AN ANALYSIS OF THE ASSOCIATION BETWEEN ERGONOMIC RISK FACTORS AND ILLNESSES IN NARROW REEF MINING IN ZIMBABWE: A CASE OF GOLDFIELDS OF MAZOWE

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF BACHELOR OF SCIENCE HONOURS DEGREE IN GEOGRAPHY AND ENVIRONMENTAL STUDIES

GWERU, ZIMBABWE

NOVEMBER 2018

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Approval form

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Declaration

This research project report is my original work and it has not been submitted to any other examination body. No part of this research project should be reproduced without my consent or that of Midlands State University.

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Dedication

This piece of work is dedicated to my sweet and loving parents Mr and Mrs Maningire whose encouragement, support, affection, and prayers of day and night, without them none of my success would be possible. This one is for you to Miss Nyasha Maningire you made it, the journey was not as easy but you managed it all.

Acknowledgements

I would like to express my deepest appreciation to my supervisors Prof S. Jerie who has the substance and attitude of a genius, he continuously and believably encouraged me to work an extra mile harder. I have been extremely lucky to have a supervisor who cared for my work responded to my queries so promptly. Without his guidance and persistent help this dissertation would not have been possible

I am especially indebted to Mr Denford A. Mwenda of Goldfields of Mazowe mine who have been supportive and an inspirer, motivator and challenger to me, giving me more zeal to produce a meaningful project. Completing this work would have been all the more difficult without his support.

Nobody has been more important to me in the pursuit of this project than my family members.I would like to thank my parents and my siblings most importantly y sister Mai Chitaka for their unending support, love and guidance in whatever I pursue, ultimately they gave me more strength to go on.

Finally I would like to thank God, my Father above all fathers the Almighty who was with me and is still with me for protecting, leading, loving me, providing for me and guiding me jealously since day one. Without his willingness I would not have reached this far.

Abstract

The main aim of the study was to analyse the association between ergonomic risk factors and illnesses in narrow reef mining at Goldfields of Mazowe (GFM).The analytical research design was employed and cross verification was done through combining several methods thus triangulation were both qualitative and quantitative research approaches were used. Data was collected through the use of interviews, questionnaires, field observations using Rapid Entire Body Assessment (REBA) and secondary data sources. Excel and statistical Package of Social Sciences (SPSS) were used to analyze the data statistically and the data was presented through the use of graphs, pie-charts as well as chi-contingency tables. The research discovered that of all the ergonomic illnesses GFM workers are mostly affected by chronic back aches. This is attributed to confinement, long ore movement distances, awkward drilling postures, as well as high reliance on manual labour since mechanization is used to a lesser extent due to limited space. Amongst the ergonomic risk factors awkward positions and repetitive use of body parts affected workers significantly affecting 91% and 93% respectively and all the underground workers affected on the back with some affected on their arms, hands and legs. It was established that the body parts affected are not dependent on the occupation following a dependence chi-square test done between body parts affected and the occupation performed this implies that everyone working underground is at risk regardless of occupation because of the set-up of the mine. Besides the nature of workplace there is insufficient recovery time due to more concentration on maximising production while ignoring safety aspects (relationship between worker and his work place). The occupational safety and health management system in Zimbabwe as a whole pertaining to ergonomic issues is less effective and improvement is required. Recommendations include mechanisation of underground operations, introduction of recovery time, launching value based safety programs, establishing and intensifying training on wellness programs, NSSA to formulate a clearly stated ergonomic policy and adopting the participatory methods by NIOSH ergonomic processes and risk factor awareness in mines.

Keywords: Ergonomics, Ergonomic risk factors and illnesses, Narrow reef mining

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List of Acronyms

ANFEX	Ammonium Nitrate and Fuel Explosives
DALY	Disability Adjusted Life Years
ERF	Ergonomic Risk Factors
GFM	Goldfields of Mazowe
IOD	Injury on Duty
ISO	International Organisation for Standardization
LTIFR	Lost Time Injury Frequency Rate
LTIs	Lost Time Injuries
NIOSH	National Institute for Occupational Safety and Health
NSSA	National Social Security Authority
OSHA	Occupational Safety and Health Administration
REBA	Rapid Entire Body Assessment
SHEQ	Safety, Health, Environment and Quality
SI	Statutory Instruments
SPSS	Statistical Package for Social Sciences
VBS	Value Based Safety
WMSD	Work-related musculoskeletal disorders

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Etymologically the word "ergonomics" originates from the Greek word "ergon" a prefix indicating work and "nomos" the suffix indicating the rules of a discipline. Ergonomics is the discipline of refining the complex association between people and the design of work environment and aim at optimizing them for human use. Ergonomics is defined as the study of the design of a workplace, equipment, machine, tool, product, environment, and system which takes into consideration human being's physical, physiological, biomechanical, and psychological capabilities and optimizes the effectiveness and productivity of work systems while assuring the safety, health, and wellbeing of the workers. Fernandez and Marley (1998).

Dekker *nd* (2013) notes that the epistemological basis of this discipline institutes the scientific framework of rules and norms that guide its scientific practice and now these have become problematic also since it has to deal with issues of complexity, emergences and sustainability.

In America, the pioneers in this field were involved in both experimental psychology and engineering therefore obtaining occupational titles, human engineering or human factors reflecting a difference from the European ergonomics. As compared to European pioneers in ergonomics these were workers among the human sciences and it is for this reason that ergonomics is well balanced between physiology and psychology Singleton (*nd*). He further pointed out that this also explains why occupational hygiene, from its close relationship to medicine, particularly occupational medicine, is regarded in the United States as quite different from human factors or ergonomics. Ergonomics focusses on the human machinist in action, occupational hygiene and hazards to the human operator present in the ambient environment. With all this knowledge and further investigations put in place from different operations. Most of these industrially advanced countries incorporated their ergonomics in standards …. Nachreiner (*nd*), this helped the countries to come up with basic ergonomic principles, ergonomic legislation and policies which helped in minimizing injuries and work related musculoskeletal disorders.

Africa has relatively short story on ergonomics and ergonomics is still in its infancy in South Africa therefore not many people are aware of where ergonomics fits into their lives thus according to James and Scott (2009) and Author (2017) respectively. Due to the infancy of the history of ergonomic in Africa most of the countries in the continent have not yet fully implemented the science of ergonomics as compared to other developed countries. It can be noted that this ergonomics are practiced to some levels in daily activities but are not considered as an ergonomic decision, this is because their application is still very slow. However, there is a developing responsiveness of the necessity for ergonomics seen through the international community and local supporters who have been actively involved in establishing the discipline in North, West, Central and Southern Africa. Thus it can be evidenced in Zimbabwe now the field of ergonomics is recognized under Occupational, Safety and Health department.

Ergonomic risk factors (predisposing conditions that increases the likelihood of one developing body illnesses) are inherent in every work place or any activity leading to discomfort, fatigue, injuries and body pains. Different work places pose different risk to individual due to different work place designs. Different ergonomic risk factor includes awkward postures, high force and repetitive motion. Proper ergonomic practises helps to enhance efficiency and in eliminating significant occupational safety and health risks. Physiologically (Singleton *nd*) notes that ergonomic practices are important as it is a background to issues such as energy use, posture, and application of forces including lifting while a psychological orientation is required to study problems such as information and job satisfaction.

On the other hand, good ergonomic practises are hindered with several aspects including geological structure, equipment handling, and physiological stature of human beings amongst other factors. These affect the postures at which one will be working, (awkward body postures) leading to musculoskeletal disorders of different parts of the body. Actual work places in deep level mines present matchless challenges to ergonomic interventions. Generally, ergonomic hazards vary from one working sector to the other. Goldfields of Mazowe is one of deep level mines in Zimbabwe where narrow reef mining is being practised.

Due to the differences in the geological structures and depth at which mining activities takes place lies narrow reef mining amongst other mining techniques. Narrow reef mining is mining following a very restricted width of ore deposits less than one metre with low ceiling heights and high thermal heat loads. The hanging walls and the foot walls are fully exposed to avoid collapse while minimising dilution of the mineral with waste rock material. At Goldfields of Mazowe the reefs are as narrow as two centimetres or less. Major ergonomic illnesses reported at the mine include musculoskeletal disorders mainly affecting the back.

1.2 Statement of problem

Ergonomics has been a top discussion in occupational safety and health researches in the mining sector lately. This is mainly attributed to an increase of on duty injuries as well as gradual on set illnesses which can be traced back to ergonomic hazards. These have an effect of putting workers at great risks of developing typical illnesses such as back injuries, sprains and strains, wrist, shoulder, and elbow problems. In part this is due to the nature of the work itself. However, the discipline of ergonomics is designed to address, and hopefully mitigate such issues by examining the relationship between humans and their work. The existing literature in the mining industries for ergonomics has shown that there are many risks that are posed to individuals due to different factors such as the geological structure, repetitive motion to mention a few. Exposure to job-related hazards accounts for a significant proportion of the global burden of disease and injury, which could be substantially reduced through application of proven risk prevention strategies (Deborah Imel Nelson PhD, 2005). The work environment presents a set of hazards which if not managed appropriately may culminate in injury of personnel. Worldwide, hazardous conditions in the workplace were responsible for a minimum of 312,000 fatal unintentional occupational injuries. Together, fatal and non-fatal occupational injuries resulted in about 10.5 million DALYs; that is, about 3.5 years of healthy life are lost per 1,000 workers every year globally. Occupational risk factors are responsible for 8.8% of the global burden of mortality due to unintentional injuries and 8.1% of DALYs due to this outcome (Deborah Imel Nelson PhD, 2005).

Work-related musculoskeletal disorders (WRMD’s) are now recognized as a major occupational health problem and are linked to jobs that are repetitive, require high focus, and require continuous or repeated extreme or awkward postures (Jones, 1998). A study undertaken by Schutte in the South African mines indicated that 16% of the 1235 medical records examined at a gold mine concerned work-related musculoskeletal diseases (WMSD). Of these 15% were associated with the upper limbs, 16% with the lower limbs and 69% with the back region.

Drawing closer to an enterprise level, Goldfields of Mazowe is not spared, it has an equal share of the burden attributable to work related musculoskeletal disorders. In the year 2017 backaches alone contributed to approximately 28% of the illness cases reported and treated at the clinic. The number of cases is on a monthly basis higher than other conditions reported. This has seen a number of employees filing claims with NSSA and some being retired on medical grounds. Consequently, productivity which is one of the aims of ergonomics implementation is negatively affected hence this study.

1.3 Objectives of the study

General objectives

- To analyse the association between ergonomic risk factors and ergonomic illnesses in narrow reef mining at Mazowe Goldfields.

Specific Objectives

- To identify ergonomic illnesses associated with narrow reef mining.
- To determine the prevalence of ergonomic cases and risk factors associated with work undertaken at Goldfields of Mazowe underground operations.
- To examine if the ergonomic illness reports/complaints depend on the nature of work performed or exposure to risk factors.

General Research Questions

- Do the risk factors that narrow reef mining pose to workers communicate with the illnesses that are being reported?
- Is there a significant relationship between the ergonomic risk factors found in narrow reef mining and the illnesses reported at Goldfields of Mazowe?

Specific Research Question

- What are the ergonomic illnesses that are associated with narrow reef mining?
- What is the prevalence of ergonomic cases and risk factors they are attributed to?
- Is there any dependence between occupation and the ergonomic cases reported?
- How much ergonomic risk is attributed to the nature of work performed?

1.4 Justification

Looking at the present day statistics on illnesses that can be traced back to work related issues from different disciplines, the study of human illnesses in relation to their working environment is vital to the community. In Africa there is minimum history on ergonomic hazards and because the continent has more developing countries than developed. According to Scott and James (2009), ergonomics has a relatively short history on the African continent. For this reason, the majority of people are affected since thy have little knowledge on ergonomics and most countries in the continent have not yet adopted the science as compared to developed countries.

