. To ensure that the second version 1.1 did not become discredited in terms of validity and reliability, item level analysis was done by gender, age, ethnicity and English language fluency. Four DSI items were identified (each made up of statement pairs) as not adding substantially to the criterion validity as they were not performing consistently. Thus, these four items were removed in DSI version 1.1; this version has no loss of discrimination between candidates or loss of validity. Criterion validity was established on the DSI after the removal of the four items from version 1.0. Version 1.1 had a higher criterion validity of 0.28 than version 1.0 which was 0.24.

Version 1.0 and 1.1 were found to have significant correlations of 0.95, indicating a high degree of consistency in the ranking from both versions. This reflects the removal of four items that were found to perform less well, as well as some minor adaptations to two items to improve their localisation into languages other than English using Version 1.0 of DSI. As the two versions correlate highly, these reliability estimates are assumed to hold for Version 1.1 of the instrument.

Statistical Analysis

The statistical analysis was carried out using the IBM SPSS Statistics 20 (2011). Descriptive statistics was used to analyse the data by determining the frequency, mean, standard deviation and Pearson correlations as well as Cohen's d. The practical significance correlations coefficient was set at a small effect of 0.1, medium effect of 0.30, and large effect of 0.50. Pearson's correlation was carried out to determine the relationship between the DSI score and safety incidents, and risk profile as well as between the groups. ANOVA, t-tests and Chi-square were used to determine differences in the DSI score in relation to the variables age and years of experience used across the three groups. The representation of females was minimal; hence, comparisons on gender could not be drawn.

RESULTS

Descriptive Statistics

The mean, standard deviation and minimum and maximum score of the DSI score are discussed next.

Table 2

Mean of DSI in Total Sample

Item	N	Minimum	Maximum	Mean	Std.Deviation
DSI Score	193	26	54	41.56	5.11

Table 2 above indicates the mean of the DSI score (41.56) in a total sample of 193, with a Standard Deviation of 5.11.

Interpretation of DSI score and Band

The DSI can be interpreted through a score which is a composite of responses to pairs of statements that have been individually keyed as indicators of dependable behaviours in the workplace. A high score on the DSI is indicative of a lower risk propensity; whereas a low score on the DSI is indicative of a higher risk propensity.

The DSI scores are classified into bands reflected by colours red, amber and green and these can be refined to five levels of risk as illustrated in Table 3 that follows.

Table 3

DSI Bands

Band	Interpretation	Likely Impact
Level 1	Low Risk	A low risk candidate is likely to have a strong fit to jobs where step-by-step procedures, team work and strict working hours are important
Level 2	Moderate to Low Risk	A moderate to low risk candidate is likely to have a reasonable fit to jobs where step-by-step procedures, team work and strict working hours are important
Level 3	Moderate Risk	A moderate risk candidate is likely to have a moderate fit to jobs where step-by-step procedures, team work and strict working hours are important
Level 4	High Risk	A high risk candidate is likely to have a weak fit to jobs where step-by-step procedures, team work and strict working hours are important
Level 5	Very High Risk	A very high risk candidate is likely to have a very weak fit to jobs where step-by-step procedures, team work and strict working hours are important

Source: Ablitt et al., 2010

Safety incident types can be classified as:

First Aid Cases (FAC): A minor work-related injury, which can be treated by self under normal circumstances. Treatment includes the application of non-prescriptive treatment.

High Potential Incident (HPI): The uncontrolled release of energy or the integrity failure of a critical control with the potential to cause a single fatality.

Lost Time Injury (LTI): Injury incurred by a person during the course of duty, as a result of the injury the employee is unable to do his/her duties for one full shift or more on the day following the injury, be it a scheduled or working day.

Medical Treatment Case (MTC): A work-related injury which results in the injured receiving attention which under normal circumstances would only be received from a medical professional, for example a doctor or nurse.

Thus, participants with safety incidents against their names were coded a (1), and no safety incidents were coded as (0) against their names.

Risk Profile Factors

The risk profile is a proactive measure developed by the mine under study after intensive research that sought to identify employees who could potentially be involved in incidents in the near future. The profile is made up of various factors, ranging from garnishee orders, and sick leave out of control to absence without permission. Factors such as garnishee orders which result in employees taking home a minimum wage were briefly touched on earlier in the literature in relation to the Marikana strike workers, where it was identified that employees were not educated around loans and the pay back impact they might have on their wages. It was thus hypothesised that the risk profile factors have the ability to bring psychological discomfort such as stress to an employee, which may hinder his or her ability to solely focus at work, resulting in incidents.

