BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF ENVIRONMENTAL SCIENCE

AN ASSESSMENT OF THE CAUSES OF UNDERGROUND MINING ACCIDENTS AT SABI GOLD MINE, ZVISHAVANE

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE BACHELOR OF ENVIRONMENTAL SCIENCE HONOURS DEGREE IN SAFETY HEALTH AND ENVIRONMENTAL MANAGEMENT.

OCTOBER 2014
DEDICATION

I dedicate this project to my brothers and their spouses Mr. and Mrs. F.N Zhou, Mr. and Mrs. C.M Dzichavakwa for their unwavering support. May the Good Lord richly bless you!
ACKNOWLEDGMENTS

I would like to start by giving all the honor and glory to the Almighty God for His mercies that endures forever!

I would like to extend my sincere gratitude to my academic supervisor Mrs. L. Mabhungu, I thank you so much madam, and may the Lord God richly bless you spiritually, academically, financially, physically as well as in your marital life! All Bindura University of Science Education staff from the department of Environmental Science I thank you as well.

I would also like to extend my sincere gratitude to all my family members, mum Mai Dee, Merjue, Dee, Mai Shumie, Mai Bee and Msaigwa. I also want to thank Miss F. Madhuku, Mrs.Mudzinganyama, Mr. and Mrs.Menyani, Sabi Gold Mine SHE Officer Mr. K. Chiwawa, my friend L. Zulu and his wife and all AFM in Zimbabwe, Springs of Life Assembly church mates for the assistance you rendered. TafadzwaShumba I thank you my dear for all the support and encouragement. Not forgetting my fellow SHEM students, kudos to you all.

Last but not least, Sabi Gold Mine management for allowing me to undertake my research project at your company, I thank you so much.
ABSTRACT

Underground mining accidents are a common phenomenon in the mining sector and Sabi Gold Mine is not an exemption. This study seeks to assess the causes of underground mining accidents as well as tracing their trend of occurrences at Sabi Gold Mine. A survey research design was followed during the collection of data. The sampling frame was the underground mining department. The study population was sub-divided into 5 different strata according to underground sections which are: tramming, lashing, construction, hoisting and drilling. Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 20 using the Chi-Square tool to analyze the occurrence of accidents in relation to age of employees, PPE use, shift of work and section. Of the total participants (n=57) selected, 32 (56.1%) were once involved in an underground mining accident and 25 (43.9%) were not. Of the total accidents, 14 (25%) of the accidents were caused by rock falls, 10 (18%) by shortcuts. Lack of concentration contributed 7 (12%), PPE, defective equipment and faulty ladders contributed 5 (9%) apiece. 3 (5%) lack of communication and incompetence and improper equipment contributed 2 (3%) apiece. Rock falls and unsafe acts (shortcuts) are the main causes of accidents at Sabi Gold Mine. There is an upward trend in the occurrence of accidents from 2011 to 2014 (January to April), lashing and tramming operations being more prone to accidents than other sections. It has been also noted that night shift is vulnerable to accidents than morning and afternoon shifts. Training programs should be increased particularly towards trammers, lashers and employees who fall in 18-24 and 35-44 age groups.
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<td>Description</td>
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<td>---------</td>
<td>--------------------------------------------------</td>
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<tr>
<td>LTIFR</td>
<td>Lost Time Injury Frequency Rate</td>
</tr>
<tr>
<td>MTD</td>
<td>Messina Transvaal Development</td>
</tr>
<tr>
<td>NSSA</td>
<td>National Social Security Authority</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>ZMDC</td>
<td>Zimbabwe Mining Development Corporation</td>
</tr>
</tbody>
</table>
CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION
Mining accidents are complex in nature and it has been statistically proven that these accidents are caused by a number of factors (Saari et al., 2003). Human errors are among the chief causes of mining accidents though the common ones include rock falls, gas/fumes, misfires as well as explosions (Boniface et al., 2013). Kamalinia et al. (2012) postulated that accident causation exercises has been conducted and technological advancements were incorporated into the exploration of minerals but accidents are still occurring across the mining industry. Therefore it means that addressing mining accidents calls for a broader approach that incorporates different stakeholders across mining sector.

Two million people die from work related accidents annually and two hundred and sixty eight million get injured at work while an average of three days’ work lost as a result of injuries worldwide (NSSA Report, 2013; Hamalainen, 2013). Mining industry remains among the highest risky occupations in the world (Colemen and Kerkering, 2007) as witnessed by the number of deaths and injuries recorded each year. In the European Union, about 5 500 people die and more than 75 000 are injured to such an extent that they are not capable of going to work again (Sanmiquel, 2010).