The purpose of this study is to analyze ergonomic illnesses that narrow reef mining possess to workers. Looking at ergonomic risk factors and how they contribute to the increase in the numbers of ergonomic illnesses that are being reported at the mine. These illnesses bring loss to both the family of the worker and loss within the company. These types of losses that results in a worker compensation claim embodies an unplanned cost, where there is little or no utility value for the company on such costs. Productivity loss, morale, and humanitarian issues come into play if pro-active measures are not taken to prevent this continuity loss.

This study comes with a number of merits which benefit both the employer and employee on issues like reduced unplanned costs and loss of bread winners respectively. It reduces the impact of ergonomic hazards increasing worker safety, assets protection and job satisfaction. After the analysis this will help in developing a problem evaluation and analysis that will be used in reducing the increasing number of musculoskeletal disorder especially of the lower back pain cases at the mine. More so the results can be used to educate workers of Goldfields of Mazowe and other gold mines in Zimbabwe.

Furthermore, this study can be used with higher organizations in the field of occupational health and safety in Zimbabwe for example the future researchers, tertiary institutions and Occupational Health and Safety (OSH) subdivisions under National Social Security Authority (NSSA). The document can be used to come up with decisions which may help in policy making and the establishment of frameworks which will help in the betterment of the ergonomic discipline. For the researchers interested in field this can be a preparatory stage where they can get background information and findings. This study stands indispensable to validate the developments already in place in several organizations and paves the way for future initiatives which help fit the job design to the worker.

1.5 Description of the study area

1.5.1 Physical Geography

The study was set at Gold Fields of Mazowe a subsidiary of Metallon Corporation a South African based company with four other mines in Zimbabwe namely Bulawayo Mining Company, King's Daughter Mining Company and Goldfields of Shamva. Gold Fields of Mazowe (Pvt) Ltd, is in the business of exploration, mining and processing for Gold. It is one of the oldest mines in Zimbabwe situated in the west-central part of Harare greenstone belt, in Mashonaland Central Province. It is located approximately 40 km NNW of Harare. Orebodies at the mine generally comprise shear zones which are in-filled with gold-bearing sulphide and quartz.

1.5.2 Human and Economic Geography

Mazowe district relies on farming and gold mining including illegal mining of which 46% of the illegal miners are women. Mazowe lies in natural farming region two thus farming is practiced extensively resulting in the mine being surrounded with mostly A2 farmers which get water from the Mazowe dam which also offers recreational services to local people and visitor.

Currently the mine has active workings underground and hydro sluicing of old tailings impoundments. The mine consists of eight main departments primarily mining department serviced by the following ancillary departments namely Technical Services, Engineering, Human Resources, Metallurgy, Finance, Security and SHEQ. The labor strength of the mine stands at 1013 employees working in different capacities in the various departments with the largest strength in the Mining department.

The first claims in the Mazowe Mine area were first pegged in 1890. In 1903, Jumbo Mining Company was floated marking the first substantial development of Mazowe Mine. During the period 1906-1907, a 30-stamp mill was erected and the company secured most of the adjoining claims which include the Jumbo N.E. extension. As the mine increased in depth, pay shoots became shorter and further apart hence development was stopped by end of 1912, consequentially stopping milling by the end of 1917. Following the closure of Jumbo Mining Company in 1917, the mine was tribute to small scale miners until 1931. By 1953 a small-worker-era with the hive of activity centered on Carnbrae, Birthday, Connaught, Bojum, Bucks and Flowing Bowl, had taken over until it was surpassed by the acquisition of these small workings by LONRHO in 1953. Production continued until 1991 when Independence Gold Mining (Pvt) Limited took over.

Mine production dates back to 1890 with post 1961 production peaking in 1968, in which year a record 46,018oz were recovered. In 2002, Metallon Gold Corporation, a South-Africa based company acquired Independence Gold Mining and took over Mazowe Mine now called Goldfields of Mazowe. Underground operations are currently situated in the narrow reef Mazowe Section with significant confinement.

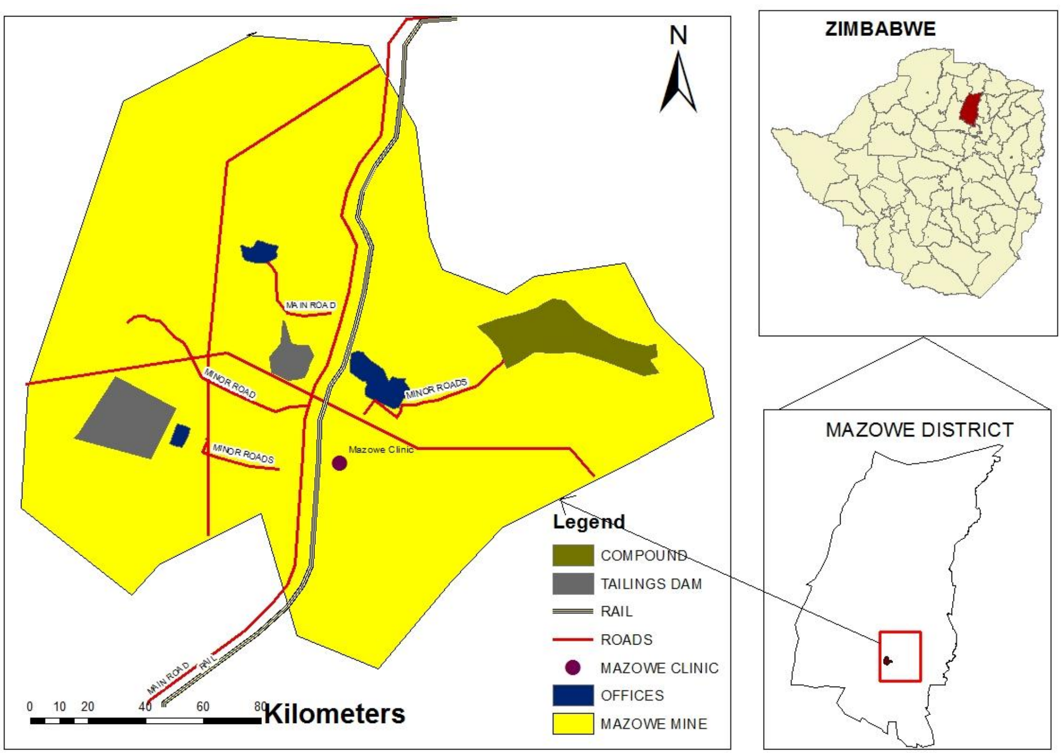

Fig 1.1: Map showing Goldfields of Mazowe mine

CHAPTER TWO: LITERATURE REVIEW

2.1 Ergonomics in the mining industry

Since mining practices encompass earth movement and the extraction of hard rocks the mining industry remains a relatively precarious industry thus you find workers in the industry are prone to injuries and death as compared to those working in other working sectors .According to Jerie (2013) mining operations in the Southern African region are associated with difficult working conditions and underground mining is especially considered to be one of the most physically demanding occupations .More-over the Bureau of labor Statistics (BLS) stipulates that their hurts (workers in the mining industry) are liable to be severe than employees in the non-public sectors. Due to cost incurred by the organization due to increased injuries in the sector it has been the duty of the employees to make sure that workers are protected by providing safe workplaces for them so that maximum profits may be attained. Evident at GFM by the book workers have the right to say no when it comes to working on an unsafe place however this is being dismissed by the fact that there are now financial shortages running within the organization and shortcuts are being made therefore the continuity of people working in unsafe conditions.

2.1.1 Aims of Ergonomics

The aim of instigating ergonomics on an organization is to ensure that the working condition is in coherence with the activities that are done by the worker. Laurig and Vedder (1998) states that ergonomics examines not only the passive ambient situation but also the unique advantages of the human operator and the aids that can be made if a work situation is designed to allow and encourage the person to make the best use of his or her ability. This aim is self-evidently valid but attaining it is far from easy for a variety of reasons. According to Marmaras and Nathanael (2006) there is interdependence among the workplace components, the working person, the task requirements, the environment, and the habitual body movement and posture that working persons adapt. Good ergonomics aims at finding the best combination for the users amongst the tool, the task, and the environment. Components are illustrated in figure 2.1.

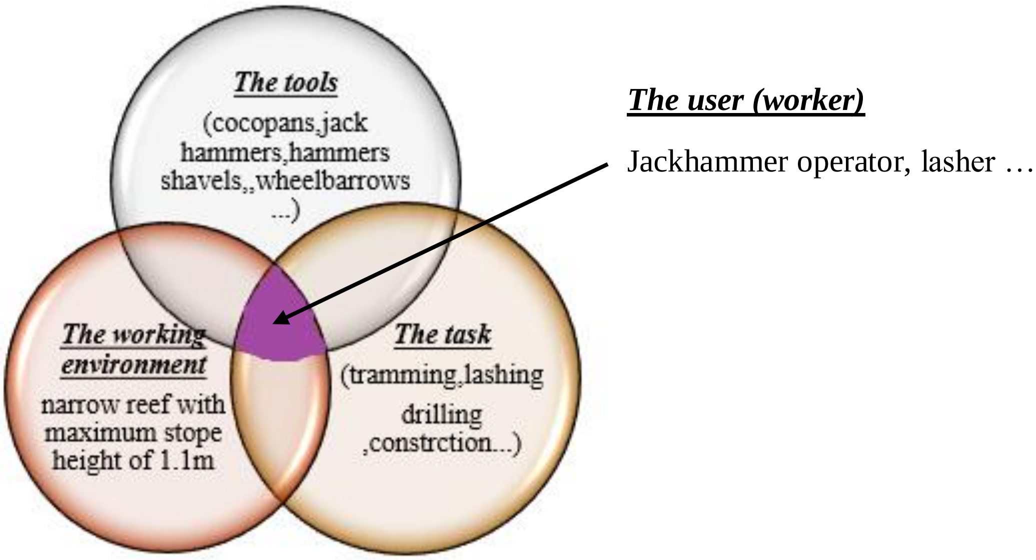

Fig 2.1: Ergonomics focus

Source: Adapted from Marmaras and Nathanael (2006)

If the best combination is not attained, then ergonomic problems may arise on either of the components being combined with major health impacts to the worker. This stress can cause immediate or long-term damage to muscles, nerves, tendons, and joints. The human operator is flexible and can easily adapt through continuous learning, but there are quite large individual differences. Some differences, such as physical size and strength, are obvious, but others, such as cultural differences and differences in style and in level of skill, are less easy to identify from one organization to the other.

Through giving maximum attention to quality ergonomic practices around the work place, a number of benefits comes along with it, benefits include:

- Reduces costs (injury expenses and medical bills) to both the individual involved and the organization.
- Improved healthy quality -ensured physical safety through prevention of WMSDs.
- Reduced absenteeism and reduced lost time injuries LTIs.
- Improved productivity and efficiency due to proper workplace designs.
- Creation of an enhanced safety culture therefore improving employee engagement.

2.2 Ergonomics risk factors (ERF)

As people always appeared to be so quick to adapt to different environments, this have allowed for little or no attention being given to how they fit into the workplace therefore creating room for more injuries in the mining sector. Workers are seen to be unaware of ergonomic principles as body postures and movements are seen to be not following standard work procedure Shinde (2012). Hagberg *etal* (1995) notes that, ergonomics and human factors are often used interchangeably in workplaces. Both describe the interaction between the worker and the job demands. The difference between them is ergonomics focuses on how work affects workers, and human factors emphasize designs that reduce the potential for human error. So it can be noted that if workers give more attention to how they fit in their workplaces occurrence of injuries may be reduced since risks are noted and attended to before occurrences of injuries.

Jaffar *et al* (2011) defined risk factors as actions or conditions that increase the likelihood of injury to the musculoskeletal systems There are a number of risks factors associated with mining tasks these include forceful exertions, awkward postures, repetitive motion, jolting and jarring, forceful gripping, contact stress, and whole body and segmental vibration. Bongers *etal* (2002) further classified these risk factors into three categories thus biomechanical exposures, physical stressors and individual risk factors. Biomechanical exposures include exposure to repetitive motion due to poor work lace design as well as deviances from neutral body alignments. Huang etal (2003) notes that psychosocial stressors at work include factors such as high-perceived workplaces stress, low-perceived social support, low perceived job control, and time pressure. While Individual factors include age, gender and not getting enough time to take a break.