Table 4 indicates the descriptive statistics according to DSI band, safety incident type and number of risk factors.

Table 4

Frequency of DSI bands, Safety Incident Types and the Number of Risk Factors

Item	Category	Frequency	Percentage
DSI Band	Low Risk	59	30.6
	Medium-low Risk	49	25.4
	Medium Risk	52	26.9
	High Risk	19	9.8
	Very high risk	14	7.3
	Total	193	100
Incident Type	No incident	158	81.9
	FAC	7	3.6
	HPI	17	8.8
	LTI	4	2.1
	MTC	7	3.6
	Total	193	100
Number of Risk Factors	0	153	79.3
	1	27	14.0
	2	10	5.2
	3	2	1.0
	4	1	0.5
	Total	193	100

According to the information in Table 4, 30.6% of the participants are classified under the low risk DSI band, with 7.3% under the very high risk band. Of the participants, 81.9% had no incidents reported with HPIs (8.8%) being the incident reported most. Illustrated in Table 4 is also the number of factors a person has against him/her; the maximum number of factors in this sample that a person can have against his/her name being four, with only one person having four factors.

Pearson's Correlations and Differences

Pearson's correlation coefficient is a measure of the strength of a relationship (linear) between paired data. In a sample it is usually denoted by r . Pearson's correlation was used to test Hypothesis 2 which was to establish if there is a relationship between the independent variable which is the DSI score and the two dependent variables risk profile group or factors as well as the safety incident or violations group. The correlation is illustrated in Table 5.

A negative correlation was found between the risk factors as well as the safety violations; the correlation is negative because the two groups did not comprise the same participants; meaning someone who appears on the risk factor will not be under the safety violations group.

Table 5

Correlation Coefficients between the DSI and the Dependent Variables

Item	1	2	3
1. DSI Score	1		
2. Safety Incident	-0.17*	1	
3. Risk Factors	-0.15	-0.14	1

*Correlation is significant at the 0,05 level

Correlations established that the DSI score and safety incidents were negatively yet significantly correlated at -0.17* ($p = <0.05$ small effect) as indicated in Table 5 above. A negative correlation was expected as a lower DSI score indicates a higher risk probability; this means that those with safety incidents obtained a lower DSI score. Indicated in Table 5 is also the negative correlation found between the DSI score and the risk profile factors. This relationship did not have a significant correlation at -0.15.

Years of experience and age were investigated as literature reports that both years of experience and age have an influence on relationship with accident-proneness or risk propensity. Years of experience, in the context of this study, refers to number of years of experience in a specific position and not the overall or total years of experience worked. Correlations were again used to test for Hypothesis 3 which was the relationship between biographical variables and the safety incident and risk factor group.

The effect of years of experience on the job and age on the safety incidents and risk factors group was investigated as illustrated in Table 6.

Table 6

Correlation of Age, Years of Experience, Safety Incident and Risk Factors

Item	1	2	3	4
1. Year	1			
2. Age	0.52**	1		
3. Incident	0.05	0.08	1	
4. Factors	0.09	0.12	-0.14	1

- *Correlation is significant at the 0,05 level
- + Correlation is practically significant $r > 0,30$ (medium effect)
- ++ Correlation is practically significant $r > 0,50$ (large effect)

As indicated in Table 6, except for the correlation of 0.52** ($p = <0.05$) between years of experience and age, no other significant relationship was observed. Therefore, Hypothesis 3 is not accepted as biographical years of experience and age did not have a relationship with safety incident and the risk factors group.

ANOVA

Analysis of Variance (ANOVA) is used to test for significant differences between the means of groups. ANOVA was used to determine if there is a statistical significant difference between the DSI scores of the three groups. A statistical significant difference was established at <0.05 level [$F = 5.55$ $p = 0.00$] $M = 138,245$. This means that there is a statistically significant difference in the means between the three groups. ANOVA was thus used to test Hypothesis 4 indicating that differentiations can be drawn between three sample groups.

Cohen's d Statistics

Cohen uses d statistics to compare the means of two groups which indicates the practical significance. This is done by the difference between the mean of the two comparison groups divided by the pooled standard deviation. According to Cohen,

effect sizes range from 0.2 which is considered to be a small effect, to 0.5 a medium effect which is large enough to be visible to the naked eye and to 0.8 a large effect (Cohen, 1988). Hypothesis 4 was further confirmed by Cohen’s *d* statistics as indicated in Table 7 below, which indicates precisely where the differences between the groups were.

