ASSESSMENT OF OCCUPATIONAL SAFETY COMPLIANCE IN SMALL-SCALE GOLD MINES IN SIAYA COUNTY, KENYA.

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A Research Project Submitted in partial fulfilment of the requirements for the Degree of Master of Arts in Environmental Planning and Management of the University of Nairobi

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

DECLARATION

I, the undersigned, declare that this research is my original work and has not been presented to any other institution for academic credit. Information from other sources has been duly acknowledged.

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Ayoo Beth Akinyi Date

C50/5465/2017

This research has been submitted with our approval as the University Supervisors

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Dr. Martin Marani Date

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Dr. James Moronge Date

DEDICATION

To my late brother *Michael Edwin Ayoo*

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ABSTRACT

Small-Scale Mines (SSM) employ millions of people worldwide. However, they have been categorized as one of the most hazardous workplaces. In Kenya, like many developing countries, occupational safety-focused interventions have not been fully addressed by the relevant regulatory bodies despite the widespread awareness of the dangers associated with SSM. This study assessed occupational safety compliance amongst small-scale gold miners in Central Sakwa Ward, Siaya County under these specific objectives: to profile occupational safety issues in small-scale mines; to ascertain the types and causes of injuries that occur among small scale miners and to examine the factors influencing compliance with safety regulations. Based on the aforementioned objectives the study hypothesized that knowledge on safety issues does not influence compliance with safety regulations and mine activities do not influence the types of injuries occurring among small-scale miners. A case-study mixed method research involving simple random sampled participants (n = 97) was carried out at small-scale gold mines in the study area. Key informant interviewees were equally contacted for pertinent information. The results suggest non-compliance with the safety requirements. Back / chest injuries and cuts constituted the most frequently occurring types of injuries accounting for (34.7%) and (26.3%) of reported injuries respectively, with shafts collapse (33.7%) being the main occupational safety issue experienced at the mines. The leading underlying causes of back/chest injuries were lifting heavy loads & awkward sitting position (34.7%). The reported injuries were distributed across all body parts; hands 41.1%, back/chest injuries 34. 7%, leg/knee/feet 12.6%, arm 7.4% and head 4.2%. Lastly, the study revealed that perceived cost of compliance, knowledge / awareness on safety requirements and administrative failures were the key factors influencing regulatory compliance. The null hypotheses that; knowledge on safety issues does not influence compliance with safety regulations and mine activities do not influence the types of injuries occurring among small-scale gold miners were tested and rejected using Pearson's Chi-Square (X^2) test at 0.05 significance level. This study showed that small scale mining sector in Kenya is marred with unsafe acts and practices which have contributed greatly to mine accidents and injuries. Measures to improve compliance with safety requirements should include formulation of by-laws at the county level to streamline mining in the county and the use of policy instruments such as taxes, prohibitions and subsidies.

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LIST OF ACRONYMS AND ABBREVIATION

CDE	County Director of Environment
COSHO	County Occupational Safety and Health Officer
DOSHS	Directorate of Occupational Safety and Health Services
DRC	Democratic Republic of Congo
GNI	Gross National Income
GoK	Government of Kenya
IOHSAD	Institute for Occupational Health and Safety and Development
KNBS	Kenya National Bureau of Statistics
MMSD	Mining, Minerals and Sustainable Development
MSMs	Mine Site Mangers
LBMA	London Bullion Market Association
NACOSTI	National Commission for Science, Technology and Innovation
OECD	Organization for Economic Co-operation & Development
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Act
PPEs	Personal Protective Equipments
RDM	Regional Director of Mines
SME's	Small and Medium-sized Enterprises
SSGM	Small - Scale Gold Mining
SSM	Small-Scale Mining
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USD	United States Dollars

CHAPTER ONE
INTRODUCTION

1.0 Background of the study

Globally mining activities have been ranked among those that employ millions of people (Kotsadam & Tolonen, 2016; Gamu *et al.*, 2015; