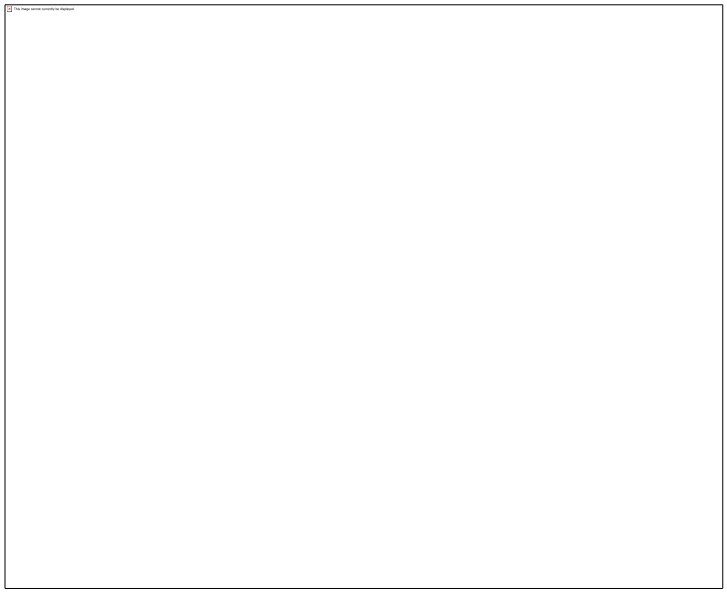
BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF ENVIROMENTAL SCIENCE

ASSESSMENT OF HEAT STRESS AMONGST ARTESENAL SMALL SCALE MINERS. A CASE STUDY OF KITSIYATOTA.



RESEARCH PROJECT

MUTOWEMBWA NYARADZAI

B200594B

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

DECLARATION

Registration number -B200594B

I Nyaradzai Mutowembwa do hereby declare that this work-related project is my original work and has not been submitted before. All the information derived from other sources is indicated in the project.

Signature of the student Date:31 May 2024

This dissertation is suitable for submission to the faculty and has been checked for conformity with the faculty guidelines.

Signature of the supervisor

……. Date…….

DEDICATION

This work is mostly to my aunt and uncle who have stood firmly as my guardians after the death of my parents and also to my siblings, without whose emotional support I would not have made it this far.

ACKNOWLEDGEMENTS

I would like to sincerely acknowledge the following persons for their contribution to this research:

- The Almighty for the light he shines in my path
- My supervisor, Mr Elvis Chiboyiwa for his encouragement, support as well as professional assistance throughout the research.
- Kitsiyatota mining workers for their cooperation during my data collection period.
- My family, who stood by me in times of difficulties and gave me hope.
- My friends Dan Torerai and Tanatswa Shindi, who by their kind of words of encouragement have helped me finish this journey

LIST OF ACRONYMS

WHO - World Health Organisation

OHS -Occupational Health and Safety

ASGM - Artisanal small scale gold mining

SPSS - Statistical Package for Social Sciences

PPE - **Personal** Protective Equipment

LIST OF FIGURES

LIST OF TABLES

Abstract

Temperatures have been increasing and impacts of climate warming are increasing the chances at which the workers are vulnerable to heat stress. In order to take care of workers health and safety, there is need to adapt to protection strategies. However, there is little to no concern taken to address this issue. At Kitsiyatota mining area, Artisanal miners have been exposed to heat stress because of the poor working conditions at the site as well as the intensiveness of the work. The primary purpose of the research is to assess the prevalence and causes of heat stress amongst small scale artisanal miners at Kitsiyatota. A cross sectional study design was used to carry out the research with the main purpose being to assess heat stress amongst small scale artisanal miners. A random sampling technique was used and a sample of 65 participants was used. Temperatures were collected and an analysis was done at the site for provision of water or shade. In order to determine the prevalence of heat stress amongst small scale artisanal miners. Using these data, exposure frequencies were computed using methods that are common in the industry. Higher temperature ranges were recorded with 74 percent of the workers' body temperatures being above 37 degrees Celsius and from the findings it was clear that almost all of the artisanal miners were experiencing the effects of heat stress from heat cramp, fatigue, heat exhaustion to fatality. The lack of shade at the site, Lack of PPE and no water provision were also main contributions despite the effect of high temperatures. It was also noted that 75 percent of artisanal miners are not trained on heat stress, they do not have enough knowledge on how to protect themselves from heat stress and its effects. In addition to that, 47.7 percent work for 5 to 7 days a week with 41.1 percent also working 5 to 10 hours a day. This is clear evidence that there is high work intensity and not enough rest which are some of the factors leading to heat stress. In conclusion, there is no rest schedules, no adequate training, no water provision, no shade all these contributing to high temperatures of the body coupled with high intensity of work being done are the conditions for heat stress. There is need to set up some structures for the workers to rest, some water provision sources like tanks for the workers to drink. There is also need to educate these miners about the effects of heat stress and to teach them how to protect themselves against heat stress and its effects.

Contents

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND INFORMATION

Studies have shown that either working outdoors and indoors exposes workers to risks that are associated with heat stress possibly because heat stress is most common in conditions which are hot and humid (Sugg et al, 2018). According to Hosakawa et al, 2019, these conditions being are caused by factors related to the environment (radiant heat, high temperatures, wind speed and humidity), factors related to occupational health (cooling systems, clothing and equipment used and physical workload), and personal factors (acclimatisation level and rehydration). Vulnerability of artisanal miners is mainly caused by tropical weather coupled with rising temperatures, lack of advanced mining technologies and barriers arising to access heat stress adaptation strategies (Nunfam et al., 2020). Very little or no attention is directed towards controlling of the hazards thus increasing the level, frequency and regularity in which risk affects the workers. Heat stress is one of the related risks and as a significant occupational health issue for miners, it can cause dehydration, exhaustion, and hit stroke. The cause of the effects was climate change, which led to increased air temperatures that exposed the miners to heat, resulting in serious heat-related illnesses or death (Nunfam et al, 2019).

Heat stress is a significant occupational health issue affecting miners, as it can cause dehydration, exhaustion, and heat stroke. The high temperatures and humidity levels in mining environments can make it challenging to regulate body temperature, leading to heat-related illnesses. Heat stress is a major occupational hazard that affects many workers in open pit mining environments. According to Kownacki et al, 2021 to be able to assess and detect heat stress, many factors have to be put into consideration and the assessment should consider all sources of heat stress which mainly comprises of three constituents which are environmental factors, the activities that are being done which are physical and the clothing. Studies show that artisanal small-scale workers are at the risk of being exposed excessively to heat when they work in hot and humid environments for which the factors include high temperatures and the humidity, wind speed, and heat (that is radiant heat), physical factors which include physical workload, equipment, shade and the shade

or cooling systems and personal susceptibility factors (Hosokawa et al., 2019). According to Nunfam, 2021 heat stress acquired from work can be caused mainly by the humidity at the workplace and temperatures which thereby are responsible for the response of the body through thermoregulation. Workers who operate mainly in extreme heat environments will eventually reach a point whereby their bodies will not be able to tolerable any temperature above the heat range of (35–37 C) therefore if the capacity at which temperature is regulated is lost, a condition that is life threatening may arise (Kownacki, 2021).

The final effects of the risks of heat stress are seen mostly seen by the manifestation of dehydration, heat oedema, heat rash, heat exhaustion, heat cramps as well as heat stroke (Lundgren et al., 2013). The other key impacts of being exposed to heat stress are, injuries, mental impairment, reduction on productivity and social ill-health although the effects depend also on individual adaptability factors (Nunfam et al., 2019). Severe heat, as referred to in the paper, occurs when the body's means of controlling its internal temperature starts to fail. As well as air temperature, factors such as humidity, radiation, wind speed, metabolic rate, and the clothing may contribute to severe heat stress (Kownacki et al.,2019)

The small-scale artisanal mining (SSM) sector is widely known for operating under informal conditions and it is done mainly by the people who are around the location of the small-scale mines who possess little to no technology and their equipment is very small (). The Small-Scale Mining sector has employed an estimate of over 500, 000 people in Zimbabwe, with an estimate of two million people being the number that mostly depend and survive through it (Butscher et al, 2020).

1.2 THE PROBLEM STATEMENT

At Kitsiyatota miners work in underground tunnels and deep pits, often with limited access to ventilation or cooling devices, and the temperatures can reach excessive levels, leading to heat stress. However, there is limited data on the extent of heat stress among them and its effects on their health. The lack of access to water or shade can increase the risk of dehydration, a common cause of heat stress. Most of these miners have not been trained on heat stress and its effects or how to properly protect themselves. As a result, artisanal miners are vulnerable to developing heat-related health conditions, which can be detrimental to their health and safety.

1.3 AIM AND OBJECTIVES

1.3.1 AIM

- To assess heat stress amongst artisanal small-scale miners from Kitsiyatota small scale artisanal gold mining area.

1.3.2 OBJECTIVES

- To determine the prevalence of heat stress among artisanal miners working in open-pit mines at Kitsiyatota.
- To identify the risk factors associated with heat stress among artisanal miners in small scale mines at Kitsiyatota.
- To evaluate the current heat stress management strategies in place for artisanal miners at Kitsiyatota.

1.4 RESEARCH QUESTIONS

1. What is the prevalence of heat stress among artisanal miners working at Kitsiyatota?
2. What are the risk factors associated with heat stress among artisanal miners at Kitsiyatota?
3. What are the current strategies for managing heat stress among artisanal miners at Kitsiyatota?

1.5 JUSTIFICATION

This research might be very helpful since the workers will be aware of the effects that heat has upon their health and be able to at least try to prevent fatal effects by doing the little they can at their small-scale mines to curb the effects of heat stress. This research aims to assess the extent of heat stress among miners and identify was to reduce its negative effects. This research will help policy makers to understand how severe the heat stress problem is and assess the possible interventions. The evidence will also help to support policy and regulations development so that there is an improvement on the working conditions, rest breaks that are mandatory and provision of shade and hydration. The results will also help to identify risks that are specific and are in heat relation such as vulnerabilities being faced by artisanal miners, tasks they perform and how intense they are as well as the work environment that are likely to expose them to heat stress the greatest. For researchers, the findings will help in identification of knowledge gaps and more information that can be used of future related studies.

CHAPTER 2: LITERATURE REVIEW

2.1 OVERVIEW OF THE GOLD MINING SECTOR IN ZIMBABWE

The Great Zimbabwe Kingdom, which flourished in the 13th century, was a major player in the region's gold trade, according to the historical backdrop of gold mining in Zimbabwe (Chikuhwa,

2019). This prehistoric society had a complex trading network and engaged in substantial gold mining, trading gold and other goods with other regions. Zimbabwe's economy depends heavily on the gold mining industry, which boosts employment, foreign exchange profits, and overall economic growth (Zimbabwe Investment Authority, 2019). Zimbabwe is one of the major producers of gold in Africa having produced around 29.6 tonnes of gold in 2021 and therefore making it 19th largest producer of gold in the whole world. The large-scale sector of gold mining has become very prevalent consisting of several large companies all around the country and an estimate of 40000 small scale artisanal are also operating all over the country. Gold makes up a sizeable amount of all mineral exports, making this industry one of the major sources of income for the nation (Reserve Bank of Zimbabwe, 2021). Major mining regions are Midlands, Mashonaland West and Central, Manicaland and Matabeleland North but the most prominent areas are Kwekwe, Shurugwi, Gwanda, Bindura and Chinhoyi. Difficulties are brought about by the absence of formalization policies and government assistance for small-scale and artisanal miners. It is challenging for miners to operate legally and sustainably when there are unclear norms and regulations unique to the ASGM sector (Tevera & Ncube, 2019). As a result, there is now a sizable unofficial industry, with miners functioning outside of the established regulatory structure.

2.2 ARTISANAL GOLD MINING IN ZIMBABWE

Because of the continuous rates of unemployment rising exponentially yearly and with the rains the scarce rains making it very hard for youths to drift to the agricultural sector, most people have nowhere to turn but to go to the areas where they are opportunities of better survival which are rich in minerals to engage in artisanal and small-scale mining (Nyavaya, 2021). According to the Zimbabwe Miners Federation, registered miners comprise of about 50,000 registered miners which operate on a small-scale basis employing averagely 10 people to work there on each claim in the country. However, the economy of the country continuous to fail drastically over the years and the artisanal miners have risen to about 1.5 million with mining sites being illegally opened in all areas which are rich in gold. Informal ASM has been observed to be expanding in Zimbabwe. The expansion of artisanal mining is not exclusive to Zimbabwe; worldwide trends indicate that job prospects in the industry are widespread. According to 15 official organisations in Zimbabwe, there are over 500,000 small-scale miners working there, most of whom are gold miners. with the Zimbabwe Miners Federation providing care for almost three million dependents indicates that there are 50,000 registered small-scale miners who employ at least ten people on average. every.16

While the economy is still in decline and the price of gold has reached reaching unprecedented heights, there are now almost 1.5 million artisanal miners worldwide. Differences in the definition of the term are reflected in the discrepancy in the reported numbers of artisanal miners and classification (Gwande 2023).

According to published research, African mining laws have been progressively changed in response to industrial challenges (Nalule, 2020). of the meanwhile, the World Bank (2019) claims that there is still a deficiency of "full, precise and trustworthy data" to guide formalisation or other policy actions in the ASM sector or on strategies for enhancing livelihoods and giving miners more authority. Thus, it is necessary to "bring attention to this 'secret sector' by investigation, gathering, and dissemination of data to enhance educate decision-makers (World Bank, 2019)

Although there are clear drawbacks to informal gold mining, it has also demonstrated its crucial nature in reducing poverty in Zimbabwe. Undoubtedly, informality has become the backbone of the local economy in Zimbabwe, supporting millions of people through employment that employs hundreds of thousands of people. It has given most of the people survival nets.

2.3 CAUSES OF HEAT STRESS

According to the Centres for Disease Control and Prevention (CDC), heat-related conditions such as heat exhaustion or heat stroke occur when the body is unable to adequately cool down. Sweating is how the body generally cools itself, however under extremely hot conditions, this may not be sufficient. In these situations, a person's body temperature increases more quickly than it can lower. The brain and other important organs may be harmed by this. The world's climate is getting hotter and more humid, particularly in the tropical and subtropical regions of the globe. Notably, the average global temperature has risen by 0.6 ± 0.2 °C since the 1850s and is predicted to rise by another 1.4 °C 2100 will be 5.8 °C and 47 °C (WMO, 2021).

According to Nunfam et al. (2021), the degree to which workers are exposed to ambient heat exposure variables (such as temperature and humidity) and occupational heat susceptibility factors (such as workload and working hours) is directly correlated with the risk of heat stress.

2.4 EFFECTS OF HEAT STRESS

According to Nunfam et al. (2019), the socioeconomic, health, and safety effects of occupational heat stress on these workers include heat-related illnesses, injuries, poor social well-being, loss of productive ability, lack of attention, and 500 impaired mental judgment.

Heat related illnesses include heat exhaustion: Symptoms of this heat-related sickness include headaches, dizziness, headaches, light headedness, and profuse sweating. It happens when the body perspires excessively, lowering its salt and water balance (CDC, 2021). In addition to that, heat stroke which is a severe heat-related sickness that can be life-threatening. It happens when the body temperature reaches a dangerously high level, typically more than 104°F (40°C). Symptoms may include confusion, rapid heartbeat, heated and dry skin, unconsciousness, and convulsions (OSHA). Dehydration is also common with sweating causing the body to lose water and electrolytes, it can result from heat stress. Symptoms of dehydration include dark urine, weariness, dry mouth, and reduced urine production (CDC, 2021). Reduced Cognitive Function is also an effect where there is an occurrence of a reduction in one's capacity for memory, focus, attention, and making decisions. Cognitive difficulties may be exacerbated by elevated body temperature and dehydration (Kjellstrom et al., 2019). Increased Accident Risk is also common. Heat stress can impair balance, coordination, and reaction times, which raises the possibility of mishaps and injuries, especially in work environments where physical labour is required (ILO, 2019).

2.5 ASSOCIATION BETWEEN ARTISANAL MINERS AND HEAT STRESS

Artisanal miners are a high risk of having heat stress because of the Nature of their working conditions. The continuous prolonged exposure to high temperatures, high intense physical labour and lack of hydration can definitely lead to illnesses related to heat stress (International Labour Organisation, 2018). In addition to that, there is no use of protective clothing or adequate equipment thereby contributing further to heat stress (National Institute for Occupational Safety and Health, 2019). Previous studies have produced concrete evidence that artisanal miners work in extreme temperature mostly reaching up to 40 degrees Celsius (Mitte et al, 2018). According to Donoghue et al (2019), these temperatures coupled with the physical demands of the artisanal mining nature, leading ton excessive levels of dehydration, heat exhaustion and heat related stroke.

CHAPTER 3: MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

3.1.1 LOCATION

The study was carried out in artisanal mining site of Kitsiyatota (17°18’48.44” S and 31°19’7.46” E) situated 1km West from Bindura (17°18’32.92” S and 31°19’57.45” E) central business district (Figure 3.1). The town is a small mining and agricultural community situated approximately 88km

due North East of Harare and is easily accessed by road and rail. The study sites are within mining claims, the bulk of which are artisanal and illegal miners.

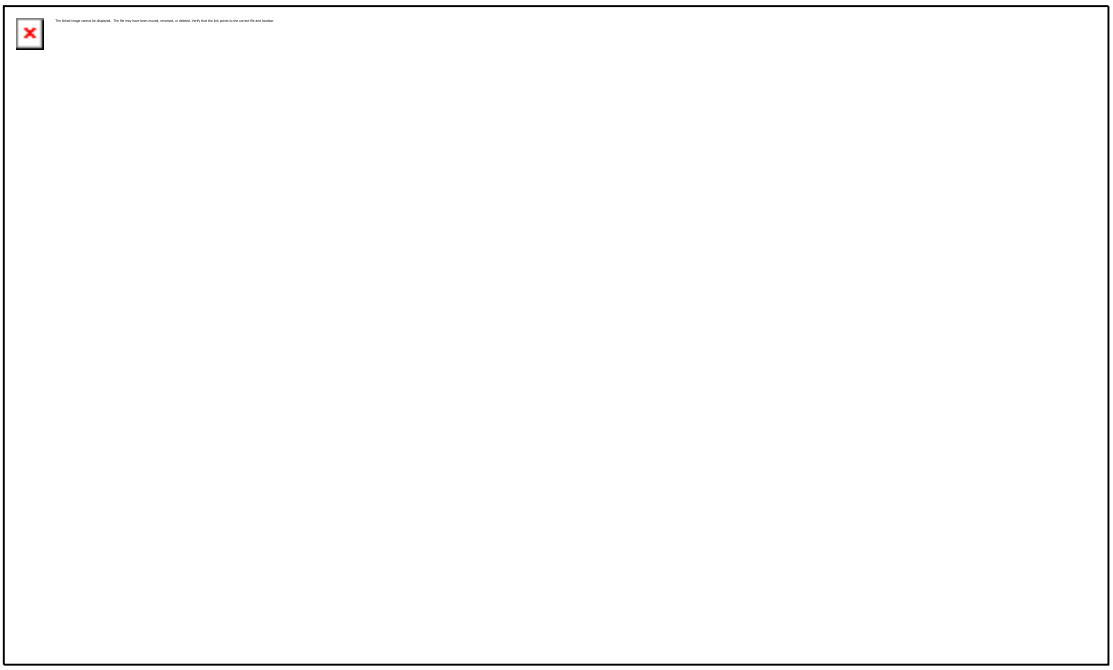


Figure 3.1: Map showing location of the study site

3.1.2 CLIMATE

The sites are situated in Zimbabwe's Agro-ecological region IIb that is characterised by distinct wet and dry seasons. The annual precipitation ranges from 750mm to 1000mm mostly occurring from December to March. The average temperature is 26^{o}C with the hottest months being October and November whereas May and June are the coldest months.

3.1.3 VEGETATION

The study sites are located in a miombo woodland that is dominated by *Brachystegia boehmii, B. spiciformis Julbernardia globiflora.* Other associated woody species include *Acacia polyacantha, Bauhinia petersiana, Diplorhynchus condylocarpon* and *Pilliostigma thoningii.* The area is also situated in a Hyparrhernia grassland dominated by *Hyparrhenia filipendula* in association with *Bothriochloa radicans, Cynodon dactylon, Heteropogon contortus, Melinis repens, Penisetum setaceum, Pogonathria squarrosa, Sehima galpini* and *Setaria sphacelata*.

3.1.4 GEOLOGY AND SOILS

The geology of the study area belongs to the Zimbabwe Craton in the Harare-Shamva Greenstone belt wedged between the Chinamora, Murehwa and Madziwa batholiths. The schist belt

commences around Harare with an East-West trend and swings north to the mining village of Mazowe on the western end. Therefore, the schist belt swings to the East through the gold mining towns of Bindura and Shamva. Part of the Bindura greenstone belt splays towards the North to form the Mt Darwin-Umfurudzi-Makaha linear belt. Metamorphic mineral assemblage indicates green schist faces to upper amphibolite faces range of metamorphic grades across the belt. The study area consists of deep well drained red loam soils of the vertosol group with distinct horizons below a topsoil that is rich in organic matter.

3.2 STUDY DESIGN

A cross sectional study design was used upon undertaking this research. This design made sure the researcher acquired knowledge on the assessment of heat stress amongst artisanal miners and the risk factors that are associated with it. It gave a clear picture of the heat stress causes and effects at Kitsiyatota. This design was a way for the researcher to gather easily within a short space of time information on the artisanal miners at Kitsiyatota. The process of acquiring data at the mine only caused minimum disruption to the production of workers at the mine.

3.3 SAMPLE AND SAMPLING PROCEDURES

To determine the sample size of the study, the random sampling procedure was used in this study to select artisanal miners at Kitsiyatota, a total of 65 participants were selected

3.4 DATA COLLECTION INSTRUMENTS

Data was gathered from participants using questionnaires, which allowed researchers to get important information straight from the source. More focus was made on the planning and development of a heat stress assessment questionnaire for small-scale artisanal mining. The questionnaires were distributed amongst the small-scale artisanal miners at Kitsiyatota mine. The questionnaire was designed to determine the prevalence of heat stress among artisanal miners working in open-pit mines at Kitsiyatota, to identify the risk factors associated with heat stress among artisanal miners in small scale mines at Kitsiyatota, to evaluate the current heat stress management strategies in place for artisanal miners at Kitsiyatota, to assess the knowledge, attitudes, and practices of artisanal miners in managing heat stress at Kitsiyatota.

3.5 ETHICAL CONSIDERATIONS

It was made sure the participants understood the goal of the study, any possible risks or rewards, their rights as volunteers, and that they could leave the study at any moment without facing any repercussions. A maintenance of participant privacy and confidentiality was ensured and personal data was anonymized.

Fairness and Equity was an important guide all throughout the participant engagement phase. Participants were chosen and treated fairly with an aim to include a varied representation of participants in the selection process and refrain from any type of bias or discrimination. Justice and respect to every participant was offered, irrespective of their socioeconomic background.

In addition to that, communication and transparency were kept intact. The research process was kept transparent and the results in a clear and understandable.

3.6 DATA ANALYSIS

Descriptive statistical analysis was performed on the data obtained from the heat stress analysis (mean and standard deviation were within the 95% confidence limit). To determine whether there were any appreciable variations in the prevalence of heat stress amongst the artisanal miners, the observed prevalence of heat stress amongst artisanal miners were analysed using the SPSS program.

CHAPTER 4: RESULTS PRESENTATION

4.1 DEMOGRAPHIC CHARACTERISTICS OF ARTISANAL MINERS AT KITSIYATOTA

N = 65

The table below shows that the age groups of artisanal miners is mostly dominated by the age 20 to 35 and they constitute the greatest percentage (52.3%) while the age 35 to 50 have the second highest percentage (26.2%).The least dominating age is of that less than 20 with the lowest percentage (21.5%). Table 4.1 shows the frequency and percentages of single and married participants. The married participants are more than the single participants with a percentage of 55,4% whilst the single participants only dominate 44.6 % of the population. The table also shows

that the males dominate the artisanal miners with a percentage of 66.2% and the females only have 33.8%.

Table 4.1: Frequency + Percentage (Age, Gender and Marital status)

Variable	Frequency	Percentage
Age		
Less than 20	**14**	**21.5**
20 to 35	**34**	**52.3**
35 to 50	**17**	**26.2**
Marital status		
Single	**29**	**44.6**
married	**36**	**55.4**
Gender		
Male	**43**	**66.2**
Female	**22**	**33.8**

4.1.2. Duration and working frequency

The results show that the majority (52.3%) has worked at Kitsiyatota for less than 5 years, followed by an average majority of (41,5%) having worked at Kitsiyatota for a total of 6 to 10 years, with the lowest percentage (6.2%) being the percentage of participants who have worked for more than 10 years. The findings also show that 27 (41.5%) of the participants work for 5 to 10 hours per day being the largest percentage with 23 (35.4%) participants working more than 10hours and only 15 (23.1) of the participants working less than 5 hours. The majority of the workers 31 (47.7%) work for 5 to 7 days, with 25 (38.5%) working for 3 to 4 days a week and only 9 (13.8) working only 2 days per week.

Table 4.2 Respondents according to number of working years, working hours per day and number of days worked per week.

Variable	Frequency	Percentage
Number of years of work		
less than 5 years	**34**	**52.3**
6-10 years	**27**	**41.5**
More than 10 years	**4**	**6.2**
Working hours per day		
Less than 5 hours	**15**	**23.1**
5-10 hours	**27**	**41.5**
More than 10 hours	**23**	**35.4**
Number of days per week		
Less than 2 days	**9**	**13.8**
3-4 days	**25**	**38.5**
5-7 days	31	**47.7**

4.2 ASSESSMENT OF HEAT STRESS AMONGST ARTISANAL MINERS

4.2.1 Water provision, shade provision and training on heat stress

Table 4.3 shows that only 5 (7.7%) of the participants say they have water provision and the rest 60 (92.3%) do not have water provision at the site. The table are also shows that 72.3% of the participants have no access to shade whilst only a percentage of 27.7 % does. Only 26.2 % of the participants have been trained but the majority of 73.8 % have never been trained in heat stress and its effects.

Table 4.3 showing respondents according to water provision and shade availability at the site and training

Variable	Frequency	Percentage

Provision of water		
Yes	**5**	**7.7**
No	**60**	**92.3**
Provision of shade		
Yes	**18**	**27.7**
No	**47**	**72.3**
Training on heat stress		
Yes	**17**	**26.2**
No	**48**	**73.8**

4.2.3Effects of Heat stress experienced at the site by the participants or their co-workers
Table 4.3 shows that the highest percentage (40%) of participants experienced fatigue, heat rash, heat cramp and fatality with the lowest percentage (22%) experiencing only fatigue and heat rash

Table 4.4showing the effects of heat stress

Variable	**Frequency**	**Percentage**
Effects of heat stress		
fatigue and heat rash	**11**	**22**
fatigues, heat rash and heat cramp	**19**	**38**
fatigue, heat rash, heat cramp, fatality	**20**	**40**

.

4.3 Factors associated with heat stress

4.3.1 Association between work frequency and experience on the effects of temperature

Table 4.3 shows that there is a significant association (0.003) between work frequency and the effects that are being experienced by the artisanal miners as well as by their co-workers.

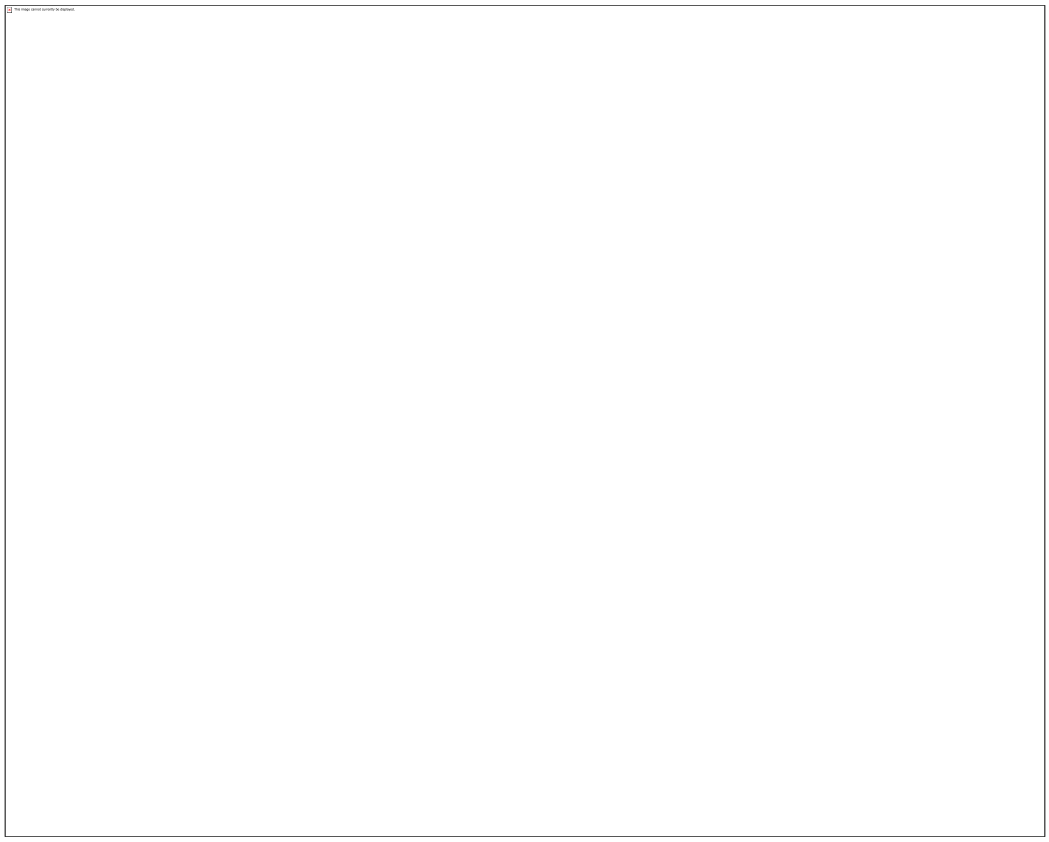
Table 4.5 shows the association between work frequency and effects of temperature

	Chi-square	df	p-value	significance
Association	16.048	4	0.003	significant

4.3.2 Possible causes of heat stress amongst artisanal miners

Results show that 32.3 % of the participants are suggesting that the main causes of heat stress were dehydration, working long hours and the hot temperatures with the rest adding other possible causes like wearing heavy clothing and lack of ventilation.