Mining industry is equally notorious when compared to manufacturing industry as can be noted from previous documented disasters that include among others, the Tanzanite mine disaster of 2002 that claimed 65 lives after floods swept into the mine tunnel (Boniface et al., 2013). Also about 177 miners were killed on September 1986 at the Kinrose Gold Mine in South Africa. In Zimbabwe, the Kamandama, Hwange Colliery disaster of June 1972 that claimed 426 miners also worth mentioning (Maunganidze et al., 2013). Also the recent disaster that occurred on June 10 2014 at Golden Valley Mine in Kadoma where 7 people died also attests how risky the mining industry is.

According to the NSSA on Guard publication of June 2013, close to 21 workers are injured in every 8-hour shift and almost 2 workers are killed on the job in Zimbabwe. For the past 20 years...
(1993-2013), a total of 192 deaths were recorded from the mining sector in Zimbabwe (NSSA Annual Statistics, 2000-2013). According to the Chamber of Mines of Zimbabwe annual report, (2013), fall of ground is the main cause of mining accidents due to inadequate roof support systems.

Sabi Gold Mine is wholly owned by the Zimbabwe Mining Development Corporation (ZMDC). The mine is into underground mining of gold has started operating around 1884 owned by the Messina Transvaal Development (MTD) before it was acquired by ZMDC in 1984 to date. Mining is done following a 5 meter wide gold reef and it stretches down to about 300 meters. The mining company has a history of accidents but however accessed reports shows that no fatality has ever happened. As stated in its Safety and Health policy, Sabi Gold Mine is committed in abiding to legal and other requirements to which it subscribes for the improvement of safety and health of its employees. Regardless of all the procedures and measures taken to prevent accidents, they still occur at an alarming rate.

1.2 PROBLEM STATEMENT
Since the re-opening of Sabi Gold Mine in 2011 following its closure in 2007 the company has recorded a rise in underground mining accidents. 26 accidents were recorded in 2011, 45 were recorded 2012, 69 in 2013 and 14 were recorded during the first quarter of 2014. A Lost Time Injury Frequency Rate (LTIFR) which is above the standard of 0.7 set by the National Social Security Authority (NSSA) was recorded. An LTIFR of 1.32 was recorded in 2012, 1.61 in 2012, 1.93 in 2013 and 1.15 during the first quarter of 2014. Sabi Gold Mine is guided by the OSHAS 18001:2007 Standard for all its operations and also abides to all relevant legal statutes such as the SI 109 Mining (Management and Safety) Regulations of 1990. Safe working procedures are documented and enforced. However, despite all this, mining accidents continue to rise at the company.

1.3 JUSTIFICATION
Understanding causes and/or trends of accidents is vital in decision making which aims to achieve zero accidents rates at Sabi Gold Mine. The results of the project would be adopted by
the company so as to help improve the production, reduce financial losses through compensation as well as improved safety and health of its employees.

Zimbabwe mining sector forms the bedrock of the economy, contributing 15.7% to the Gross Domestic Product (GDP), employing 45,800 people (Chamber of Mines Report, 2013). Basing on this, there is need for an assessment on the ever increase in mining accidents for the benefit of the nation/economy and also gold mines in Zimbabwe. This project would also add value to the mining body of knowledge in accident prevention and control.

1.4 AIM
To assess the causes and trends of underground mining accidents at Sabi Gold Mine.

1.5 OBJECTIVES
1.5.1 To determine factors that causes underground mining accidents at Sabi Gold Mine.

1.5.2 To determine the trends on the occurrence of underground mining accidents at Sabi Gold Mine.

1.6 RESEARCH QUESTIONS
1.6.1 What are the factors that lead to the occurrence of underground mining accidents at Sabi Gold Mine?

1.6.2 What are the trends in the occurrence of underground mining accidents at Sabi Gold Mine?
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CAUSES OF MINING ACCIDENTS
Mining accidents are caused by a number of factors and the introduction of modern-day mining technologies did not completely solve the problem (Saari et al. 2003, Zakaria et al. 2012). Factors that causes accidents include unsafe acts, unsafe conditions, job factors, personal factors and many other factors (Hughes and Ferret, 2010). Different theories concerning the occurrence of accidents were postulated to figure out the causes of accidents were brought about.

2.1.1 DOMINO THEORY
The theory is dated back to the late 1920’s and it was put forward by Heinrich Domino. Hughes and Ferret (2010), suggested that when an accident occurs it follows the Domino theory which attests that accidents don’t just happen but they are caused. According to the Domino theory, 88% of all accidents are caused by unsafe acts, 10% are caused by unsafe conditions and 2% occurs naturally, by “God”s case”. The theory proposed a “five-factor accident sequence” in which each factor would actuate the next step in the manner of toppling the dominoes lined up in a row (Stringfellow, 2010).