Ergonomic risk factors (ERF) is a situation(s) which is present that might cause harm to the worker. According to Mat Rebi (2003) ERF is situations that exist or created intentionally or unintentionally that could or might contribute to results contravene or against the principles or philosophy of ergonomics that could or might harmful to the health and well-being of workers or users at work or after work. EFRs can be confirmed by carefully studying the injury and illness statistics Bhattachanya and McGlothlin (2012). This will aid organizations to identifying ergonomic hazards that are existing in different workplaces together with incident investigations.

Vaidogas (2010) add on to say the identification of ergonomic hazards is based on ERF which incorporate conditions of the work process, workstations, or work method which contribute to the likelihood of developing WMSDs.

2.3 Common Work-related Musculoskeletal Disorder (WMSD) associated with narrow reef mining

Factors that had practical importance and that were significantly associated with injury severity included mine worker's age, part of the body injured, type of accident, agency of accident, and mine worker activity Hull *etal* (1996). The part of the body injured is one of the most key determinant to injury severity. In the Queensland mining hand injuries were the second most commonly reported lost time injury after back pain, (Queensland Government, 2013). Common WMSD risks factors associated with mining tasks include forceful exertions, awkward postures, repetitive motion, jolting and jarring, forceful gripping, contact stress, and whole body and segmental vibration. Common WMSDs associated with narrow reef mining are listed in the table below together with the section of the body affected and the cause:

Table 2.1: Common WMSDs associates with narrow reef mining.

WMSDs	Occupational risk factor (cause)
Back Pains (Back bone)	-working in an encroached posture /working while positioned in an awkward posture
Tension neck syndrome	Prolonged restricted and awkward postured
Carpal tunnel syndrome(wrist)	Repetitive wrist motion
Thoracic outlet syndrome (shoulder)	-Carrying heavy loads for long distances on the shoulder -Prolonged shoulder flexion
Hand-arm vibration syndrome vibration (hand and wrist)	-exposure to vibrating machinery (jackhammers)
Epicondylitis (elbow tendonitis)	-Repeated or forceful rotation of the forearm and bending of the wrist at the same time.

Source: Adapted from Collins et al (2011)

2.4 Ergonomic principles that contribute to work place designs

The objective of strategically planned workplace designs is to try and make sure that the design is appropriate for as many people as possible and to have clearer picture of the Ergonomic principles of posture and movement which performs a pivotal role in the provision of a safe, healthy and comfortable work environment. Ergonomic principles should be applied in any workplace design taking into account all components thus the tools, task, environment and the worker. Chim (2017) adds on to say that these should be applied including the work and non-work areas. Posture and movement at work will be dictated by the task and the workplace, the body's muscles, ligaments and joints are involved in adopting posture, carrying out a movement and applying a force. The muscles provide the force necessary to adopt a posture or make a movement. Poor posture and movement can contribute to local mechanical stress on the muscles, ligaments and joints, resulting in complaints of the neck, back, shoulder, wrist and other parts of the musculoskeletal system.

Some of the essential Ergonomic principles are described in the table below:

Table 2.2: Ergonomic principles

Ergonomic Principle	**Description**
Work in the power zone. Kipping work close to the body	The power zone enables one to keep work close to the body. For example, the power zone for lifting is between mid-thigh and mid chest this is where the arm and back can lift the most with the least amount of effort. If the task is too far from the body the arm will be outstretched and the trunk bent over forward
Maintain joints in a neutral position	In the neutral position the muscles and ligaments, which span the joints, are stretched to the least possible extent
Limit the weight of loads that is lifted	There are guidance weight limits that are stipulated for an individual be it males or females
Alternate postures and movements (reduction of repetitive motions)	No posture or movement should be maintained for a long period of time. Prolonged postures and repetitive movements are tiring.
Reduce excessive vibration	Regular and frequent exposure to vibrating can lead to health effects such as white finger disease and carpel tunnel syndrome.
Use mechanical aids/ transport accessories	There are many aids and accessories that are used to move or lift loads for example cocopan, conveyor belts, forklifts and other

Source; Adapted from Occupational Health and Safety Authority (2006)

2.5 Management of ergonomic hazards

Longer shift lengths and fatigue, mental overload, alternating heavy physical work, reduced task variation, sedentary work in fixed and/or awkward postures and whole-body vibration all have risks on workers. Taking also into account increasing of age of some of the workforce is also of concern when it comes to the management of ergonomic hazards. From the above mentioned ergonomic principles on section 2.4 some principles have been incorporated in many countries legislations for instance in Irish. As noted in the background of the study GFM recorded the highest LTIFR and Severity rate in the Metallon Group primarily due to the nature of workplace as well as lack of a defined and accredited Safety System. Kareproducts an online source notes that ergonomic hazards can be avoided if an effective ergonomic assessment programme is implemented as well as promoting awareness throughout the whole organization. Below is an ergonomic solution pyramid by OSHA publications 2012:

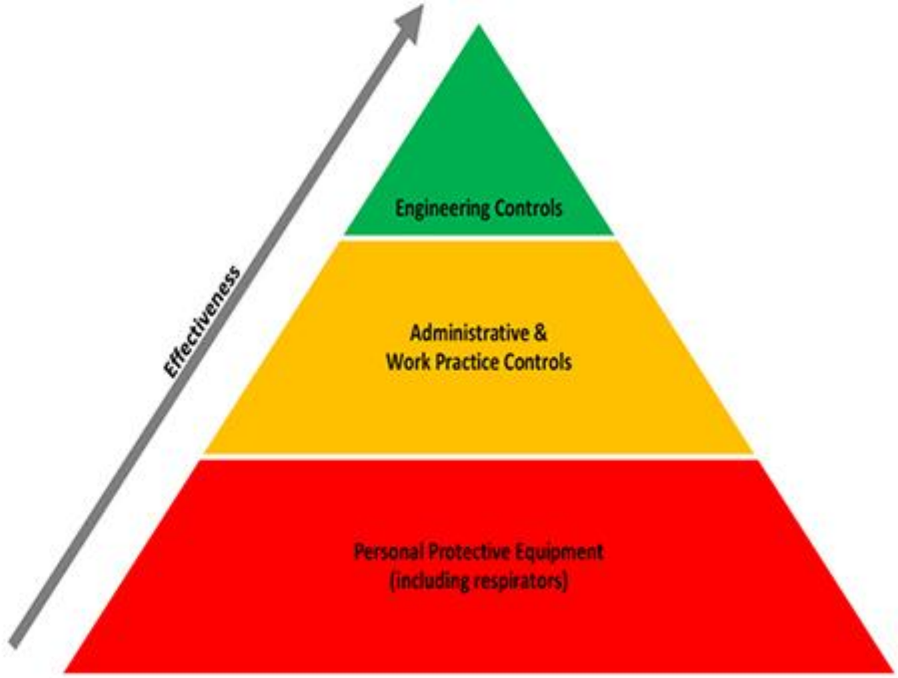

Fig 2.2: Ergonomic solution pyramid

Source: OSHA 2012

Table 2.3: Ergonomic control methods.

TYPE OF CONTROL	WORKPLACE EXAMPLES
Engineering controls Thus implementing physical changes in workplaces so as to reduce risks on the job	-Use of lifting equipment and moving machinery for example fork lifters and scrapper winch respectively thus reducing force exertion -Redesigning tools so as to enable neutral postures -reduction of weight of loads for example when carrying explosives to the charging place
Administrative and work practice controls Establishment of effective procedure	-Allowing for time off, work rotations so as to reduce the effects of repetitive motion and fatigue -Require stop working orders if people ae working on an unsafe work place - Require that heavy loads are only lifted by two people
Personal protective equipment Use protective clothing to reduce exposure to risks	-use of padding so as to reduce direct exposure o vibration e.g. when one is using a jackhammer

Source; Adapted from 0SHA (2012)

After evaluating and controlling the work risk factors, assessing the workplace for ergonomic risk conditions generally involves two steps of identification of the existence of ergonomic risks and quantification of the degree of ergonomic risk. Ergoweb (2007) point out that engineering, administrative and work practice controls are included in prevention and control of ergonomic risk conditions. Management and workers are educated to risk conditions (Ergoweb, 2007). The development of participative approaches to problem solving in some parts of the mining industry is encouraged.

2.6 Knowledge gap

It can be noted that ergonomic studies are still being carried out and ergonomic concerns worldwide have become of great importance, therefore greatly contributing more knowledge in ergonomics. More studies focus on ergonomic hazards, risk factors, WMSDs and some ergonomic principles. However, in Zimbabwe it can be noted that there is more concentration on the need to maximize production whilst ignoring the safety aspects of working conditions and worker (relationship between worker and his workplaces) leading to the increasing numbers of workers suffering with neck and back pains in the mining industry. This is yet to be addressed in the industry as a whole since it can be noted on other mines that workers are still working long hour, working in unsafe working areas without taking breaks or rotations to reduce the effects of repetition so as to meet the company targets per day. There is need to come up with ergonomic legislation on a standalone basis so that information will not just circulate amongst the management officials but to workers on the ground as well.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter articulates the possible designs that has been used by the writer to attain targeted study determinations. Kothari (2004) defined research methodology as a way to systematically solve the research problem. Since it is a way to systematically solve the research problems in this chapter different data collection methods are going to be employed and the data collected will be analysed. Thus all the procedures that are going to assist till the outcomes of the results are going f to be elaborated in this chapter. These include the research design implemented, research type and different approaches that are used to collect and analyse the data till all the determinations of the reach are addressed.

3.2 Research design

McNabb (2013) stipulates that a research design necessitates paradigms used to incorporate study components into articulate and coherent way in ensuring that the problem under research is effectively addressed. Edmonds and Kennedy (2012) elaborated it as the framework that indicates the time frame in which data will be collected, how and when the data will be analyzed. The type of the study being under taken is an analytical case study. Due to the analytical nature of the case study the researcher used the analytical research design. The design allows the researcher to look for information from different angles analyzing the illnesses that are due to narrow reef mining and also gives room for additional information since direct contact with the people that are involved in the issue being deliberated on is made through interviews that were used in the study. Cross verification of data was done through combining several research methods thus triangulation where both qualitative and quantitative approaches where used. These research approaches offer direction to the scholar guaranteeing that collected information responses to the intended objectives of the research.

By virtue of the largely measureable data that can be presented through the use of numbers and analyzed using statistics that lies in this study, the researcher qualifies quantitative techniques in the research.

3.3 Population and Sample

3.3.1 Target population

This is the total group of individuals to which the researcher is interested in and intend to gather and analyze information from them for the purpose of the study being undertaken. According to Chikwekwete (2007) population is group of individuals that share one or more characteristic in common. In this study the inquired population is from which events are recorded and these are worker that are directly exposed to activates conducted within narrow reefs. These included the drillers, lashers as well as the trammers working at Goldfields of Mazowe. These were targeted in the research because their contributions and opinions was of great use in the qualitative and quantitative aspects required in the study and they're the people who are carry out the duties on real time situations and faces all the challenges on the ground. The top officials like the SHEQ officers and the mine captain were also targeted since they are the ones who control most of the operations and are responsible for decision making at the mine. The Human resources department through the clinic was also targeted in the research since information of the illnesses reported was captured in their department and was of great use to the study.

3.3.2 Sample size and its determination

According to the qualitative data collection during the pre-survey, Goldfields of Mazowe has a total mine strength which currently employs 852 workers and of the 852 employees 270 are underground workers of which that is the population that the researcher is targeting. For the purpose of gathering accurate and meaningful information the employee had to meet the following –

- Willing to take part in the research study.
- Should strictly be a GFM worker and have more than one-year work experience at the mine.
- Should be 18 years and above.
- Should be of either sex.