Table 7

Differences in the Sample Groups on Cohen’s d Statistics

DSI Score							
Control (N=120)		High Risk Factors (N=38)		Total (N=158)			
Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	D	
42.48	4.83	40.42	4.48	41.98	4.82	0.43	
DSI Score							
Control (N=120)		Safety Incidents (N=35)		Total (N=155)			
Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	D	
42.48	4.83	39.66	5.96	41.84	5.22	0.54	
DSI Score							
High Risk Factor (N=38)		Safety Incidents (N=35)		Total (N=73)			
Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	D	
40.42	4.48	39.66	5.96	40.05	5.22	0.15	

There was a difference of a small effect size ($d = 0.15$) between the means of the risk factor profile and safety incidents group.

There is a practically significant difference between the DSI means of the control group and safety incidents ($d = 0.54$) and the control group and the high risk factors ($d = 0.43$), both to a medium effect, which according to Cohen’s definition of medium effect, will be observable in practice.

The safety incident group obtained the lowest DSI score of the three groups with a mean of 39.66; a low DSI score indicates higher risk propensity or probability.

Figure 1 shows the DSI bands and ranking of the three sample groups according to the bands ranging from Low to Very High, where clear differences are evident between the three groups.

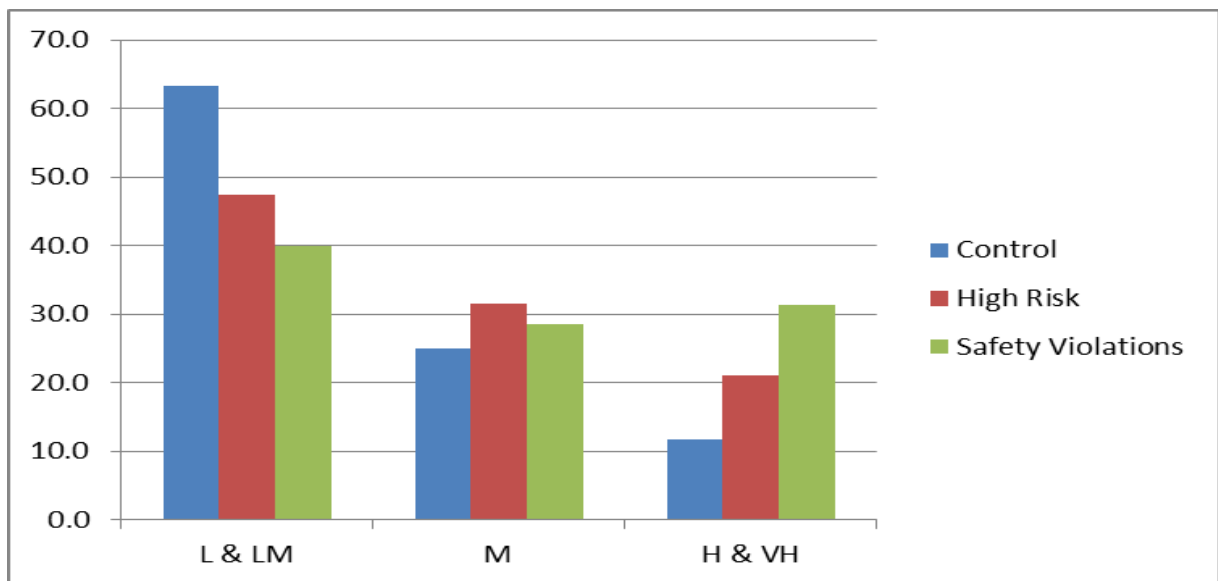


Figure 1. DSI bands across the 3 sample groups

The safety incident group has a greater percentage of people classified under the very high (VH) and high (H) DSI band, followed by the high risk employees from the risk profile. The control group has the greatest percentage people classified in the band of low risk (L).

No relationship between the DSI and age could be determined; however, a correlation between the DSI and years of experience was further investigated by dividing the sample into two with the purpose of getting two or more less equal groups in terms of experience. The sample was divided into two groups, (n = 83) participants of the sample had between 0-3 years' experience and (n = 110) had between 4 and more years of experience. Only one participant had 27 years of experience and this was seen to be an outlier, the participant was excluded from the analysis and this yielded no difference; thus, in continuing the participant was included.