Fig 4.1showing respondents according to possible causes of heat stress



CHAPTER 5: DISCUSSION OF RESULTS

This chapter is to provide a summary of the research that has been conducted and to come up with a tangible conclusion on the findings of the research. The recommendations have been explained

in order to help with studies that will be done in the future to conduct studies that are similar in comparison. The project looked into knowledge, attitude and practises with regard to heat stress.

5.1 Assessment of heat stress amongst small scale artisanal miners

5.1.1 Effects of heat stress

Findings show that almost every participant has experienced or has witnessed a co-worker experience some or all of the effects of heat stress. The effects are heat rash, heat cramp, fatigue and fatality. These findings are clearly showing evidence of the lack of knowledge on how to properly protect themselves from the effects of heat. This could also be because artisanal miners do not have PPE to protect themselves when mining. Similarly, to the study done in Ghana on barriers to occupational heat stress risk adaptation of mining workers by Nunfam et al., 2019 whose findings showed that these workers unlike those in large scale mining do not make use of rests in between working hours, their cooling systems are very simple and poor and close to ineffective, with no participation opportunities in training programmes and a much lesser use of PPE as a strategy to adapt to occupational heat stress.

5.1.2Association between work frequency and experience on the effects of heat stress

The study (Table 4.4) indicated that there is a significance (0.03) significance level. This result shows that there is an association between work frequency and the experience on the effects of heat stress that is experienced by the participants and their co-workers. This was a clear indication that long cycles of work without resting can elevate strain and reduce performance compared to shorter working periods. The results also indicated that longer working frequencies results in higher core body temperature and more harmful effects. A similar study was undertaken by Ravanelli, N., et al. (2019) on examination of the relationship between work frequency and the physiological and cognitive responses upon working in hot environments. According to the conclusions of the study, working periods which are shorter in length comprising of breaks in between are associated with lower core body temperatures and the performance of workers will always remain improved comparing to longer working periods with no constant breaks.

5.2Risk factors associated with heat stress

5.2.1 Water provision at the site

As shown by **Table 4.3,** it is evidence that there is no adequate water provision at the site. Only a small percentage (7.7%) of the participants agreed that they had adequate water provision but the rest (92.3%). This shows that there are more cases of dehydration at the site. This also shows that despite the high temperatures that are in Bindura, people have no source of income that they can even decide to work under such harsh conditions in order to provide for their families. The public Health Act states that the supplier (mine manager or operator) is responsible for ensuring the supply and safety of piped water but this is not the issue at Kitsiyatota, the results show absence of any water source even the basic ones like a tank. A study conducted by Hentschel et al discussed the challenges and opportunities faced by artisanal miners and small-scale gold miners and these challenges included water provision and the conclusion was because sometimes their mining methods pollute nearby water sources plus the lack of a responsible party to oversee if conditions are good then conditions will always remain bad unless strict policies are put in place. This large percentage of workers were willing to work under conditions which can cause harm is probably because of lack of knowledge on the effects of dehydration on their health and most of the participants have never been trained on heat stress since there is no formality only the few older participants seem to have been trained. This could be because they could have been previously employed at other companies. Nunfam et al., 2019 concluded that inadequacy of knowledge and behaviour that can cope up, no training on regular basis for work safety and matters associated with health and lack of commitment by those in charge are very common practises amongst small scale artisanal miners.

The table also shows that there is no adequate shade provision at the site. This might probably be because artisanal miners mainly have their focus on extraction and processing of their minerals rather than focusing on creating a comfortable environment. In addition to that, the absence of regulations and enforcement regarding worker safety on their working conditions at the sites contributes to the absence of setting up of shades at the site. In 2021, a similar study was undertaken then published in the Journal of cleaner production focusing on the environmental and social impacts of artisanal and small-scale mining in sub–Saharan Africa. The study showed that deforestation and therefore destruction of natural shade, then the study also highlighted that there is low to no significance concern for worker health and safety.

5.2.2 Main possible causes of heat stress and its effects

According to the results (**Fig 4.3**) the majority of the participants suggested that the possible causes to the effects of heat stress were dehydration, hot temperatures, no adequate PPE, lack of ventilation and working for longer hours. This could be because there is no adequate water provision at Kitsiyatota mine and there are no nearby natural sources like rivers or dams to sustain the artisanal miners. There is also no provision of PPE by those in charge of the mine so most of these artisanal miners just wear their normal clothes to work. These causes are also attributed to the fact that these artisanal miners lack knowledge, expertise and training on heat stress. Most studies have been clear evidence that the effects of being exposed to heat in industries, including mining, can be traced back to personal, environmental as well as occupational related risk factors, and these manifest mostly as heat exhaustion, heat cramps, heat rash, dehydration, heat oedema and heatstroke (Nunfam et al, 2021).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

Under summary, the evaluation of heat stress amongst small scale artisanal miners raises serious questions about the workers' health and safety under hot conditions. The results highlight critical need for efficient solutions to lessen the negative impacts of heat stress and safeguard the health of the miners. First of all, the evaluation draws attention to how small-scale artisanal miners extended exposure to high temperatures might put them at risk for heat related ailments such as heat exhaustion and heat stroke. There is also no adequate availability of water and shade and these are the conditions necessary for heat stress to occur. In addition to that, every participant has experienced or has seen a coworker experience the effects of heat stress. This shows that the prevalence of heat stress is very high.