From the targeted population of 240 the researcher used the Yamane equation to calculate the sample population size. The sampling frame was created from the clinic records of the illnesses recorded. In this case the number of respondents from each department involved in the research was proportional depending with total number of people in that department. Yamane (1967) employs the generally accepted 95% confidence level which attracts an error percentage of 10%. The Yamane (1967) equation formula is as follows:

$$n = \frac{N}{1 + \mathrm{N}(\mathrm{e})^2}$$

Where N is the desired population

, n is the sample size

And e is the error percentage margin set at 10% for 95% confidence level

Therefore $$n = \frac{240}{1+240(0.05)^2}$$

$$= \frac{240}{1 + 240(0.0025)}$$

$$= \frac{240}{1 + 0.6}$$

$$= \frac{240}{1.6}$$

$$= 150$$

Through substitution of the symbols in the equation the researcher managed to calculate the sample population size that is 150 people.

3.3.3 Sampling strategy

Random sampling was done in the selection of questionnaire respondents that were used during the study. Random sampling is sampling a number of individual derived from a statistical population given and in the selection of the individuals everyone has an equal chance of being chosen. Due to large workers' numbers random sampling was pertinent, appropriate and economic over other sampling techniques. Through random sampling 150 employees were randomly chosen to respond to the questionnaire survey which was conducted by the researcher. More over purposive sampling was also employed for top officials in different departments for people so as to obtain primary data for specific case. For example, in this study purposive sampling was used to carryout interviews i.e. the sister in charge was purposively interviewed specifically for ergonomic cases, their occurrence, prevalence according to records kept and her knowledge of the cases for the time period she was at the mine.

3.4 Methods of data collection

3.4.1 Documentation

The researcher used both primary and secondary data sources. Primary data was attained directly from workers using open ended questionnaires, interviews and general observations. In addition to that from previous documents that the researcher obtained from the mine clinic, primary data was obtained from the found documents which contain the name, nature of work, injuries. The data was collected in retrospect for the years preceding the time the study was conducted so as to effectively examine the trend and pattern on the occurrence of illnesses and incidents that are associated with narrow reef mining. The strength of using this type of data collection tool is when obtaining information based on scientific knowledge as reviewed and recorded by qualified medical personnel it eliminates and recall biasness by individuals when conducting interviews. It also supports data attained from primary sources and secondary data sources used.

3.4.1 Questionnaire Survey

In the research in order for the researcher to obtain more data which consist of both qualitative and quantitative data, open ended and closed questionnaires where developed. These questionnaires were developed targeting those employees who have been working and are still working in narrow reef sections who are involved in different operations such as tramming, drilling, lashing and senior captains responsible for different sections of the underground operations. Questionnaires in the research were used to make self-reports from workers and data from workplace exposure to physical factors was collected. Open ended and closed questionnaires were developed in the research. According to Sakaran (2000), Questionnaires are one of the most effective data collection method especially when large number of people are to be reached. The questionnaire consists of three sections that's section A with personal data, section B with information on ergonomic causal factors that answers to objectives of the research, lastly section C with ergonomic policy issues which governs them and worker's suggestions. From the objectives of the research, questionnaires will be used to establish whether illness complaints being reported are depended on the nature of work being performed of exposure to risk factor and to determine the prevalence of the risk factors associated with narrow reef mine.

Questionnaire were distributed to different individuals using the drop and pick method between the period 2-9 July 2018, questionnaires were convenient to the researcher since it is inexpensive and follow-up was made easy. In addition, names of the people being issued the questionnaires was not required so it gave the people that room to respond to questions confidently and freely with privacy. 150 participants were randomly selected to fill questionnaire first group was from the night shift followed with the day shift. Of the 150 questionnaires 111 were retained. The Questionnaire which was distributed is shown on appendix 1.

3.4.2 Interviews

These are one of the most commonly used instruments for data collection and according to Dirwai and Gwimbi (2003) an interview refers to a dialogue between an interviewee and the interviewer with a purpose. The interviewer used semi-structured. According to an online source Evaluation Toolbox (2010) Semi-structured interviews are used to understand how interventions work and how they could be improved, semi-structured interviews allows respondents to discuss and raise issues that you may not have considered. The interviewer sets up a general structure by deciding in advance the ground to be covered and the main questions to be asked and the detailed structure is left to be worked out during the interview. Issa (2002) postulates that they allow for the collection of first hand data as well as for a greater depth of response from the respondent. Because of its less formal in nature this type of interview was selected by the researcher because the interviewees felt relaxed which gives more room for the researcher to explore and go unswerving towards the area of concern.

The main aim of the interviews was to determine the contribution of the purposively sampled key informants from different sections of the mine that are linked directly to hazards associated with narrow reef mining starting from the general employees to the management section. This was done to assess the ergonomic stresses occurring due to the nature of work being done in relation to the illnesses being reported so as to evaluate contributions the interview guide in appendix 2.

Table 3.1: Target respondents and the rationale for their selection

Interviewee	Reason(s) for interview.
SHEQ officer	❖ Responsible making sure all safety and occupational issues are addressed within the organization. ❖ Record keeping of all reported illnesses
General handworker **(2 from each crew)**(lashing tramming and drilling)	❖ They are involved on the real time activities that are carried out in the narrow reef section on a daily basis.
Sister in charge from the mine clinic	❖ Attends to all occupational injuries that occurs at the mine and keeps all the previous records of injuries and other clinical records.
NSSA factories inspectors	❖ Responsible for implementing and enforcing occupational safety laws. ❖ Help with comparative information of non-narrow reef mines and narrow reef mines in terms of risk factors and mostly reported ergonomic illnesses.

3.4.3 Field observations

For vivid, in depth and tangible information the researcher engaged on a participant observation. This type of observation was engaged on because the researcher will be working close to participants and all the events taking place will be closely observed thus gathering information in depth. Creswell (1998) notes that field observations are a systematic direct data collection technique which involves the use of all researcher's sense to examine either people or the natural situation. This technique played a pivotal role in the research because it allowed for the researcher to have a clear picture on how the participants are working in what conditions, postures, techniques used and how they adapt. Chikwekwete (2007) states that they are a way of obtaining data through observing characteristics and activities in their setting. In addition, as one of the determinations of the study, this technique was used to mainly identify major ergonomic illnesses that are associated with narrow reef mining. The observations where supported with photographs as they were apprehended during the observation in conjunction with the observation checklist that was drafted to guide field observation was the Rapid Entire Body Assessment.

Rapid Entire Body Assessment (REBA)

The REBA is one of the observational postural analysis ergonomic assessment instrument that the researcher employed in the study. The tool was used to assess the postures in the narrow reef mine setting therefore meeting one of the research objective that is to determine prevalence of ergonomic risk factors and to see their relationship with the reported illnesses assess. .Madani and Dababneh (2016) noted that REBA provides a quick and easy measure to assess a variety of working postures for the risk of work-related musculoskeletal disorders (WMSDs). The instrument can be used to assess the whole body as compared to other postural instrument for instance the Rapid Upper Limp Assessment (RULA) which only deals with the upper limps. Hashim *et al.* also states that the REBA assessment is suitable for whole body evaluation and is best for both static and dynamic work. The REBA assessment form that the researcher used is shown on (Appendix 3) and was used to assess the Jackhammer Operators, Lashers and the Trammers. In case of the research being undertaken the Rapid Entire Body Assessment was used to measure ergonomic risks associated with the nature of work performed or exposure to risk factors.

3.4.4 Secondary data sources

Secondary data sources used by the researcher where records from the mine clinic as well as from the GFM Safety Health and Environment accident record books. Data from the previous records from previous years was used to determine the prevalence, rate and trends at with narrow reef associated illnesses were occurring. Previous statistics and records were used by the researcher to identify ergonomic illnesses associated with narrow reef mining as well as reading along the trends so as to come up with graphs showing prevalence of ergonomic cases.

3.4.5 Data analysis and presentation.

Perez (2014) states that this is the process of organizing data into logical, sequential and meaning categories and classification. The researcher employed different analytic tools and procedure to analyze the obtained data from questionnaires, interviews and the observations. The Statistical Package for Social Sciences (SPSS) and Microsoft Excel were employed to analyze and present nominal and ordinal data from the questionnaires. This allowed for the use of cross tabulation of variables that is the physical working conditions and the illnesses being reported using the Chi-Square tests to identify association between variables. The data from observations and interviews was analyzed and presented through writing to complement some information that was presented using graphs for instance the REBA occupational scores. Photographs that where captured during the observations were presented to show clear and vivid evidence of postures of individuals while working.

3.4.6 Ethical issues

According to David and Resnik (2015) ethical standards promote the values that are essential to collaborative work, such as trust, accountability, mutual respect, and fairness and also helps to build public support for e research. In order to accomplish this the researcher attained an approval letter from the Geography and Environmental Studies Department which was presented to the Mine Manager hence assisting the researcher to be granted permission to carry out the study at Gold Fields of Mazowe. Participants were informed about the research verbally, discretion of gathered information and the namelessness of the participant was guaranteed on. Only willing participants were made subjects to the research, the researcher created a consent form for the respondents so that they would sign before participating in the study.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter aims at analysing the association amongst the ergonomic risk factors, the reported ergonomic illnesses and narrow reef mining at Goldfields of Mazowe. This is conveyed by bringing order, structure and meaning to the data that was collected by the researcher. The data used in this chapter was collected through the use of questionnaires, interviews, field observations using the Rapid Entire Body Assessment (REBA), and secondary data source mostly for previous statistics. The chapter encompasses the discussion of the results gathered from this research in comparison with other previous related ergonomic researches. The results and discussions existing in the chapter will be guided by the objectives of the study stipulated in chapter one.

4.1.1 Respondents

The chapter discusses the data analysis and findings from 111 questionnaires of which the targeted population was 150 people. This leaves the researcher with 74% respondent percentage of which all of them were males with maximum response because the researcher allowed for the respondents to feel free to ask were they do not understand and even express themselves in vernacular language.

4.2 Organisational SHEQ structure for Goldfields of Mazowe

The Head of the department at group level is the Group SHEQ Manager. He oversees the functions of the department across the group which consists of Bulawayo Mining Company, Goldfields of Shamva, King's Daughter Mining Company and Goldfields of Mazowe. The organizational structure, however, varies from mine to mine depending on the nature and scale of the operation. At Goldfields of Mazowe the SHEQ Head of Department is the Senior SHEQ Officer who reports both to the Mine Manager (Head of Operation) and Group SHEQ Manager. The Senior SHEQ Officer oversees the function of the department in liaison with other Heads of Departments. Below the Snr SHEQ Officer is the SHEQ Officer who coordinates the day to day running of the department. Also key to the SHEQ Officer's roles is the Development and Implementation of SHEQ Systems and Industrial/Occupational hygiene management. There is a

Safety Officer below the SHEQ Officer who mainly oversees Safety and Health Management for Underground Operations as well as critical skills training such as First Aid and Blasting Lessons among others. Below him is a SHEQ Assistant who mainly oversees Safety and Health for Surface operations. The SHEQ Assistant also has a dotted line reporting protocol to the SHEQ Officer who he works hand in hand with for SHEQ Systems development. For underground operations the Safety Officer is assisted by two Assistant Safety Officers.

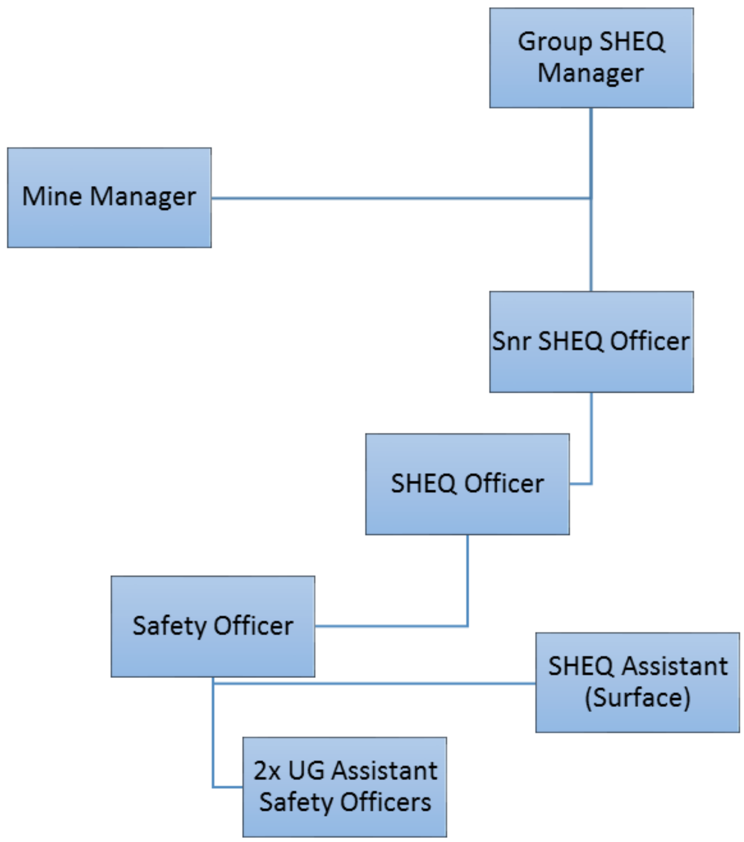

Fig 4.1: GFM SHEQ Organogram

Source: Field Work (2018)

4.3. Illnesses reported at GFM mine clinic

To identify the prevailing ergonomic illnesses associated with narrow reef mining at GFM, the information was assembled from the mine's clinic records through the sister in charge. Figure 4.2 presents the top ten reported illnesses with their different percentages.

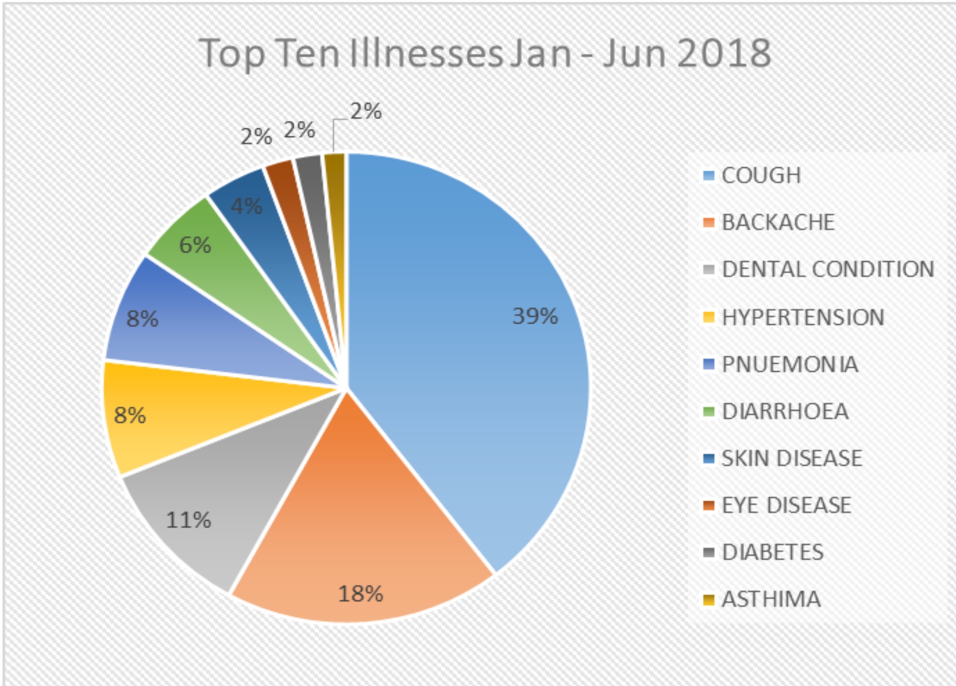

Fig 4.2: GFM Top Ten Illnesses

Source: Fields work (2018)

Noted in figure 4.2 backaches are the only ergonomically associated illness constituting 18% of the total illnesses with the second highest percentage following cough with 39%. This finding is supported with Tawiah et al (2015) who argues that low back pains are the most frequently reported WRMSD complaint in any industry. This profile accounts for the prominent illnesses reported and treated at the clinic. The ailments which are not mentioned in the list a very negligible.

4.3.1 Work-related ergonomic illnesses associated with narrow reef mining.

Although mining has become gradually mechanised there is still more manual handling (high physical work demand) that is involved in the process. Thus ergonomic illnesses constitute the second largest category of occupational diseases at Goldfields of Mazowe. According to NIOSH (2008) there are a number of factors associated with back pains some can effectively controlled while some cannot. GFM is not an exception, its work place design having stopes heights as low as 1.1m due to ore deposits and job designs (lashing, drilling) in restricted space exacerbates exposure to different risk factors such as awkward postures. The arduous nature of underground workings as well as restrictive workplace characteristic of the Mazowe narrow reef mining puts a strain especially on the back causing long term chronic back aches. Shown in figure 4.3 are shows the risk factors that workers are exposed to.

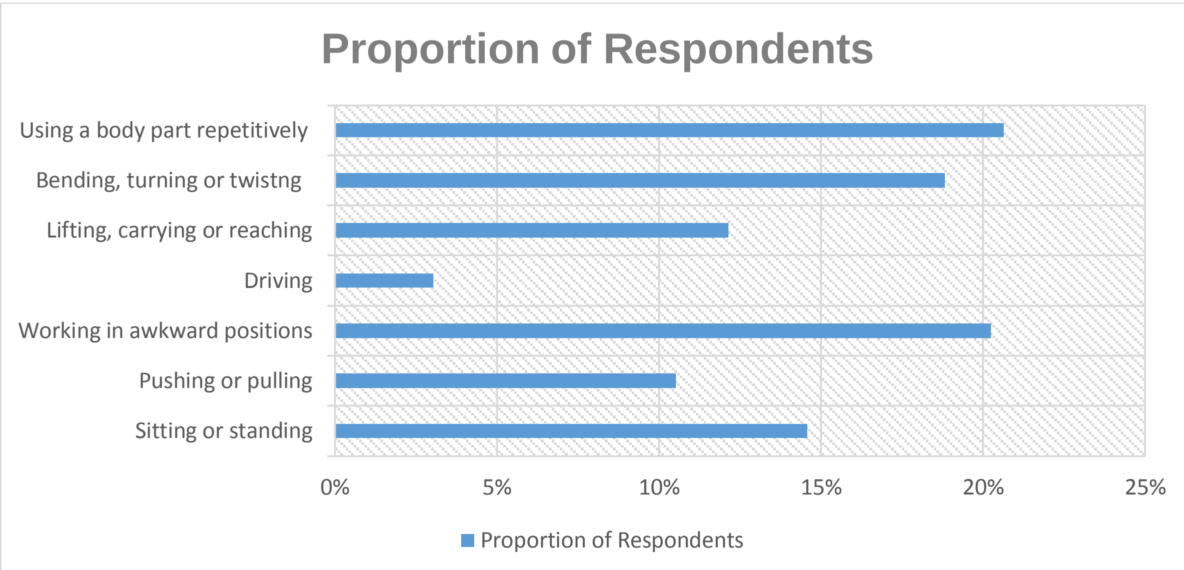

Fig 4.3: Prevalence of Ergonomic Risk Factors

Source: Field work 2018

The major significant factors causing musculoskeletal disorders in narrow reef mining picked from the questionnaires include the use of body part repetitively, working in awkward positions followed by non-neutral body postures (bending, turning or twisting) affecting almost if not all the underground workers. These factors are worsened by high physical work demands of mining operations whilst working on confined working stations. For example, the drillers are subjected to work on much confined areas with sealing heights less than 1.1 meters therefore they are forced to work in encroached positions while bending and this continues for prolonged hours. According to Anderson et al (2012) working in bent and encroached postures in confined spaces leads to higher intradiscal pressure and increase physical demands as compared to standing. Plate 4.1 shows drilling operations taking place in a very restricted area to the extent that the assistant operator is even kneeling.

Plate 4.1: Drilling operation taking place in confined areas

In plate 4.1there is massive evidence showing the extent of restrictiveness of the workplace with extreme bending posture, vibrations from the jack hammer and repetition of work (working on such places 9+ hours every day). Due to high degree of restrictiveness in narrow reef mining high demand of physical demand and extreme bending these are to a larger extent attributed to occurrence of back pains and in the long run leading to chronic back aches. Jerie (2013) supports this view while referring to most mining environments in the southern region and argued that mining takes place in very restrictive work areas with low ceiling heights and still involves large elements of physical work in spite of the introduction of engineering measures and mining equipment aimed at making work in the mining industry easier. In an interview with the SHE Officer he also mentioned that stope heights are low with an average of 1.1 m which leads to minimal mechanization due to restrictive space hence there is reliance to manual labor.

4.4. Prevalence of Ergonomic Related Illnesses and Ergonomic Risk Factors

4.4.1 Chronic Back Aches Cases Prevalence

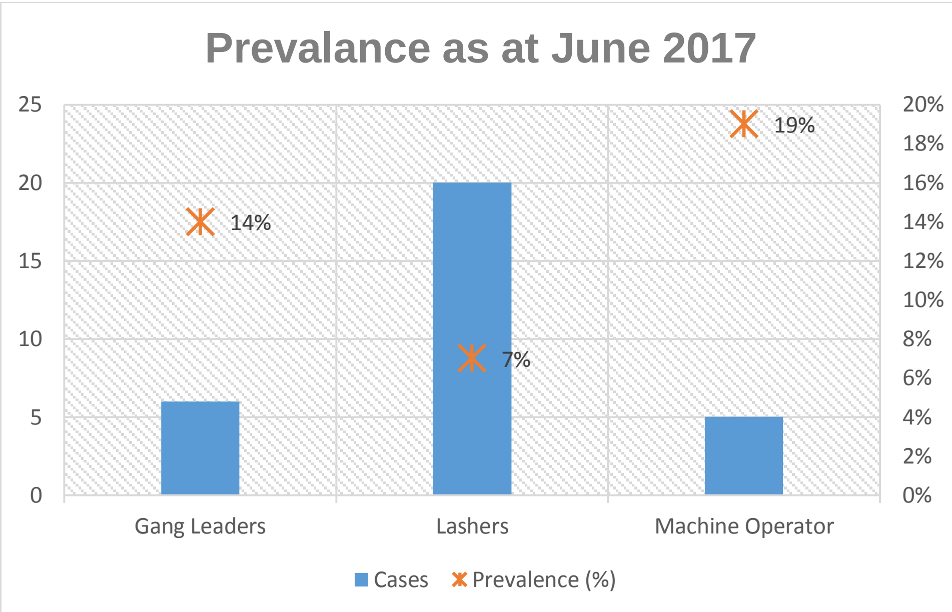

Fig 4.4: Back Ache Cases Prevalence

Source: GFM SHEQ Reports (2017)

Figure 4.4 shows the prevalence of chronic back cases as at June 2017. The data only accounts for the chronic cases only excluding temporal acute cases of short duration. The overall prevalence for the Mining department was at 49% which is relatively high implying that approximately 10% of the underground workforce suffered from chronic back pain. The Occupation with the highest prevalence was Machine Operation (Jack Hammer drilling) with an overall of 19% followed by the gang leaders with 14%. The Lashers occupation was inclusive of the trammers as they alternated between lashings and tramming with 7%. This is mainly attributed to restrictive work spaces and high demands of physical working thus it can be noted that workers who perform heavy manual occupations in restrictive areas are prone to back pains. This is also evidenced from figure 4.5 which shows more lost shifts resulting to absenteeism being obtained from the mining departments due to back aches.

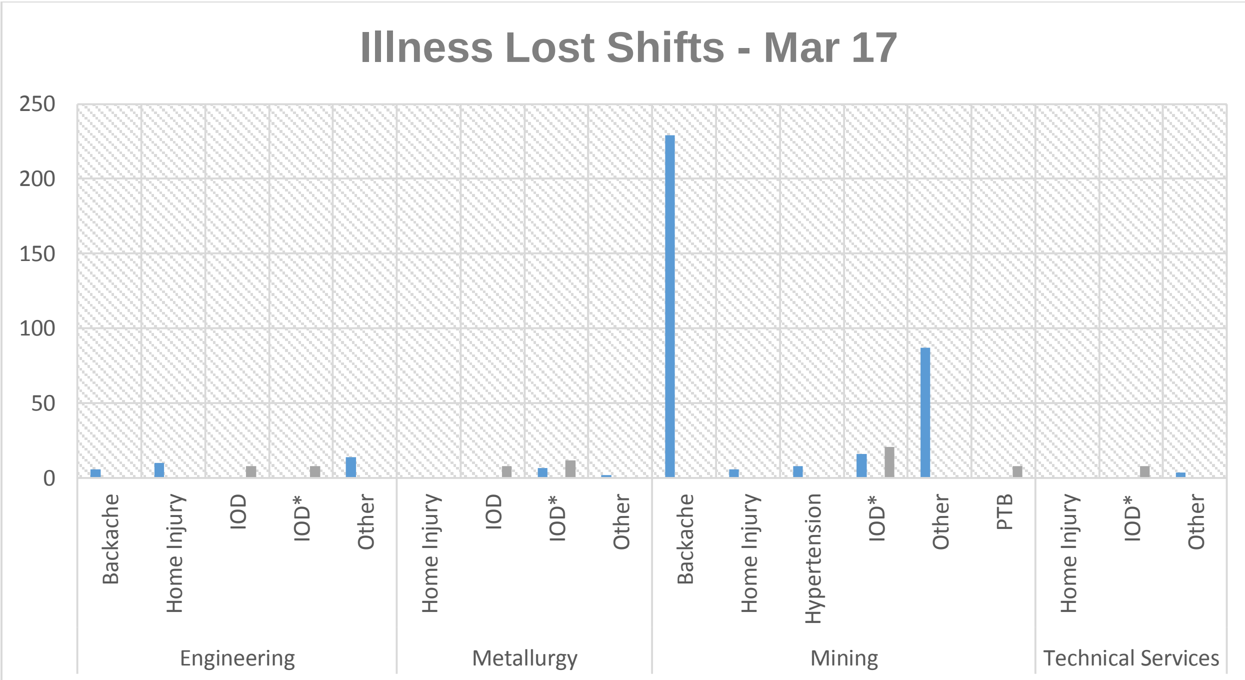

Fig 4.5: Illness Lost Shifts

Source: GFM SHEQ Reports (2017)

Figure 4.5 was adapted from a study done by the SHEQ department in March 2017. The bulk of the lost shifts were in the Mining department with the highest attributed to backaches, which mainly consists of workplaces with restrictive spaces (confined) due to the method of mining (narrow reef).This finding was consistent with an interview held with the SHEQ officer in which he mentioned that these back pains are attributed but not limited to long ore movement distances for both the lashing and tramming, for the drillers he mentioned awkward drilling postures and poor ground movement techniques as well as ore manual work reliance due to minimal spaces which does not allow for more mechanization. Schutte studied South African mines and the study indicated that 16% of the 1235 medical records examined at a gold mine concerned WMSD. Of these 15% were associated with the upper limbs, 16% with the lower limbs and 69% with the back region thus also leaving GFM a victim on back region issues.

In addition, during an interview with the Sister in Charge statistics showed that back aches contributed to the highest number of lost shifts due to the nature of the mine being narrow reef. The sister also mentioned that generally as people age back pains occurs but in some cases the age at which people are starting to report these back aches is lower than that what is expected thus some workers even starts to report back aches in their late 20s and she strongly associated this to the nature of workplace and occupation. Figure 4.6 shows the age profiling of people who are affected with chronic back aches.

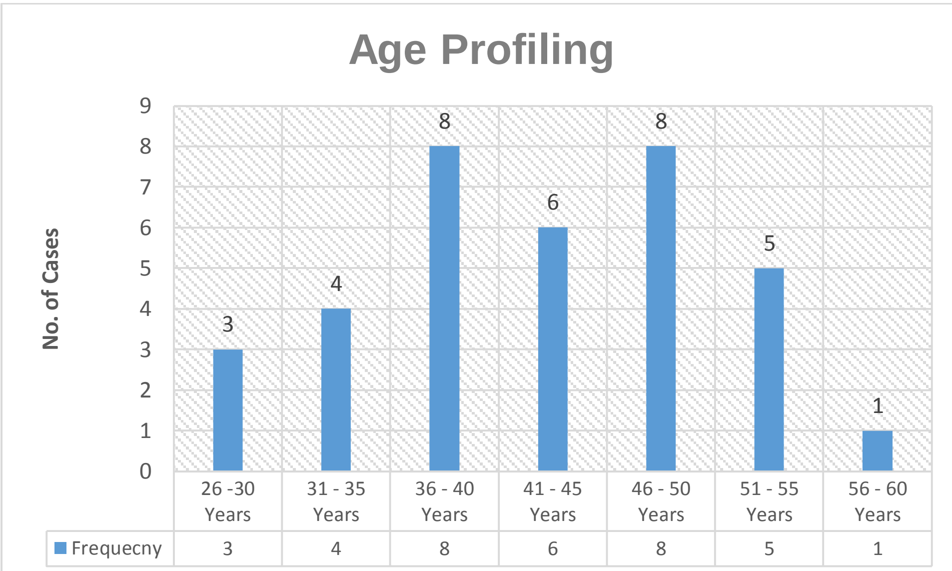

Fig 4.6: Age Profiling

Source: Field work (2018)

The average age of the cases is 42 years. Using statistical analysis, the ages are negatively slanted indicating a relationship between old age and susceptibility to back aches. This indicates a gradual effect due to continued exposure to ergonomic hazards such as working in awkward postures and excessive bending mostly for the machine operators and the lashers. This means age in combination with occupation directly influences occurrence of back ache, once back pains occurs they are more likely to continue hence prevalence of back pains in aging workers is more likely to increase.

4.4.2 Distribution of Pain Complaints

In the responses received in the questionnaire survey these trends were established.

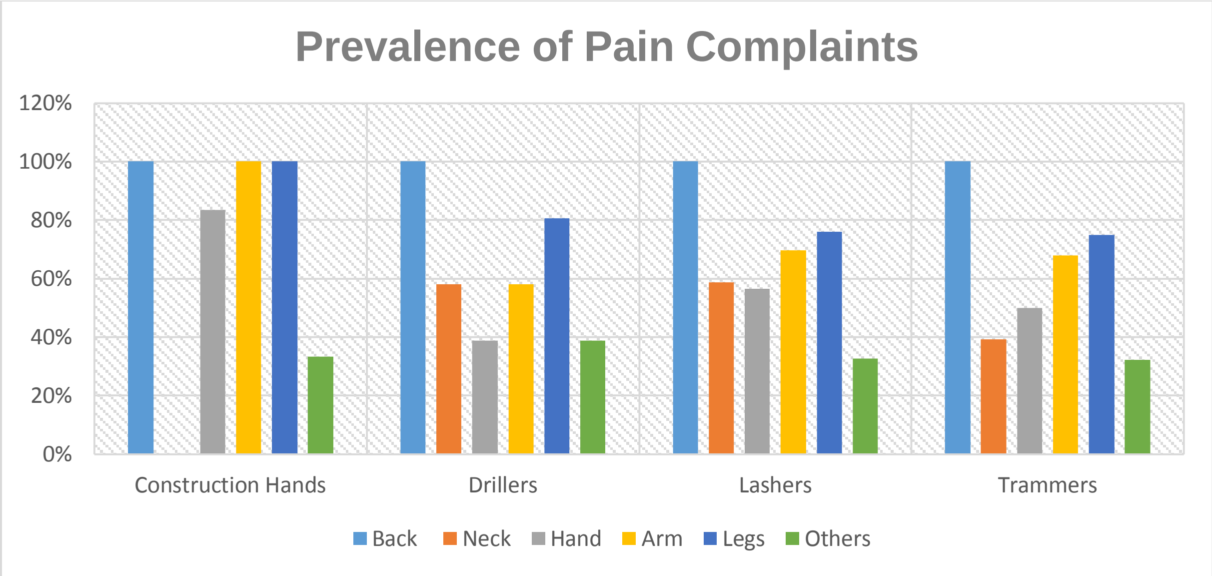

Fig 4.7: Prevalence of Pain Complaints

Source: field work (2018) The graph shows the percentage speculative pain sustained in relation to the part of the body and occupation done. In summary 100% of the respondents stated that they suffer back pain as they execute their work this is because most underground workers are involved in heavy physical work, transportation of explosives working in confined areas as well as excessive bending and twisting. While 83%, 74%, 57%, 39% and 34% also linked leg, arm, hand, neck and other pains to the work they perform. These results depend on the occupation that's why it can be noted that lashers and trammers obtain approximately 70% and 75% pain on their arms and legs respectively because they repetitively use them. Trammers pushing the cocopan exerting force o it so that they can move it and for the lasher moving ore while bending for a prolonged period of time. These pains are caused mostly by reliance on manual handing since work areas have limited space and mechanization can to a lesser extent be implemented. It is important to note that most of the pains are short lived hence were not accounted for in the clinic statistics as they were not reported. There is a possibility that pain could be mistaken with fatigue.

4.4.3 Ergonomic Risk Factors Prevalence

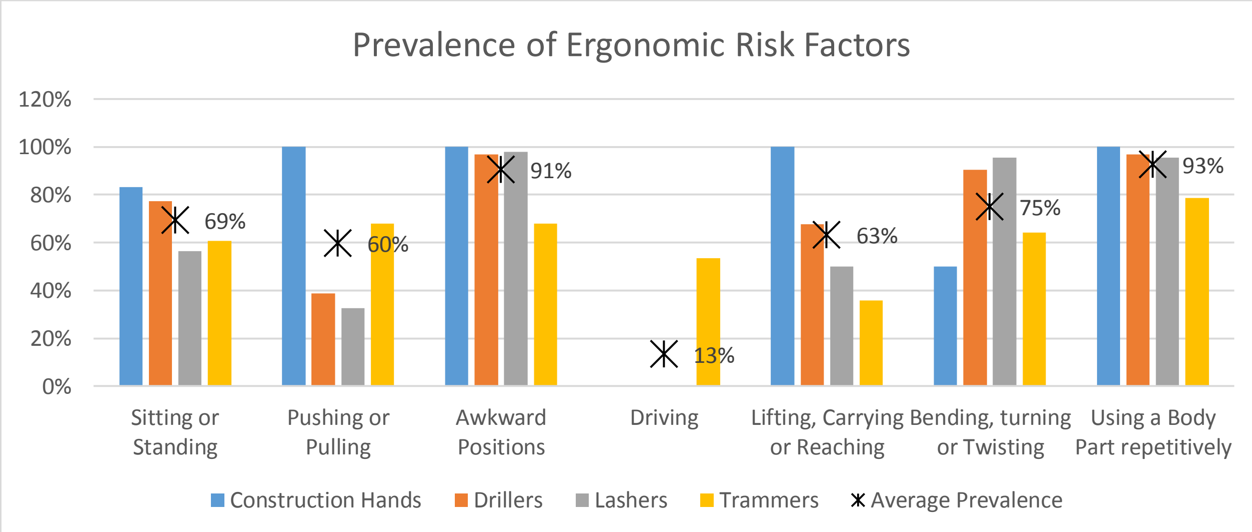

Fig 4.8: Prevalence of Ergonomic Risk Factors

Source: Field work (2018)

Figure 4.8 shows the prevalence of ergonomic risk factors in the four occupations which were sampled. The most prevalent risk factor was repetitive body use followed by awkward body positions, with the lowest being driving. All Occupations had a percentage average of above 79% due to the nature of routine and physically rudimental work performed. Above 87% of workers were exposed except for trammers who worked in drives whose dimension were recently corrected increasing head room and workspace. These workers spend most of the times in stopes with an approximate average height of 1.1m but allowing ±1.3m standing room. The lashers are most affected as they spend their whole shift lashing/shoveling ore in those stopes. Pulling and pushing as well as lifting, carrying and reaching was most prevalent in the Construction Occupation due to their nature of work which involves moving materials for construction of work areas as well as the construction work itself. On average the 76% and 67% of the risk factors were present in the Construction Hand and Drillers occupations with those accounting for the highest in the data analyzed.