According to the theory, the five factors are: a) social environment or inherited behavior; b) fault of the person (carelessness, bad temper, recklessness and so on); c) unsafe acts or conditions (improper use of PPE); d) accident and e) injury. Occurrence of an accident follows a sequence and the removal of one factor ultimately prevents the accident from occurring (Stringfellow, 2010). According to Li and Poon (2013), the process starts from the final domino where a personal injury occurs as a result of an accident. An accident occurs as a result of personal or mechanical hazard that exist only through the fault of careless persons or poorly designed or improperly maintained equipment. Faults of persons are inherited or acquired as a result of their social environment and the environment is where and how a person was raised and educated.

In his other study in USA in 1950, H. W Heinrich concluded that, for every 1 major accident there are 30 minor accidents, 300 near misses and several at risk behavior. According to Zakaria et al. (201 2), human errors can be regarded to as unsafe acts which he defined to as human action that departs from hazard control or job procedures to which the person was trained which causes exposure of the person to the hazards. Unsafe conditions, personal factors and job factors are also attributed to human errors.
2.1.2 HUMAN FACTORS THEORY
The theory was developed by Heinrich in the late 1920s and aims to point human errors as the main causes of accidents. Chen and Zorigt (2013), stated that human error is the fundamental reason behind accidents and management being responsible for the prevention of accidents. Human factors theory consists of three broad factors which are overload, inappropriate response and inappropriate activities. Overload is defined by the imbalance between the loads carried by the employer in relation to his/her personal capabilities. Inappropriate responses are the unsafe acts done by the employee whilst at work. Inappropriate activities, according to the theory, are when the employee executes duties which he/she is not capable.

2.2 CLASSIFICATION OF ACCIDENTS
According to the ILO Code of Conduct Practice (1996) as cited by Hamalainen et al (2006), occupational accident is an occurrence arising out of or in the course of work which result in fatal occupational injury or non-fatal occupational injury. Mining accidents are classified according to their severity, first aid cases, minor (non-lost time), major (lost time) and fatality (death) (SI 68:1990). According to the Taiwan Labor Safety and Health Act as quoted by Cheng et al. (2012) major accident is accidents that causes injuries to three or more persons or causes death of at least one person at the time it occur.

Hamalainen (2006), postulated that there are two types of accidents and these are: individual and organizational accidents. Individual accidents are the ones where the individual is both the agent of the accident and the victim. Organizational accidents are very rare though they are more catastrophic. These are the events which have multiple causes and they occur within complex modern technologies.

2.3 ACCIDENT TRENDS IN ZIMBABWE
According to NSSA On guard Volume N. 18 June 2013 close to 21 workers are injured every eight hour work day and almost 2 workers are killed on the job each day in Zimbabwe. NSSA annual reports show that a total of 172 fatalities were recorded since the 2000 till 2013 (NSSA Annual Report, 2013). The Chamber of Mines of Zimbabwe 2013 shows that 51.4% of the mining accidents are caused by the fall of ground and the rest by some other factors such as gassing, explosives, shaft among others.

Figure 2.1 : Trends of fatalities in the Zimbabwean mining sector for the past 20 years.
Figure 2.1: Frequency distribution of Zimbabwe mining fatalities.

**SOURCE:** NSSA ANNUAL STATISTICS REPORT 2000-2013
2.4 ADVERSE EFFECTS OF MINING ACCIDENTS
Occurrence of an accident causes untold suffering to both the casualty and the company in many aspects. Hrymak and Perezgonzalez (2007), stated that the consequences of an accident to the casualty’s social life include: lack of concentration, changes in decision making, depression, isolation and also changes in family life. Hughes and Ferret (2010) argued that accident effects follow the Iceberg Theory which talks of direct and indirect costs. According to the theory, direct costs are those costs which are directly related to the accident. For example, absence of employees, damage to equipment, production loss and medical costs. Indirect costs are those costs which may not be directly attributable to the accident but they may result from a series of accidents. These include recruitment of new employees, legal expenses, investigation time as well as legal expenses.

2.5 ACCIDENT INVESTIGATION
Zakaria et al (2012), postulated that to understand why and how an accident happens is the first step in finding the solution. The idea behind accident investigation is to establish all the factors that directly or in-directly contributed to the accident in question. A number of researches have shown that accidents do not just happen on their own but they are caused by a number of factors, chiefly being the human error (Domino Theory). Hamalainen (2010), asserted that gone is the era when accidents were thought to as being from the gods and connected to the nature.