T-tests are a widely used statistical method for the purpose of drawing comparisons between group means. T-tests were done to determine the significance of years of experience and the DSI score. There was not a practically or statistically significant difference in the scores for the DSI between employees with 0-3 years' experience ($M = 41.88$, $SD = 5.22$) and those with 4 years or more experience ($M = 41.32$, $SD = 5.03$) with $d = 0.11$ and $t(191) = 7.55$, $p = 0.451$.

Chi-squares are statistical tests used to compare observed data with data one would expect to obtain according to a specific hypothesis. Chi-square was then used to determine if there are differences in the safety incidents of participants who have incidents and participants with no incidents with 0-3 years and 4 and more years of experience. Chi-square was also used to determine if there are differences in the high risk profiles of participants with one or more factors versus participants with no factors with 0-3 years' experience on the job and those with 4 years and more experience on the job.

The differences were investigated and a statistically significant difference in the safety incidents group ($\chi^2 = 5.215$, $df = 1$, $p = 0.022$) was found, but not for the high risk factors group ($\chi^2 = 0.005$, $df = 1$, $p = 0.942$).

DISCUSSION

The objective of this study was to investigate if the DSI had the predictive capability of identifying risk employees from the three sample groups; also to determine if there would be differences using the variables of age and years of experience across the three groups, drawing similarities between the groups with high risk and safety incidents.

Pearson's correlations were used to determine the various correlations between the DSI score safety incidents and high risk factors group. A negative yet significant correlation was found between the DSI score and the safety incidents group, whereas no significant correlation was found between the DSI score and the high risk factors group.

Clear and significant differentiations were established between the three sample groups, thus confirming the hypothesis that the DSI has the ability to differentiate between the three groups based on the DSI score of the risk factors and the safety incidents group with a $d = 15$; and a large difference between the DSI score of the control and the safety violations group; as well as the control and risk factors group. This was expected as there should be a differentiation between participants who have no incidents or risk factors against their names and those who have incidents and are on the risk profile. The hypothesis of the DSI being able to identify accident-prone individuals is confirmed by

the results of the safety violations sample having a particularly lower DSI score in comparison with the other two groups, as these are the groups that have incidents against them, followed by the risk profile group with a mean of 40.42. Based on this, the hypothesis of the instrument having predictive capacity is confirmed, as the risk profiles participants' accident probability is higher than the control group, based on their lower DSI score in comparison with the control group. Across the three sample groups, the control group maintains the highest DSI score. It is important to note that employees on the risk profile have already been identified as potential risk employees based on the characteristics embedded in the risk profile; thus, their lower DSI score in comparison with the control group substantiates this.

A bar graph was used to illustrate the spread of the three sample groups across the DSI bands. It was found that the safety violation group has more people classified under the very high and high band, as this group's DSI score is lowest, followed by the risk profile employees. This is merely a graphical representation of what was stated regarding the significance of $d = 15$ between the risk profile group and the safety violations group. The control group has the highest number of people clustered in the band of low risk.

There were no differences found between safety incidents and risk factors of the two age categories 22-35 and 36-51. This is contradictory to literature findings of Catchpole (2005) stating that young drivers may engage in risky behaviour because of their unawareness of the risk involved in their behaviour, as a result of inexperience and error. However, inexperience does not account for all the variance in their risky driving. Furthermore, no statistically significant difference was found for both age groups against the safety incidents and the high risk factors group. Thus, the hypothesis of the biographical variable as well as the safety incident group and risk factor group could not be fully accepted and could only be partially confirmed as significant relationships were only found between the DSI score and safety violations, particularly for employees with only four and more years of experience. No correlations were established for the DSI and the high risk factors group or even safety incidents group for both age categories as well as employees with 0-3 years' experience with no safety incidents and risk factors.

There were various limitations to the study; the most significant being the time that the study was administered in. Employees were highly sensitive as it was shortly after the wild-cat strikes in the industry, employees were thus reluctant to participate in the study and reveal their identity. Questionnaires which were completed anonymously were excluded from the sample as they could have been in either one of the two groups of safety violation or risk profile. This was done in order not to influence the results in any way. Language difficulties and getting a fair female representation in the sample also posed a challenge and limitation.

RECOMMENDATIONS

It is recommended that the mine under study starts making use of a DSI as part of its selection process in the recruitment of operators. This will assist in determining the risk propensity of potential employees and in developing more proactive measures of managing safety. It is also recommended that a cross-functional, integrated way of working patterns be established between the various departments, this would entail an integrated approach to managing safety where the Safety department implements safety interventions that are to a degree centred on human behaviour through the assistance of behavioural experts who sit in HR departments.