RECOMMENDATIONS

After the assessment of heat stress amongst small scale artissnal miners, the following are the recommendations

- Improvement of ventilation to lessen accumulation by better workplace design underground
- Providing cooling measures for example shades to rest in and access to water for cooling and constant hydration
- Training of artisanal miners on possible causes, effects and how to protect themselves from heat stress

REFERENCES

- Tevera, D., & Ncube, A. (2019). The Political Economy of Artisanal and Small-Scale Gold Mining in Central Zimbabwe. Journal of Contemporary African Studies, 37(1), 79-97.

- UNDP Zimbabwe. (2020). UNDP Zimbabwe Annual Report 2019. Retrieved from https://www.zw.undp.org/content/zimbabwe/en/home/library/undp-zimbabwe-annual-report-2019.html
- Reserve Bank of Zimbabwe. (2021). Economic Review. Retrieved from https://www.rbz.co.zw/assets/2021_Economic_Review.pdf
- Zimbabwe Investment Authority. (2019). Zimbabwe Investment Authority Annual Report 2019. Retrieved from http://www.zia.co.zw/publications/ZIA%20Annual%20Report%202019.pdf
- Centers for Disease Control and Prevention (CDC). (2021). Extreme Heat and Your Health. Retrieved from https://www.cdc.gov/disasters/extremeheat/index.html
- The Public Health Act
- Kjellstrom, T., et al. (2019). Heat, Human Performance, and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts. Annual Review of Public Health
- International Labour Organization (ILO). (2019). Guidelines on Heat Stress: An Occupational Safety and Health Guide.
- Nunfam, V.F., 2019. Social Impacts of Climate Change and Occupational Heat Stress and Adaptation Strategies of Mining Workers in Ghana. https://ro.ecu.edu.au/theses/2273.
- Nunfam, V.F., Adusei-Asante, K., Frimpong, K., Van Etten, E.J., Oosthuizen, J., 2020.
- Barriers to occupational heat stress risk adaptation of mining workers in Ghana. Int. J. Biometeorol. 1–17. Nunfam, V.F., Adusei-Asante, K., Frimpong, K., Van Etten, E.J., Oosthuizen, J., 2020a.
- Barriers to occupational heat stress risk adaptation of mining workers in Ghana. Int. J. Biometeorol. 64, 1085–1101. Nunfam, V.F., Adusei-Asante, K., Van Etten, E.J., Oosthuizen, J., Adams, S., Frimpong, K., 2019a.
- The nexus between social impacts and adaptation strategies of workers to occupational heat stress: a conceptual framework. Int. J. Biometeorol. 63 (291), 1–14. Nunfam, V.F., Afrifa-

Yamoah, E., Adusei-Asante, K., Van Etten, E.J., Frimpong, K., Mensah, I.A., Oosthuizen, J., 2021.

- Construct validity and invariance assessment of the social impacts of occupational heat stress scale (SIOHSS) among Ghanaian mining workers. Sci. Total Environ. 771. Nunfam, V.F., Oosthuizen, J., Adusei-Asante, K., Van Etten, E.J., Frimpong, K., 2019b.
- Perceptions of climate change and occupational heat stress risks and adaptation strategies of mining work 2019c. Climate change and occupational heat stress risks and adaptatof mining workers: perspectives of supervisors and other stakeholders in Ghana
- Nunfam, V. F. & Afrifa-Yamoah, E. (2021). Heat exposure effect on Ghanaian mining 759 workers: a mediated-moderation approach.
- Nunfam, V. F., Adusei-Asante, K., Frimpong, K., Van Etten, E. J., & Oosthuizen, J. (2020). 762 Barriers to occupational heat stress risk adaptation of mining workers in Ghana.
- Kjellstrom, T., Freyberg, C., Lemke, B., Otto, M., & Briggs, D. (2018). Estimating population 694 heat exposure and impacts on working people in conjunction with climate change
- Artisanal and small scale mining by Thomas Hentschel, Felix Hrischka and Micheal Priester

APPENDICES

APPENDIX 1

RESEARCH QUESTIONNAIRE

SECTION A

Good morning/ afternoon. My name is NYARADZAI MUTOWEMBWA. I am a student at Bindura University of Science Education doing Safety, Health and Environmental Management

Registration number B200594B. I am doing a research on "Heat stress amongst small scale artisanal miners at Kitsiyatota gold mine in Bindura". I am inviting you to take part in the study by answering a few questions about that particular topic. This study requires only your voluntary participation. Your identities and information will not be disclosed and will be considered as confidential. The findings from this study will be used to make recommendations of heat related effects on artisanal small scale miners that operate all over Zimbabwe.

QUESTIONNAIRE Guide No…… Date…….

SECTION B: DEMOGRAPHIC INFORMATION *(please tick your response in the space provided*)

1)AGE OF THE PARTICIPANT

☐ 1) Less than 20
☐ 2) 20 to 35
☐ 3) 35 to 50

2)MARITAL-STATUS

☐ 1) Single
☐ 2) Married

3)GENDER

☐ 1) Male
☐ 2) Female

4)Years working at Kitsiyatota as *mukorokoza* ……..

SECTION C: EXPOSURE TO HEAT AND HEAT STRESS EFFECTS

5)DURATION OF WORKING TIME (*in hours)*

☐ 1) Less than 5 hours
☐ 2) 5 to 10 hours
☐ 3) More than 10 hours

6)FREQUENCY OF THE WORK (*e.g., number of days worked per week)*

☐ 1) 1 or 2 days
☐ 2) 3 to 4 days
☐ 3) 5 to 7 days

7)WHAT KIND OF COOLING SYSTEM DO YOU USE FOR THE BODY……
……
……
……
……
……
…….

8)AVAILABILITY OF SHADE AT THE SITE

☐ 1) Yes
☐ 2) no

9)HAVE YOU EVER EXPERIENCED THE FOLLOWING OR SEEN ANY CO-WORKER EXPERIENCE ANY OF THE FOLOWING SYMPTOMS?