Accident investigation is done to ascertain the causes of an accident through application of different techniques such as the root cause analysis, the tripod, the „5” whys among other techniques.

2.6 ACCIDENT PREVENTION
Hamalainen (2010) argued that accident prevention should be centered on human errors as highlighted by Heinrich (1929) who concluded that 88% of the total accidents results from human errors. Programs that focus on human performance are to be implemented and the programs include, on job training, update training, motivational programs and also safety inductions.

Accident prevention requires for a collective bargain that requires both employer and employees” input. According to Chen and Zorigt (2013), accident prevention lies in the hands of the management since it is the one that provide resources, trainings, PPE and so on.

2.7 MAJOR FINDINDS ON RELATED STUDIES
In a study carried out in Queensland Mining in Australia by Patterson and Shappell (2010), mining accidents do not happen in isolation but they result from a chain of events. The events
normally start from an organizational level up to the unsafe act by the operator. Reason (1990) as quoted by Patterson and Shappell (2010), postulated that accident prevention should start from controlling human error that comes in four levels, that is, (i) organizational influences (ii) unsafe supervision (iii) preconditions for unsafe acts and (iv) unsafe acts of the operator(s).

Jacinto and Soares (2008) carried out their study on the causes of occupational accidents in the Portuguese Mining and Quarrying sector. The study focused on the causes of mining accidents basing on the circumstances of its occurrence taking consideration of the work environment, working process, specific physical activity and deviations. Any deviations from a safe work/operating procedure may cause accidents (Jacinto and Soares, 2008).

Breuer et al. (2002) investigated the role and impact of legislation and law enforcement on the rate of occupational accidents in the mining industry in Germany. In the same line of research, Laurence (2005) debated the changes in the Australian mining industry regulatory structure from compliance-based to a risk based approach in relation to mining accidents. Laurence concludes his paper by saying that (i) management and regulators should not continue produce more and more rules and regulations to cover for every aspect of mining, (ii) detailed prescriptive regulations, detailed work procedures and voluminous safety management plans will not “connect” with a miner and (iii) achieving more effective rules and regulations is not the only answer to a safer workplace.

Sanmiquel et al (2010) analyzed work related accidents in the Spanish mining sector basing on a system designed to allow coding of a sequence of events that immediately proceeded to an accident. According to the study, events that can lead to an accident can be classified in one of the four ways, that is, environmental events (poor illumination, poor ventilation), equipment events (malfunctioning, defective), medical events (epileptic, diabetic) and behavioral events (at risk behavior).

Lenne et al, (2012) carried out a study on understanding systematic factors involved in mining accidents and to examine organizational and supervisory failures that that causes mining accidents in Australia. Human Factors Analysis and Classification System (HFACS) analysis method was being used. Jansen and Brent (2005) postulated that mining accidents are preventable and as a result they carried out their study in North-West province, South African mines analyzing accident causation basing on Safety Management Systems (SMS) and Behavior Based Safety (BBS).
CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 STUDY AREA DESCRIPTION
The study was carried out at Sabi Gold Mine which is wholly owned by the Zimbabwe Mining Development Corporation (ZMDC) and is located in the Midlands Province, Zimbabwe, 12 kilometers South-East of Zvishavane town at an altitude of 912 m above sea level at 20°23'47.17S and 30°07'58.37E. The location of Sabi Gold Mine is shown in figure 3.1 below.

Figure 3.1 : Map showing Zvishavane district and the location of Sabi Gold Mine
3.2 RESEARCH DESIGN
A survey research design was used and the population under study was underground mining workers (n=191). Both primary and secondary data sources were used in the collection of data.

3.3 DATA COLLECTION
Data collection tools used were questionnaires and a checklist which was used during underground walk through survey.

3.3.1 Determination of factors that cause underground mining accidents at Sabi Gold Mine

To achieve the objective, semi-structured type of questionnaires were used to collect the data (refer to appendix 1). Respondents were not allowed to write their personal identity information on the questionnaire for confidentiality purposes. The researcher also informed respondents on the nature and purpose of the exercise thereby promoting free participation of the employees without any cohesion to them.

Study population (underground mining workers) was sub-divided into strata as according to each one’s section. Five distinct strata were formed as follows: lashing, hoisting, construction, tramming and drilling. Strata were not homogeneous in size as sections were also not similar in size: tramming: 44; lashing: 60; hoisting: 25; construction: 14 and drilling: 48. The figures include supervisors of each respective section.