High percentage prevalence's of ergonomics risk factors can be attribute to several factors, for instance the distance of movement while transporting materials such as explosives, lifting drilling equipment from point of storage to work stations, continuous bending while lashing, as well as twisting and turning while fitting the pipes. The researcher observed that when the drillers are about to charge they collect explosives from the underground magazine to their charging places traveling approximately 500 meters plus while carrying a load of 20kgs of ANFEX fertilizers.

Long working hours without having to rotate working areas was noted, of the 111 workers issued with questionnaires 87 workers worked more than nine (9) hours, seven (7) day a week of which the normal stipulated working hours is 8 hours and according to Mywage.org/Zimbabwe an online source it states that in Zimbabwe every Collective Bargaining Agreement provides for minimum of eight hours per day, subject to the nature of work, and 40 hours per week. This adds up to at most 6 hours 30 minutes per day for seven days instead most of the workers are working twice as their normal working hours. The sister in charge argued that working excessive hours in such confined working areas doing more of heavy physical demanding work contributes to the increasing numbers of chronic back aches. Table 4.1 shows more than half of the underground workforce work more than 8 hours showing a total of 65.8% workers working for 12 hours. This is consistent with the GFM sister in charge's notion that chronic back aches are being worsened with the fact that most workers work all days of the week therefore workers are not getting sufficient recovery time at the end of the day.

Table 4.1: Frequency of respondents and total numbers in percentages

		Frequency	Percent	Valid Percent
Valid	5	2	1.8	1.8
	8	22	19.8	19.8
	9	2	1.8	1.8
	10	6	5.4	5.4
	11	6	5.4	5.4
	12	73	65.8	65.8
	Total	111	100.0	100.0

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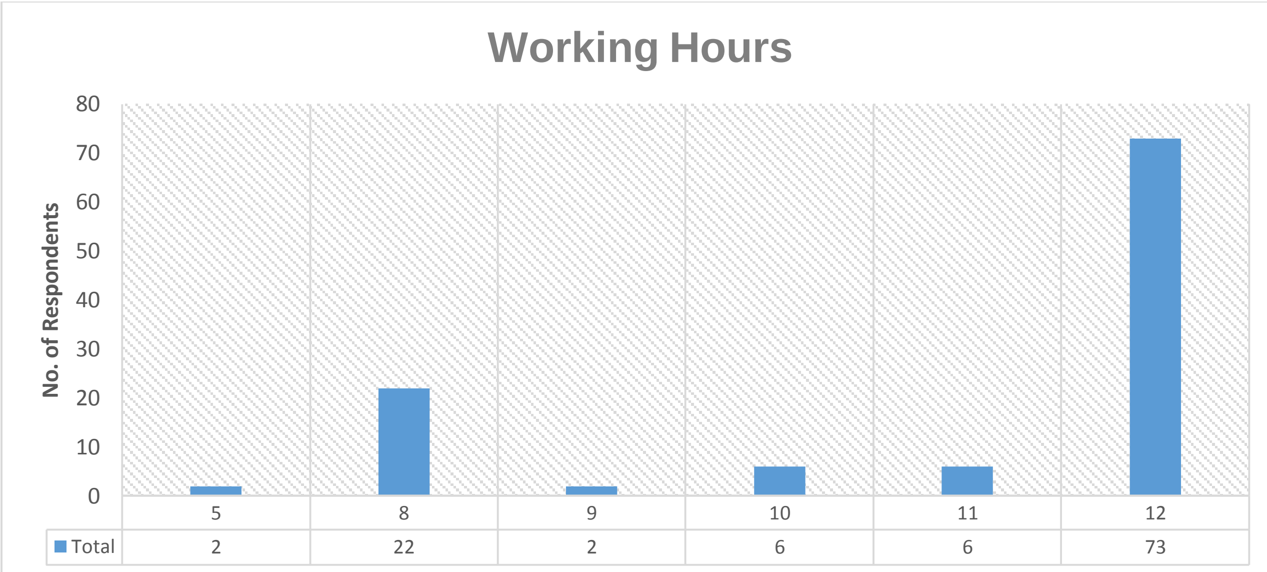

Fig 4.9: Working Hours

Source: Field work (2018)

4.5 Relationship of Occupation, Pain Complaints and Risk Factors

4.5.1 Occupation vs Pain Complaints

A Chi-Squared test was performed to establish if there was any dependence between occupation and the nature of pain experienced by workers. The hypotheses were as follows:

H_0: Body parts affected are not dependent to the occupation performed.

H_1: Body parts affected are dependent to the occupation performed.

Table 4.2: Chi-cross tabulation table

Expected Fi	Construction Hands	Drillers	Lashers	Trammers
Back	6.5	30.4	47.4	26.7
Neck	3.3	15.3	23.9	13.5
Hand	3.4	15.6	24.3	13.7
Arm	4.4	20.5	32.0	18.0
Legs	5.1	23.8	37.1	20.9
Others	2.2	10.4	16.2	9.1

Below is the contingency table used: -

Table 4.3: Chi - Contingency Table

	Construction Hands	Drillers	Lashers	Trammers
Back	6	31	46	28
Neck	0	18	27	11
Hand	5	12	26	14
Arm	6	18	32	19
Legs	6	25	35	21
Others	2	12	15	9

At 5% level of significance the Chi – Squared test perfomed using Excel returned a P value of 0.917 which is larger that the critical P – Value of 0.05. Therefore accepting the null hypothesis and a conclusion that the parts affected are not dependant on the occupation performed this is in consistance with the data anaylsis. Considering in the chronic back ache cases discussed in 4.2 and prevalence of ergonomic risk factors this dependence of no association can be observed on body parts affected almost all workers were affected on their back be it trammers, lashers, driller or the construction hands. The drillers had the highest chronic back ache prevalence in the study done by the mine and invariably so was the average 67% of the risk factors existing in the Drilling occupation (2^{nd} highest). This implies that the higher the ergonomic risk the higher the likelihood of developing a chronic ergonomic illness (back ache)

4.6 Rapid Entire Body Assessment (REBA) results

In order to assess the risks of work-related entire body disorders the researcher used the Rapid Entire Body Assessment (REBA) tool which was developed to assess workers postures so as to determine the risk index of work-related musculoskeletal disorders WRMSDs. The last objective of the study was to examine the relationship of the illnesses reported and the nature of work performed, the REBA in this case is used to determine how much risk does the working conditions and posture pose to the worker’s ad to what extent. Table 4.3 shows the REBA decision table.

Table 4.4: REBA score and decision table

Score	Level of Ergonomic risk
1	Negligible risk, no action required
2-3	Low risk, change may be needed
4-7	Medium risk, further investigation, change soon
8-10	High risk, investigate and implement change
11+	Very high risk, implement change

As seen from table 4.3 score 1 represents the user at a negligible risk and no action is required. Ranging from 2-3 and 4-7 are low to medium risks respectively and further investigations are required to see if changes can be implemented. Scores stating from 8 going up are indicative of high risk and implementation of necessary changes is instantly needed.

Figure 4.10 shows the REBA scores observed by the researcher and the average score for the lasher, trammers, construction hand, drillers and the trammers-lashers was 13.5. This implements that the majority of the workers if not all are exposed to high risk and the implementation necessary changes needs to be implemented instantly. Drillers obtained the highest scoring of 15 followed by construction hand with 14 this shows the above mentioned activities carries a very high risk and the posturers have adverse effects on worker’s musculoskeletal systems.

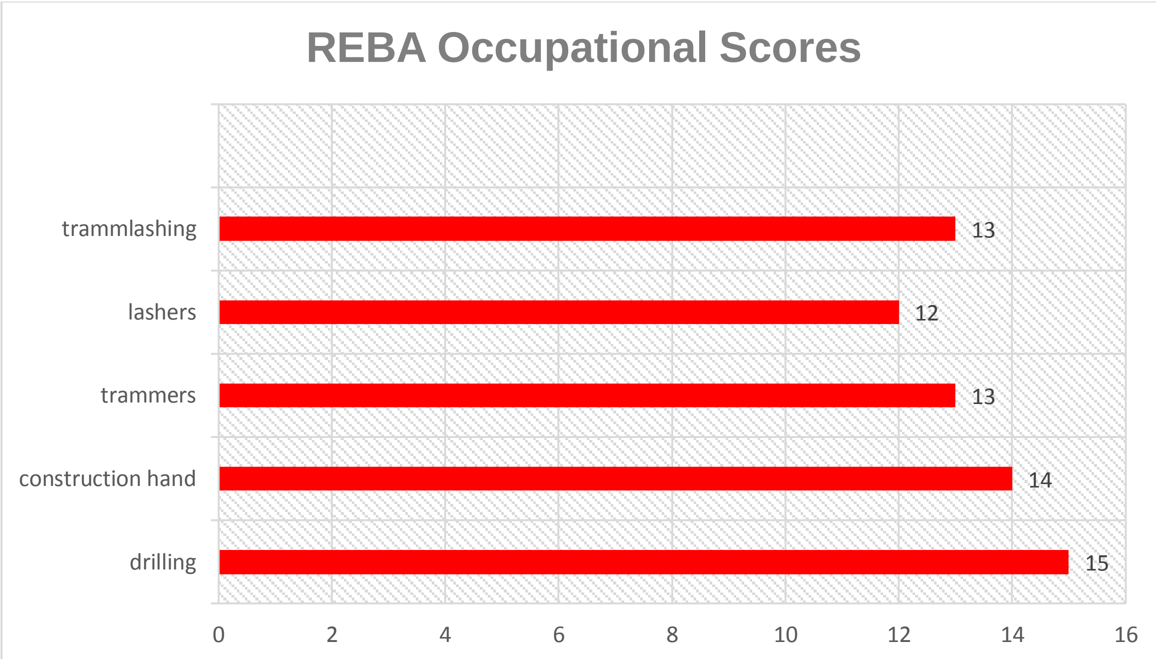

Fig 4.10: REBA Occupational scores

Source: Field work (2018)

Figure 4.10 illustrates the results of the Rapid Entire Body Assessment observation of the underground workers. In case of Goldfields of Mazowe workers are mostly affected on their back due to nature of the mine being narrow reef which do not allow for mechanization because of confinement making the operations rely more on manual handling. This means there is more demand for heavy physical work thus leading to workers obtaining chronic back aches attained from different risk factors. Derived from the REBA results there are ergonomic deficiencies in narrow reef workstation designs and this intensifies the risks of attaining ergonomic illnesses in narrow reef mining.

4.7 Workplace ergonomics, SHEQ standards and legislation

Throughout the process of data collection (issuing out of questionnaires, interviews and observations) the researcher noted that from most of the mines top officials are aware of the existence of some international and national legislations that governs OHS. Mazowe Mine like other mines in Zimbabwe is required to follow Occupational Health and Safety legislation in all its operations. Amongst these GFM follows Safety Health and Environmental (SHE) policies/ legislations which includes ISO 14001 and ISO 45001:2018. Of particular importance at

Goldfields of Mazowe is the ISO 45001:2018 which standardises the management of Safety and Health issues. One of the clauses compels the organization to identify all Safety and health risks and come up with management actions to address areas of deficiency and this also includes ergonomic issues. It is however noteworthy that correction of ergonomic deficiency is a long term project which involves mine redesign which requires extensive capitalization.

The Factories and Works Act governs the underground operations looking at factors like workplace designs and the equipment used. It states that every occupier of any factory shall keep in the form and manner prescribed an accident register and shall record in such register the particulars of any accident or injury. This helps to trace back on root causes of incidents, however this law only deals with instant injuries and as of ergonomics some injuries come in the long run depending on period of exposure for instance chronic back which shows signs after the harm will already have occurred. Therefore, a gap can be noticed that ergonomic hazards are given partial but not all attention. Section 14(8) and section 13(5) respectively states that machinery shall be subject to examination and inspection and the inspector may at any reasonable time enter upon any factory or premises where machinery is in use.