REFERENCES

- Ablitt, H., Burke, E., & Vaughan, C. (2010). *Dependability and Safety Instrument (DSI) version 1.1* Technical Manual.
- Adams, E. (1976). Accident causation and the management systems. *Professionals Safety*, Oct, ASSE.
- Af Wåhlberg, A., & Dorn, L. (2009). Bus driver accident record: The return of accident-proneness. *Theoretical Issues in Ergonomics Science*, 10(1), 77–91.
- Arbous, A. G., & Kerrich, J. E. (1951). Accident statistics and the concept of accident-proneness. *Biometrics*, 7, 340-432.
- Bartram, D., & Brown, A. (2005). Five factor model (Big Five) OPQ32 report. Thames Ditton, UK: SHL.
- Bennet, D. J., & Passmore, D. L. (1984). Correlates of coal mine accidents and injuries: A literature review. *Journal of Accident Analysis and Prevention*, 16(1), 37–45.
- Beirness, D. J. (1993). Do we really drive as we live? *The role of personality factors in road crashes. Alcohol, Drugs and Driving*, 9, 129-143.
- Blumberg, M. S., & Coffin, J. C. (1956). Syllabus on work absence. *Arch Industry, Health*, 13, 55-70.
- Bridger, R. S., Brasher, K., Dew, A., & Kilminster, S. (2008). Occupational stress and strain in the Naval Service 2007. *Occupational Medicine*, 58, 534-539.
- Broadbent, D. E., Cooper, P. F., Flitzgerald, P., & Parkes, K. R. (1982). The cognitive failure questionnaire and its correlates. *British Journal of Clinical Psychology*, 21, 1-16.
- Cummings, A. M., & Saleh, J. H. (2011). Safety in the mining industry and the unfinished legacy of mining accidents: Safety levers and defense-in-depth for addressing mining hazards. *Safety Science*, 49, 764–777.
- Catchpole, J. (2005). Learning to take risks. The influence of age and experience on risky driving. *Research report ARR 362*.
- Cooper, D. (2002). Human factors in accidents. Institute of Quarrying, North of England-CoalPro Seminar, Ramside Hall, Durham, UK.
- Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. Orlando, CA: Academic Press.

- Day, A., Brasher, K., & Bridger, R. S. (2012). Accident-proneness revisited: The role of psychological stress and cognitive failure. *Journal of Accident and Prevention*, *49*, 532–535.
- De Winter, J. C. F., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research*, *41*, 463-470.
- Didla, S., Mearns, K., & Flin, R. (2009). Safety citizenship behaviour: a proactive approach to risk management. *Journal of Risk Research*, *12*, 475–483.
- Donald, I., & Young, S. (1996). Managing safety: An attitudinal-based approach to improving safety in organizations. *Leadership & Organisation development Journal*, *17*(4), 13–20.
- Farmer, F., & Chamber, F. G. (1926). A psychological study of individual differences in accident rates. *M.R.C industry. Fat Res. Bd. Rep no*, 38, H.M.S.O., London.
- Fernandes, R., Job, R. F. S., & Hatfield, J. (2007). A challenge to the assumed generalizability of prediction and countermeasures for risky driving: different factors predict different risky driving behaviours. *Journal of Safety Research*, *38*, 59–70.
- Ferguson, D. (1972). Some characteristics of repeated sickness absence. Occupational Health Section. *School of Public Health and Tropical Medicine*. University of Sydney, Australia.
- Fortuin, G. J. (1955). Sickness absenteeism. *Bulletin World Health Organisation*, *13*, 513–541.
- Froggatt, P., & Smiley, J. (1963). The concept of accident-proneness: A Review. *British Journal of Industrial Medicine*, *21*, 1–11.
- Geller, E. S., & Wiegand, D. M. (2005). People-based safety: The source, Virginia Beach, VA: Coastal Training and Technologies.
- Goldberg, D., & Williams, P. (1998). *A user's guide to the General Health Questionnaire NFER Nelson*. Basingstoke, Hampshire: Basingstoke Press.
- Greenwood, M., & Woods, H. M. (1919). The incidence of industrial accidents upon individuals with special reference to multiple accidents. *Industrial Fatigue Research Board, Medical Research Committee, Report 4*. Her Majesty's Stationery Office, London.