Questionnaires were randomly distributed so as to avoid systematic errors as each member was granted his/her equal chance of participation.
Table 3.1: Total number of respondents selected in each stratum.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Stratum Size</th>
<th>No. of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashing</td>
<td>60</td>
<td>17</td>
</tr>
<tr>
<td>Drilling</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>Tramming</td>
<td>44</td>
<td>13</td>
</tr>
<tr>
<td>Hoisting</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Construction</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>191</strong></td>
<td><strong>57</strong></td>
</tr>
</tbody>
</table>

3.3.2 Determination of the trends on the occurrence of underground mining at Sabi Gold Mine

The same questionnaire used for the first objective was used to answer this second objective. A walk through underground mine survey was conducted using checklist (*refer to appendix 2*). Walk through survey complimented data gathered using questionnaires as the researcher would have first-hand on what really transpires on the ground. Also SHE documents such as accident registers, SHE annual and monthly reports as well as accident statements were reviewed. These records provided information on the total number of accidents occurred in a particular time and highlighting the causes of each accident.

3.4 DATA ANALYSES

Data collected was analyzed using the Statistical Package for Social Sciences (SPSS) version 20 and analyzed using the chi-square tool to determine if there is any relationship between the occurrence of accidents and age or shift or sections or PPE. The $p$ values below 0.05 were considered to be statistically significant. The results of the tests were presented in graphs and pie charts drawn using excel.
CHAPTER FOUR

RESULTS

4.1 QUESTIONNAIRE DISTRIBUTION AND RESPONSE RATE ACROSS THE STRATA.
All questionnaires (n=57) issued out were returned back giving a response rate of 100% as illustrated in table 4.1 below.

Table 4.1 : Frequency distribution of questionnaires across strata.

<table>
<thead>
<tr>
<th>Stratum</th>
<th>No. of questionnaires distributed</th>
<th>No. of questionnaires collected</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashing</td>
<td>19</td>
<td>19</td>
<td>100%</td>
</tr>
<tr>
<td>Drilling</td>
<td>12</td>
<td>12</td>
<td>100%</td>
</tr>
<tr>
<td>Tramming</td>
<td>13</td>
<td>13</td>
<td>100%</td>
</tr>
<tr>
<td>Hoisting</td>
<td>5</td>
<td>5</td>
<td>100%</td>
</tr>
<tr>
<td>Construction</td>
<td>8</td>
<td>8</td>
<td>100%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>57</td>
<td>57</td>
<td>100%</td>
</tr>
</tbody>
</table>
4.2 FREQUENCY DISTRIBUTION OF AGE GROUPS AMONG INJURED AND NONINJURED WORKERS

Figure 4.1 below illustrates accident casualties as per age. A total of 11 (19.2%) employees were injured in the 18-24 years age group and 5 (8.8%) employees were not injured in the same age group. 5 (8.8%) were injured and 8 (14%) were not injured in the 25-34 age group, 10 (17.5%) were injured and 5 (8.8%) were not in the 35-44 age group. In the 45-54 age group both injured and non-injured were 5 (8.8%) and a single person (1.8%) was injured, 2 (3.5%) were not injured in the 55-64 year age group.

![Frequency distribution of accident victims as per age group.](image)

Figure 4.1 Frequency distribution of accident victims as per age group.
4.3 FREQUENCY DISTRIBUTION OF INJURED WORKERS IN RELATION TO WORK STATIONS.
The figure shows that 5 (8.8%) employees were injured in the drilling section and 7 (12.3%) were not injured in the same section. In the construction section injured was equal to un-injured in number, 4 (7.0%). In the lashing section 12 (21.1%) employees were injured and 7 (12.3%) were not injured. 10 (17.5%) employees were injured in the tramming section and 3 (5.3%) were not and lastly in the hoisting section 1 (1.8%) employee was injured and 4 (7.0) were not injured.

Figure 4.2: Frequency distribution of injured persons in different sections
4.4 FREQUENCY OF ACCIDENT VICTIMS AS PER AGE ACROSS WORKING TIMES (SHIFTS)

Figure 4.3 below shows that 5 (8.8%) were involved in accident while on afternoon shift, 6 (10.5%) during night shift and no injury was recorded during morning shift in the 18-24 year age group. 3 (5.3%) employees were injured during morning shift, 2 (3.5%) were injured during night shift and none were injured during afternoon shift in the 25-34 age group. In the 35-44 age group, 4 (7.0%) were injured during morning shift, 1 (1.8%) employee injured during afternoon shift and 5 (8.8%) were injured during night shift. In the 45-54 age group, 2 (3.5%) were injured during morning shift, 3 (5.3%) in the afternoon shift and none was injured during the night shift. Only 1 (1.8%) employee was injured during morning shift in the 55-64 year age group.