There is therefore slow traction compounded by the financial costs as well as voluntary/self-compliance stance taken by the International Standard, it is not enforceable by law. In the Zimbabwe National Occupational Safety and Health Policy (2014) to provide for ergonomic, prevention of occupational incidents there is a principle which states that every worker has the right to refuse to undertake unsafe work and each worker have the right to fair and safe labor and to know practices. It also states that most injuries occur due to uncontrolled work factors, environmental conditions and state equipment. This law is being violated.

In addition, there are other legislation affecting GFM this includes the pneumoconiosis Act Chapter 15(8) which states that no person shall employ a worker in dusty occupation in as much as wet drilling and watering down is practiced dust is still produced from other operations such as blasting and lashing therefore it can be noted that this is effective to a less extent because when blast is still settling and when lashing all other workers in other sections are affected. It can be noted that inasmuch as mines GFM is complying to SI 109 which supports wet drilling for underground drilling so as to reduces dust however this is not effective.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The final findings of the study imply that there is a protuberant association between the ergonomic risk factors and the reported ergonomic illnesses in narrow reef mining at Goldfields of Mazowe. Employees who are directly involved in the underground operations including the lashers, drillers, trammers and construction hands are mostly affected as it was noted that approximately 10% of underground worker force suffered from chronic back aches. According to the research findings this is mainly attributed to confinement, long ore movement distances, awkward drilling postures, few scrappers and no proper equipment for transporting materials like explosives hence the reliance on manual labour. Consequently, due to high reliance on manual labour associated with narrow reef mining, postulated from factors above, chronic back aches were the only significant ergonomic illness that was reported by the workers at the mine clinic.

Workers from the mining department are mostly affected with back aches comparing with all other departments at the mine. Amongst the ergonomic risk factors awkward positions and using a body part repetitively affected workers significantly affecting 91% and 93% respectively and on average all the seven risk factor stands at 66% which is relatively high. The illness reported and the body parts that are affected are depended on the nature of work performed evidenced by the drilling occupation with 67% of the risk factors and was also in consistence with the study that was carried out by the mine SHEQ department which show the occupation to be having the highest chronic prevalence.

Pertaining the analysis of the topic undertaken, it can be concluded that there is a significant relationship\ association between the ergonomic risk factors and the reported ergonomic illnesses in narrow reef mines. It can be noted that some workplace designs and job designs exacerbates exposure to ergonomic hazards and of those characteristics GFM workplace design and job designs are not an exception, these characteristics makes it difficult to effectively control ergonomic hazard. It was observed that working in a narrow reef mine exposes workers to back aches due to the work place design which is confined in nature and expose workers to continuous bending awkward\crouched postures and use of body pats repetitively. Due to these chronic back aches numerous shifts are lost and not only that becomes an issue of concern these also bring losses in the organisation resulting to shortages of work force, loss of bread winners to the families and loss of employment to the individual as well.

The researcher also established that apart from the nature of the work place design, in the field there is more concentration on the need to maximise production whilst ignoring the safety aspect (relationship between worker and his work place) this also contribute to the increase in numbers of back ache cases at the mine. Insufficient recovery time over the course of the working days was also noted this have strong association with ergonomic illnesses such as chronic back aches and in order to reduce some of the ergonomic illness some measures should be taken into considerations.

5.2 Recommendations

Based on the findings derived from the research study, the following recommendations are suggested for GFM;

Mechanization of underground operations - It was noted that there is over reliance on manual handling underground and given the confined/ restrictive work areas underground workers are bound to suffer ergonomic strain and invariably fatigue. Introduction of more scrappers for mechanical lashing, LHDs for drilling this will reduce the strain on the workers hence reduce occurrence of ergonomic illnesses.

Introduction of recovery time - Insufficient recovery time was strongly associated with back aches so implementing breaks from work (time off) as well as reduction of workload is also suggested for Gold Fields of Mazowe.

Launching Behavior Based Safety program – For example Value Based Safety programs the drive in such program is to promote safety as value not merely a priority which changes. Promotion of VBS in the community will help in improving safety awareness hence promotion of a safety culture. In line with VBS programs that cultivate and promote a safety culture to include but not limited to:

- Incentive scheme; recognition of safe workers both on duty by setting up promotions which reward safe practices.

Adoption of participatory methods for mines ergonomic processes and risk factor awareness – GFM's SHEQ department also needs to adapt the NIOSH participatory method of mines ergonomic processes and risk factor awareness program which demonstrate practical ergonomic principles. In addition, the department should facilitate an ergonomic team which consist of workers from all underground sections and supervisors to oversee ergonomic implementation on all underground operations.

Establish and intensifying training on wellness programs - such as training of manual handling (physical activities) and fatigue management. This will raise awareness and offer comprehensive health service for all employees through encouraging appropriate alterations in personal habits, lifestyle and the environment in ways that reduce ergonomic risk and enhance health and wellbeing.

Formulation of clearly stated Ergonomic policy - NSSA should come up with a standalone policy on ergonomics as it is an important aspect when it comes to a sound occupational health and safety of an organization.

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Appendix 1: Questionnaire for the underground work force

Complements of the day to you Sir \Madam! Thank you for sparing your time to take part in filing in this questionnaire. I am an undergraduate student at Midlands State University studying Geography and Environmental Studies and my name is Nyasha Maningire. I am doing a research entitled ‘An analysis of the association between ergonomic risk factors and illnesses in narrow reef mining in Zimbabwe. A case study of Goldfields of Mazowe’. The purpose of this questionnaire is to try and find out if the work place stature can be linked to the illnesses that are being reported. All information provided will be used or academic purposes therefore confidentiality is guaranteed.

Section A: **Demographic information**

<u>NB: Tick where applicable</u>

1. Age	*18-25*	*26-34*	*35+*			
2. Sex	Male	Female				
3. Length of service	<5yrs	*5-10*	*10-15*	*15-20*	*>20*	
4. Marital status	Single		Married			
5. Department	Job title					
6. Working hours	*>8hrs*		*±8hrs*		*<8hrs*	
7. Number of working days per week						
8. Educational level						

Section B: Information on ergonomics causal factors.

9.Outline the activities involved in your current job

……
……
……
……
………………………………………………………………………………………………………..

10.Do your workplace conditions pose any risk of attaining injuries to the musculoskeletal systems

Yes ☐ no ☐

11.If so what parts of the body are mostly affected

……………………………………………………………………………………………………..

12.What are the main ergonomic hazards arising due to the nature of your work place being a narrow reef

……
……
……
…………………………………………………………….

13.How often do people report incidents that are directly associated with the nature of work.

NB: Tick where applicable

Incidents	**Daily**	**Weekly**	**Monthly**	**Yearly**
(a)Near misses				
(b) Lost time injury				
(c)Reportable incidents				
(d) Fatal incidents				

14.What do you think is the main cause of the occurrences of these narrow reef related incidents
………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………………………………….

15. (a) Are you familiar with the term ergonomics . Yes ☐ No ☐

(b) If yes what do you know about ergonomics
………………………………………………………………………………………………………
………………………………………………………………………………………………………
…………………………………………………………………………………….

(c) Does the mine engage workers in any ergonomic training in relation to the nature of your work place Yes ☐ No ☐

(d)If yes how frequent are they conducted
Fortnight ☐ Monthly ☐ Yearly ☐

16. What are the consequences of practicing poor ergonomics or ignoring ergonomic principles while working?
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………………………………………………………..

17. What do you think should be done to reduce or minimize the occurrence of ergonomic illness mentioned above
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………………………………………………………………………………….

Section C: Management and legislative Issues

18. (a)Do you report incidents/injuries to the management? Yes ☐ No ☐

(b) If yes how long does it take for the management to respond ……………………………………………

19.Does the organization cater for all the medical expenses involved
………………………………………………………………………………………………………

………
…………………………………………………………………………………………….

20. (a) Are there any measures put in place by the mining management team to reduce the occurrence of above mentioned Yes ☐ No ☐

(b)If yes name them
………
………
……………………………………………………………………….

(21). Are these measures effective. Yes ☐ No ☐

(b)if they are not effective, what is/are the causes of their ineffectiveness
………
………
………
… ………………………………………………………..

(c)What do you think should be done
………
………
………………………………………………………………………………

THE END

THANK YOU

Appendix 2: Semi structured interview guide for the underground workers

Complements of the day to you Sir \Madam! Thank you for sparing your time to take part in this interview. I am an undergraduate student at Midlands State University studying Geography and Environmental Studies and my name is Nyasha Maningire. The purpose of this interview is to try and find out if the work place stature can be linked to the illnesses that are being reported to the mine clinic.

Name :

Jackhammer Operator ☐

Lasher ☐

Tramming member ☐

1. For how long have you been working at GFM?
2. What are the major hazards that you experienced while conducting your duty?
3. What are the causes of these hazards?
4. What precautions do you take in order to address the above mentioned problems?
5. Have you ever conducted any training based on the nature of your work place?
6. What do you think should be done to address these problems encountered?

For the clinic sister in charge

1. How long have you been working at GFM?
2. Do you have any records of illnesses that you can relate to the nature of the mine being a narrow reef mine? If yes, what are the illness?
3. Over the time period you have been working at the mine are these illnesses related to narrow reef mining increase or decreasing. Give reasons for any of the answer given if increasing why the increase if decrease are there any strategies that where implemented to reduces the prevalence.
4. For instance, if one is ill with either of the above mentioned illness what special medication do you recommend?

5. What makes you determine that this casualty must be put on light duty, or go back to his actual job or should not come back to work at all

For the management (Senior SHEQ officer)

1. For how long have you been working at GFM?
2. Is there any accident that have happened at the mine that you can relate to the nature of the work place?
3. What do you think should be done to address the issue of ergonomic illnesses that are associated with the nature of workplace at GFM being narrow reef?
4. For those workers not coming to work at all do you compensate them if yes with what?

Appendix 3: Observation Checklist

What to observe

1. The working conditions, how do they conduct their work in such confined work places?
2. Before starting any work what do they do?
3. What are the hazards that are likely to occur when working in areas of confinement?
4. Techniques that are used in such working areas, knelling supporting using life line etc.

REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

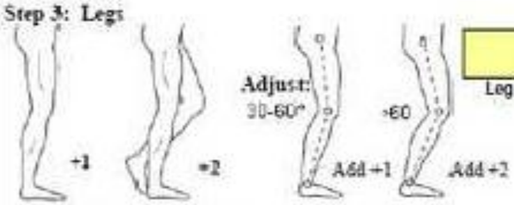
Neck Score

Step 2: Locate Trunk Position

Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs



Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A

Posture Score A

+

Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score

=

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C.

Score A

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A	Neck	1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B	Lower Arm	1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table C

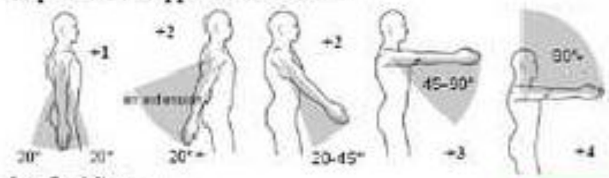
Score A (score from table A +load/force score)	Score B, (table B value +coupling score)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + Activity Score

Final REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:



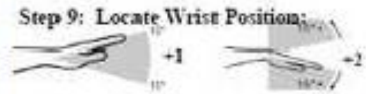
Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 8: Locate Lower Arm Position:

Lower Arm Score

Step 9: Locate Wrist Position:



Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B

+

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, *good:* +0
Acceptable but not ideal hand hold or coupling acceptable with another body part, *fair:* +1
Hand hold not acceptable but possible, *poor:* +2
No handles, awkward, unsafe with any body part, *Unacceptable:* +3

Coupling Score

=

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Task name: ______________ Reviewer: ______________ Date: ____/____/____

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rbarker@ergosmart.com (816) 444-1667

This tool is provided without warranty. The author has provided this tool as a simple means for applying the concepts provided in REBA.