- Griffin, M. A., Hart, P. M., & Neal, A. (2000). The impact of organisational climate on safety climate and individual behaviour. *Safety Science*, 34, 99–109.
- Holland, C., Geraghty, J., & Shah, K. (2010). Differential moderating effect of locus of control on effect of driving experience in young male and female drivers. *Journal of Personality and Individual Differences*, 48, 821–826.
- IBM SPSS Statistics for Windows Version 20.0 (2011). Armonk, NY: IBM Corp.
- Johan, B. A., & Dawson, N. E. (1987). Youth and risk: Age differences in risky driving, risk perception, and risk utility. *Alcohol Drugs and Driving*, 3, 13–29.
- Kasap, Y. (2011). The effect of work accidents on the efficiency of production in the coal sector. *S Afri J Sci*, 107(5/6)9. doi:10.4102/sajs.v107i5/6.513.
- Kecojevic, V., Komljenovic, D., Groves, W., & Radomsky, M. (2007) An analysis of equipment-related fatal incidents in US mining operations: 1995–2005. *Journal of Safety Science*, 45, 864-874.
- Kweon, Y. J., & Kockelman, K. M. (2003). Overall injury risk to different drivers: Combining exposure frequency, and severity models. *Accident Analysis and Prevention*, 35, 441–450.
- Lim, M. S. C., Murray, J., Dowdeswell, R. J., Glynn, R. J., & Sonnenberg, P. (2011). *Unnatural Deaths in South African Platinum Mines 1992-2008*. (6)9, e22807. doi:10.1371/journal.pone.0022807.
- Maritime Coastguard Agency. (2007). *Fatigue in Seafarers*. MCA/181/2007.
- McEwen, B. S. (2006). Protective and damaging effects of stress mediators: Central role of the brain. *Dialogues in Clinical Neuroscience*, 8(4), 367–382.
- Murray, J., Sonnenberg, P., Nelson, G., Bester, A., & Shearer, S. (2007). Cause of death and presence of respiratory disease at autopsy in HIV-1 seroconversion cohort of southern African gold miners. *AIDS* 21.
- Ormel, J., Von Korff, M., Ustun, T. B., Pini, S., Korten, A., & Oldehinkel, T. (1994). Common mental disorders and disability across cultures: Results from the WHO collaborative study on psychological problems in general health care. *JAMA*, 272, 1–8.
- Permana, H. (2012). *Risk Assessment as a strategy to prevent mine accidents in Indonesian mining*. Universitas Publishing House, Petroșani, Romania. ISSN-L 1220 – 2053 / ISSN 2247 -8590

- Quinlan, M., & Bohle, P. (1991). *Managing occupational health and safety in Australia*. Melbourne, Australia: MacMillan.
- Rohrmann, B. (2004). Risk attitude scales: Concepts and questionnaires. Project Report. Retrieved from <http://www.rohrmannresearch.net/pdfs/rohramann-racereport.pdf>.
- Schmidt, K. H., Neubach, B., & Heuer, H. (2007). Self-control demands, cognitive control deficits and burnout. *Work and Stress*, 21, 142–154.
- Shinar, D., & Compton, R. (2004). Aggressive driving: An observational study of driver, vehicle and situational variables. *Accident Analysis and Prevention*, 36, 429–437.
- Statistics South Africa. (2010). *Mortality and causes of death in S.A, 2008. Findings from death notification*, Pretoria, South Africa.
- Struwig, F. W., & Stead, G. B. (2001). *Planning, designing and reporting research*. South Africa: Cape Town. Pearson Education.
- Vavrik J. Accident-prone. *Recovery* (1999), 9, 2–4.
- Walker, G. H., Stanton, N. A., & Young, M. S. (2008). Feedback and driver situation awareness. A comparison of SA measures and contexts. *Transportation Research Part F*, 11, 289–299.
- Weaver, D. A. (1971). *Symptoms of operational error*. Professional Safety Journal.
- Williamson, A. (2003). Why younger drivers are over represented in crashes? Summary of issues. Update of literature review: literature 2000–2003. *Report for motor accident authority, April 2003*. NSW Injury Risk Management Research Centre University of New South Wales.
- Work-Related Lung Disease Surveillance Report. National Institute for Occupational Safety and Health Publication No. 2008-143. (2007). Retrieved from <http://www.cdc.gov/niosh/docs/2008-143/default.html>.
- Wreathall, J. (1995). *Organizational culture, behavior norms, and safety*. Proceedings of the International Topical Meeting on Safety Culture in Nuclear Installations. pp. 24–28. Vienna, Austria.