FATIGUE

☐ 1) yes
☐ 2) no

HEAT RASH

☐ 1) yes
☐ 2) no

HEAT CRAMP

☐ 1) yes
☐ 2) no

FATALITY

☐ 1) yes
☐ 2) no

10)WHAT DO YOU THINK WAS THE MAIN CAUSE OF THE ABOVE SITUATIONS?.....
.....
.....
.....
.....
.....

11) IS THERE ANY SOURCE OF SHADE TO REST NEARBY?

☐ 1) yes
☐ 2) no

12) ARE THERE ANY WATER SOURCES NEARBY OR IS THERE ADEQUATE WATER PROVISION?

☐ 1) yes
☐ 2) no

13)DO YOU UNDERSTAND THAT HIGH TEMPRATURES CAN HAVE AN IMPACT ON YOUR HEALTH?

☐ 1) yes
☐ 2) no

14) DO YOU KNOW HOW TO PROTECT YOURSELF FROM HEAT AND THE EFFECTS OF HIGH TEMPRATURES?

☐ 1)yes
☐ 2)no

IF YES , HOW DO YOU PROTECT YOURSELF FROM HEAT AND ITS EFFECTS?.....
.....
.....
.....

15) HAVE YOU EVER BEEN TRAINED ON HEAT STRESS AND ITS EFFECTS?

☐ 1) yes

☐ 2) no

16) IS THERE ANY HEAT SURVEILLANCE AT KITSIYATOTA MINE?

☐ 1) yes

☐ 2) no

17) IS THERE ANY REST SCHEDULE AT THE MINE?..... IF YES, HOW MANY HOURS DOES IT TAKE?.....AND AFTER HOW MANY HOURS OF WORKING DOES ONE REST …….

18) DO YOU UNDERSTAND THE DIFFERENCE BETWEEN METABOLIC HEAT AND ENVIRONMENTAL HEAT?

☐ 1) yes
☐ 2) no

19)WHAT DO YOU THINK CAN BE DONE INORDER TO SURVIVE THE HOT CONDITIONS AND THE EFFECTS OF HEAT?……
……
……
……
……
……
……
…….

20) Have you had any water to drink today ?

☐ 1) Yes
☐ 2) No

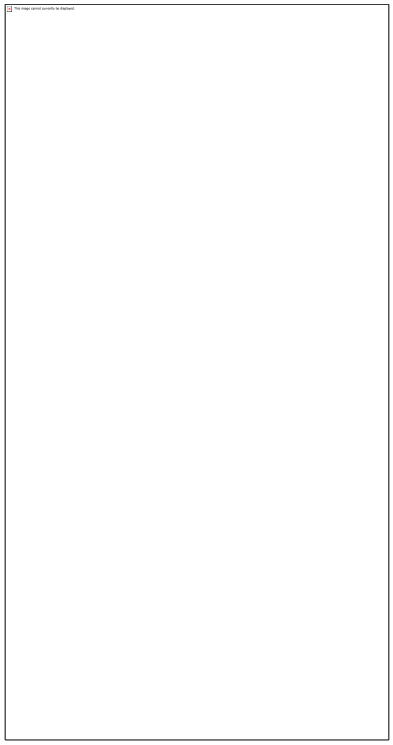
21) How is your sweatrate?

☐ 1) Low
☐ 2) Normal
☐ 3) High

22)Measured body temperature …….. degrees Celcius.

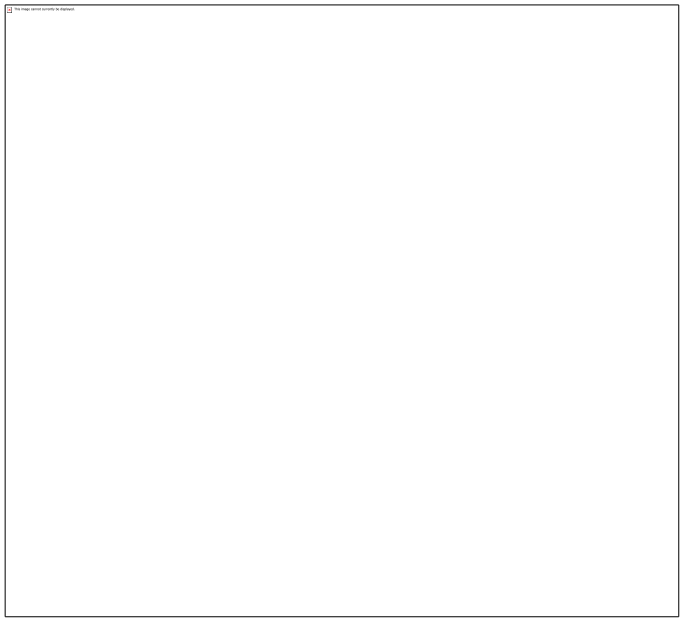
DATA COLLECTING INTRUMENTS: MEDICAL INFRARED THERMOMETER

APPENDIX 2



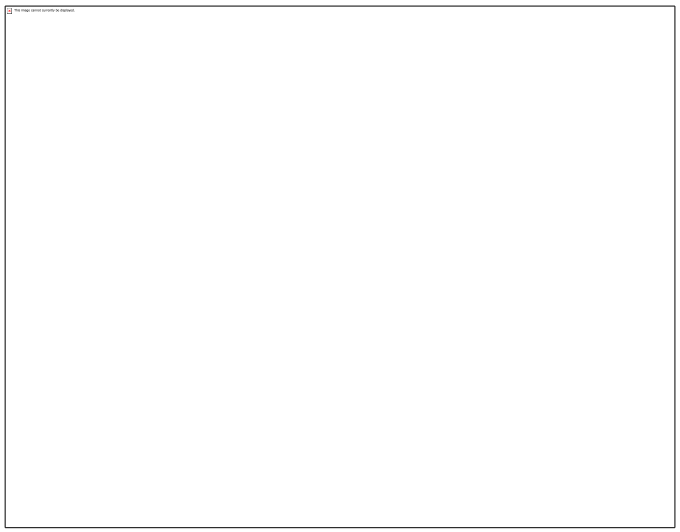
APPENDIX 3

PICTURES TAKEN AT KITSIYATOTA



Participants ready to go underground

APPENDIX 4



Kitsiyatota conditions without water supply or shade