Figure 4.3: Frequency of injured persons in a shift in relation to age group.
4.5 DIFFERENT CAUSES OF ACCIDENTS DURING UNDERGROUND MINING OPERATIONS.

The figure below shows that rock falls are the main causes of accidents, contributing 25%, followed by shortcuts that account for 18%, lack of concentration 12%. Inadequate personal protective equipment (PPE), defective equipment and faulty ladders all account for 9% apiece. Lack of knowledge contributed 7%, incompetence and improper equipment both contributed 3% apiece.

Figure 4.4: Different causes of underground mining accidents at Sabi Gold Mine.
4.6 PERCENTAGE DISTRIBUTION OF PPE TRAINING AND USE AMONG UNDERGROUND EMPLOYEES AT SABI GOLD MINE

Figure 4.6 below shows that of the injured employees (n=32), 66% (21) were using PPE and 34% (11) were not. Also 72% (23) of the employees were trained on the proper use of PPE and 28% (9) were not trained.

Figure 4.5: PPE training and use percentages.
4.7 ACCIDENT TRENDS ON THE OCCURRENCE OF MINING ACCIDENTS AT SABI GOLD MINE.

Figure 4.7 below shows the trends of underground mining accidents. 17 (13.5% of n=126) lost time and 9 (17% of n=53) non-lost time accidents were recorded in 2011. In 2012, 32 (25.4%) lost time and 13 (24.5%) non-lost time accidents were reported. As from January to April 2014, 8 (6.3%) lost time injuries and 5 (9.4%) non-lost time injuries were recorded.

Figure 4.6: The trends of accidents at Sabi Gold Mine from January 2011 to April 2014.
4.7.1 FREQUENCY ON THE MODE OF OCCURRENCE

Figure 4.7.1 shows that the highest number of accidents recorded resulted from ‘struck by mode’ and it occurred in 2013. Underground mining workers are susceptible of being struck by loco motives, struck by rocks during grizzly operations, lashing and dislodging of ore. It can be also noted that struck by mode is high in all the years under review.

Figure 4.7: Frequency distribution of mode of accident occurrence.
4.7.2 FREQUENCY DISTRIBUTION OF PART OF BODY INJURED

Figure 4.7.2 below shows that the hand was more susceptible to injuries across the period under study. There is an increase in the rate of hand injuries over the period under study. 43 were recorded in 2013, 16 in 2012, 12 in 2011 and 6 in the first quarter of 2014. All other injuries increase with time as well as can be shown in figure below.

![Body part graph](image)

Figure 4.8: Frequency distribution of injuries by body.
CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

5.1 CAUSES OF UNDERGROUND MINING ACCIDENTS AT SABI GOLD MINE.

Figure 4.3 shows the occurrence of underground mining accidents in relation to different sections. According to the figure, tramming section has shown to be very risky as 77% of the trammers were involved in an accident. This could be as a result of the state of ore boxes (visually dilapidated) where ore is dislodged from, lack of employee update training and also poor state of the locomotives. Paithanker (2011), asserted that dump trucks contributed about 42% of underground mining accidents in the haulage ways. At Sabi Gold Mine trammers had a target of dislodging 40 coco pans of ore into grizzly hence exerting pressure on employees and this could be a reason for high accident rate in this section. This concurs with the findings of Chimamiseet al (2013), who in his study concluded that employees who have targets are at high risk of injury than those without set targets.

Lashing section shows to be the second risky section at Sabi Gold Mine with more than half of lashers injured. This is perhaps due to the fact that lashing is considered as the least operation at the company. New and in-experienced employees who are susceptible to injuries are deployed to this operation (Jansen and Bret, 2005; Kamalimiaet al. (201 2). Sari et al (2004), postulated that employees tend to underestimate potential dangers that could arise in haulage and ore box operations due to the misconception that when one is not drilling or barring down then he or she thinks to be safe. Table 4.2 shows that there is a relationship between the occurrences of accidents and section where one is working in.

Figure 4.4 shows that a number of accidents occurred during night shift. 40.6% of the total accidents occurred during night shift perhaps due to poor concentration. Poor concentration could be resulting from feeling asleep while at work. There is no big margin between the number of accidents that occurred during morning and afternoon perhaps due to the fact that the rate of feeling sleepy as low as compared to night shift. This is however differs from the study carried out in North-Western mining region in South Africa by Jansen and Brent (2005), which attest that high accident numbers occurs during morning shift. The results show that the occurrence of an accident is dependent to the shift.
As can be shown by figure 4.4, rock falls are the main causes of underground mining accidents at SGM. This could be as a result of poor and inadequate underground support systems as well as the use of defective support mechanisms. Boniface et al. (2013), and Cheng et al. (2012), also concluded that rock falls are the chief causes of accidents during mining operations. Jansen and Brent (2005), also echoed the same, concluding that rock falls are the main causes of fatalities in South African mines.