CHAPTER 3: CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

In this chapter conclusions will be drawn from the study. Findings from the literature as well as empirical results will be included. The chapter will also shed light on limitations of the study and recommendations for future research.

3.1. CONCLUSION

This study explored the ability of the psychological assessment known as the Dependability and Safety Instrument with accident-proneness across three varying sample groups, namely the safety incident, risk factor and control group. Variables explored in relation to these three groups included the years of job experience and the age factor. The DSI score was also investigated along with these variables.

Hypothesis 1 is accepted as the DSI was able to identify the safety incidents group as accident-prone; this was established by the significantly lower DSI score of the safety group, as a lower DSI score indicates higher risk probability.

Hypothesis 2 was partially confirmed with the correlation established between the DSI score which is the independent variable, and the safety incidents, the dependent variable. This relationship was a negative linear relationship. The correlation found between the DSI and the second dependent variable, the risk factors, was not significant.

Literature revealed contradictory evidence pertaining to years of experience and age. The findings from this research indicate that there is no significant relationship between the DSI score as well as age across the three groups, but significant relationships were found between the DSI score and years of experience for participants with four or more years of experience from the safety incidents group. This finding is supported by literature from De Winter and Dodou (2010) who indicated that more experienced workers were more accident-prone. Thus, hypothesis 3 which proposed that biographical variables have a relation with accident-proneness across the three sample groups is partially accepted, as correlations were only found with years of experience on the safety incidents groups and not on the risk factors groups. Besides the correlation between years of experience and age, there were no other significant correlations.

As expected, large differences existed between the risk factors and safety incidents group in relation to the control group; and small differences existed between the risk factors and safety incidents group. This confirms Hypothesis 4, as clear differentiations and distinctions were established between the three sample groups through the DSI.

According to Butani, (1988); Chi and Wu, (1997); Kecojevic, Komljenovic , (2007); Groves, Radmosky , (2007) workers with the least experience have higher fatality rate than workers with more than 15 years of experience. Literature by Rohrmann (2004) has significant findings on the relationship that exists between years of experience, age, gender, and accident-proneness. However, this study only found a correlation between the DSI score and years of experience, specifically for employees with more years of experience.

Even though in this particular study no significant findings were found for age, there is a relation between age and accidents as can be seen in statistics that indicate that generally Iron Ore operations and alumina mills report the largest proportions of injured/ill older workers, at 46.3% and 44.9 % , respectively (Fotta & Bockosh, 2000).

It can to some extent be assumed that older workers are primarily workers who have more years of experience and thus research done by Ismail (2010) states that workers who were involved in the fatal accidents are more likely to belong to the same age group and experience group. Hence if that is the case the current study assumes it would be fair to then say according to the findings that it was the older, more experienced workers who appeared on the safety incidents group hence the significant relationship between years of experience and safety incidents. However the above is subject to vast variations and cannot be considered to be entirely valid.

While aging slows down some cognitive functions like the ability to process complex problems, it can enhance other cognitive skills such as ability to reason and ability for better verbal command (Illamarinen, 2001). The use of psychological assessments that specifically assess psychomotoric ability, older workers may struggle as they require fairly good psychomotoric ability.

The conclusion that can be drawn from these results is that organisations need to move to a more humanistic and behaviour-orientated framework for managing safety where dimensions such as personality and accident-proneness or the aspect of human error are explored more in the safety interventions designed.

It is becoming apparent that employee's attitudes and behaviour govern how they identify risks in the workplace and therefore a behaviour-oriented approach is required. This is also particularly important as results from the DSI and its relations to age and experience indicated that personality continues to manifest well beyond the age of forty.

Making use of the DSI in future recruitment for operators will allow the organisation to employ a more pro-active approach to safety, and to be measured against leading- and not lagging indicators in terms of safety.

3.2 LIMITATIONS

There were various limitations in the study that contributed directly to the size of the sample. One of the first limitations was the specific time during which the assessments were administered, particularly only a couple of months after the strike at the particular mine. This resulted in employees being reluctant to participate in the study. Furthermore, participants did not want to reveal their names, thus posing a challenge when having to split the sample group; as there was a number of anonymous participants who could have possibly been in the safety incidents or risk factors group, this resulted in the sample size between the risk factors and the safety incidents group being smaller.

A second limitation was the poor reading ability of the participants, as the majority had difficulty in understanding the survey. These were mainly participants without a Grade 12 education. Such participants had to be excluded from the study as the minimum requirement to do the DSI is a Grade 12 qualification, resulting in a further reduction in the sample size.

The mining industry, including the mine in this study, is predominantly male-dominated. There were a very limited number of female participants in the study,

limiting the ability to explore the relation that gender would have had with the DSI score or within one of the three sample groups.

3.3 RECOMMENDATIONS

After careful analysis of the study, the following recommendations are made:

3.3.1 Recommendations for the Industrial Psychological Centre (IPC) of the Organisation

It is recommended that the centre employs the DSI as part of its recruitment process for operators. This will enable the centre to develop trends and patterns around the behaviour of operators; these trends can be used to expand on the concept of accident research in the behavioural context. In addition, it is recommended that the IPC use a personality survey such as the Work Style Questionnaire which has a correlation of 0.72 with the DSI score. This is important as the literature supports the notion that there is a relationship between personality and accident-proneness; thus, in addition to the risk profile, a risk “personality” profile can be developed which can be tied into the scores of the DSI. Making use of the DSI will not only benefit the mine under study in terms of saving on costs incurred as a result of accidents, but also identify potential employees with counter-productive behaviour such as absence, as the items are designed to tap into such facets of behaviour.

3.3.2 Recommendations for the Safety Departments

It is recommended that the safety departments put a process in place that requires them to consult with the IPC in the event of an accident, in order to be able to identify the risk propensity of the employee based on the DSI, should this assessment be employed as part of the recruitment process. It is recommended that the safety departments start drawing up trends in terms of age, gender and experience of people who are involved in accidents and develop safety initiatives around such trends. These trends could also be used as a basis for future research for the IPC, not necessarily on assessments such as the DSI, but other psychomotoric assessments that are being used.

It is recommended, based on literature as well as on the findings of this study, that the safety department further explores a concept known as safety behaviour citizenship which is a proactive measure for risk management. Lastly, it is recommended that the safety department starts working closely with industrial psychologists to seek assistance in developing interventions that are more orientated towards human behaviour.

3.3.3 Recommendations for Super-users of the Risk Profile (HR Community)

It is recommended that the super-users of the risk profile embark on an in-depth analysis of the factors of the profile by also drawing up patterns and trends in terms of gender and age. By exploring which age or gender group most commonly appears on which factor will assist the HR community to come up with specific tailor-made training interventions.

3.3.4 Recommendations for Future Research

It is important to note that this study was carried out on a small scale and merely served as a pilot study. Thus, in future it would be recommended that a larger sample size be attained where there is a fair representation of female participants. In addition, future research can focus on the DSI as well as its correlation to existing assessments that are currently being made use of in the mine, such as the Vienna Test system to specifically focus on the variable of age between the two assessments; even though the finding from the study indicated no significant relation between age and the DSI score. A larger sample size with a more diverse population of age ranges might yield different results.

The current study was solely focused on haul truck operators. However, it leads to questioning what the results might have looked like for jobs that are considered less risky.

4. REFERENCES

- Chi, C.F., & Wu, M.L. (1997). Fatal occupational injuries in Taiwan, Relationship between Fatality Rate and Age, *Safety Science*, 27, 1–17.
- De Winter, J. C. F., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research*, 41, 463–470.
- Fotta, B., & Bockosh, G. (2000). *The Aging workforce: An Emerging Issue in the Mining Industry*. National Institute for Occupational Safety and Health.
- Groves, W., Kecojevic, V., & Komljenovic D. (2007). Analysis of fatalities and injuries involving mining equipment. *Journal of Safety Research*, 38(4), 461–470.
- Ilmarinen, J. (2001). Finnish Institute of Occupational Health, Department of Physiology Occupational and Environmental Medicine.58:546; doi:10.1136/oem.58.8.546
- Ismail, M.N.M. (2010). An Analysis of Fatal Incidents In Metal and Non-Metal Mines from 2002-2006. A thesis in Energy and Mineral Engineering, Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science.
- Kecojevic, V., Komljenovic, D., Groves, W., & Radomsky M. (2007). An analysis of equipment related fatal accidents in U.S. mining operations: 1995–2005. *Safety Science*, 45(8), 864–874.
- Rohrmann, B. (2004). Risk attitude scales: Concepts and questionnaires. Project Report. Retrieved from <http://www.rohrmannresearch.net/pdfs/rohramann-racereport.pdf>