Shortcuts contribute a vital portion in the occurrence of accidents at SGM. Shortcuts can be best regarded to as unsafe acts by the operator where he/she knowingly ignores the safe operating procedures. According to a research by Domino (1929), unsafe acts contribute 88% of the total accidents that occurs. In a bid to save time and meet targets, employees resort to shortcuts that will result in in the occurrence of accidents and this is also supported by Kamalinia et al. (2012).

Lack of concentration perhaps due to prolonged working hours, excessive work or personal social problems can result in the occurrence of an accident. Chimamise et al. (2013), alluded that working without rest results in the reduction in employee concentration levels. The chi-square cross tabulation test shows that there is no relationship between age and the causes of accidents.

Figure 4.6 shows that more injured employees were using personal protective equipment and more of them were trained on the use. Even though employees were provided with PPE and trained on its use, accidents still occurred. This is because PPE is the last line of defense; engineering, administrative and substitution measures should be prioritized (Chimamise et al., 2013).

5.2 TRENDS OF ACCIDENT OCCURRENCE AT SABI GOLD MINE.
Figure 4.1 show that 18-24 year age group is more prone to mining accidents than any other age group. This is perhaps due to the that employees in this age group lacks experience as supported by Sari et al. (2004), who indicated that younger miners in the Turkish mines experience more injuries as compared to older miners. Exposure time plays a pivotal role in the occurrence of accidents; young age groups are more exposed as they do most of the manual underground work while their older counterparts have assumed supervisory roles. Also as pointed out by Boniface et
al. (2013), young and active age group is highly involved in risk-taking behavior more than the older age-group.

There was a decrease in the number of injured employees in the age group of 25-34 years. This is perhaps due to the fact of acclimatization to the mining environment. However there is an increase in number of injured persons in the age group of 35-44. This is due to high exposures as supported by Sari et al (2004), who stated that more mine employees fall under this age group. Predisposing factors such as socio-economic factors, family issues mostly affects this age group thereby rendering the group more prone to accidents (Kamalinia et al., 2012). Also as alluded by Jansen and Brent (2005), this age group becomes more prone to accidents due to complacency as most employees in the group have more than 10 years’ experience.

There was no difference between injured and non-injured employees in the 45-54 age groups due to the fact that few people are falls into this category at Sabi Gold Mine. Also most employees in this category have been elevated to supervision positions. This also in line with the study carried out by Boniface et al (2013), at Mererani mine in the Northern Tanzania. In the 55-64 age group there was very low injury rate due to less exposure as a result of few employees in this category.

Most employees in this age have retired and have left the mining industry.

Figure 4.7 shows that there is an increase in the trend of accident occurrence at Sabi Gold Mine. This is perhaps due to the fact that the management is not addressing the root causes of the causes. As shown in figure 4.6, the supply of PPE is somehow commendable but accidents still occurs pointing to negligence of more important controls such elimination, substitution and engineering. More employees are struck by rocks and locomotives perhaps due to improper barring down, defective locomotives as well as failure to follow safe working procedures. Also more employees sustained hand injuries perhaps due to inadequate training on proper handling of tools.
CHAPTER SIX

6.1 CONCLUSIONS
Tramming and lashing operations are the most risky operations at Sabi Gold Mine as compared to some other underground operations. It has been noted that rock falls and failure to follow safe working procedures (shortcuts) are the main contributors of accidents at Sabi Gold Mine.

The trend in accident occurrence follows a zigzag pattern where it will be high during morning shift, lowers down during afternoon shift and then very high during night shift. Also accidents mostly occurred in the 18-24 and 35-44 age groups and also in most cases being hand injuries.

6.2 RECOMMENDATIONS
• Sabi Gold Mine management should come up with appropriate underground roof supporting systems such as the use of roof bolts, timber blocks or wire mash to cater for rock falls. Proper training on all trammers and lashers on safe operating procedures is also another option.

• There is need for an increase in training and awareness sessions on workers particularly those who fall in 18-24 and 35-44 age groups. It is of paramount important for Sabi Gold Mine management to rotate lashing operations, they should not only be done during night shifts.

• The study recommends for a need of similar studies among ZMDC gold mines so as to find out where Sabi Gold Mine lacks.
REFERENCES


Stringfellow M.V. (2010) Accident Analysis and Hazard Analysis for Human and Organizational factors, Massachusetts Institute of Technology.


APPENDICES

Appendix 1: Questionnaire

Dear Respondent

I am a student at Bindura University of Science Education, currently undertaking Honours Degree in Safety Health and Environmental Management kindly request for your participation and assistance. I am carrying out a research project entitled “An assessment of the causes of underground mining accidents at Sabi Gold Mine, Zvishavane”. All the information you disclose will be kept confidential and will not be used for any other purpose except for this academic research.

Instruction

• Please do not write your name on the questionnaire.
• Tick the appropriate response or give a brief explanation in the spaces provided where applicable.

SECTION A: Respondent’s Demographic Data

1. Sex
   Male
   Female

2. Age
   Below 18 years
   18-24 years
   25-34 years
   35-44 years
   45-54 years
   55-64 years
   65+ years
3. Period of employment/period of employment?

4. Which section do you work at?

- Drilling
- Construction
- Lashing
- Tramming
- Hoisting

5. How long have you been in the section?

- Weeks
- Months
- Years

6. What is your occupation/position? (e.g. hoist driver, lasher, supervisor, etc)

7. For how long have you been working at your current job?

8. Level of education?

9. Length of your shift?
10. Do you take alcohol/Munotorazvinodhaka here?

YES                   NO

SECTION B

1. a Have you been involved in any underground mining accident/Makambopindamunjodziyepasipemugodhi here?

YES                   NO

i. Briefly describe what happened/Titsananguireikutizvakafambasei.

ii. Where did the accident occurred/Njodzi iyi yakaitikira papi?

iii. Date and time of accident/Musinenguwawakaitikanjodzi

iv. Were you putting on proper Personal Protective Equipment/Clothing (PPE)/Maivemakapfekahembedzinokudziviriraikubvamunjodzi here?

v. Were you trained on the proper use of PPE/Maivemakadzidziswa here kushandisahembeidzinenzirayakanaka?

YES                   NO

vi. What equipment(s) were you using/Ndeipi midziyo yamaishandisa?

vii. Were you trained on the task/Maive makadzidziswa here basa iri?
viii. Did you carry out risk assessment and made all necessary corrections prior to carrying out your task?

ix. Was the working not slippery or too hot?

x. Prior to the accident, were you suffering from any personal problems?

xi. What does the Standard Operating Procedure/regulation say when carrying out such a task?

2. In your opinion, what are the main causes of underground mining accidents?

3. What should be done to avoid these accidents?

4. Are safety talks conducted prior to the commencement of every shift?

   If no, kindly explain why?
5. Where you undergone SHE induction session prior to employment/Makaitwaindakishini here musatimatangabasapamakasvikapakambani?

YES  NO

6. Before commencing your duties after you have come from leave days, are you re-inducted/Kopamunodzokakubvakurivhimunoitwa here indakishinizvekare?

YES  NO

7. Are you aware of necessary procedures taken when reporting an accident/Munoziva here nzirayekutauriravakuru kana muchingemapindamunjodzi?

YES  NO

8. May you explain to us the procedure/Mugatiudzawo here mazivisiroamunoita?

9. Are tripods carried out during accident or incident investigation/Tsvagurudzyakadzamainoitwa here kana pachingepaitikanjodzi?

YES  NO
### Appendix 2: Checklist

<table>
<thead>
<tr>
<th>No.</th>
<th>PARAMETER</th>
<th>LEGAL REQUIREMENT</th>
<th>SCORES</th>
<th>COMMENT</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Personal Protective Equipment supply and use.</td>
<td>SI 68:1 990 III Schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SHE Training and appointments.</td>
<td>OSHAS 1 8001:2007 Clause 4.4.2</td>
<td></td>
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<tr>
<td>3</td>
<td>Ladder ways.</td>
<td>SI 1 90:1 990 Section 57 (1)</td>
<td></td>
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<tr>
<td>4</td>
<td>Underground support systems.</td>
<td>SI 1 09:1 990 Section 34 (5)</td>
<td></td>
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<tr>
<td>5</td>
<td>Closing of audit gaps and NCs</td>
<td>OSHAS 1 8001:2007 Clause 4.5.3.2</td>
<td></td>
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<tr>
<td>6</td>
<td>SHE complaints book and accident register.</td>
<td>SI 1 09:1 990 Sections 40 (1) and 271 (1)</td>
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<td>respectively</td>
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<tr>
<td>7</td>
<td>Communication procedure.</td>
<td>OSHAS 18001:2007 Clause 4.4.3.1</td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Adherence to safe working procedures.</td>
<td>OHSAS 1 8001:2007</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>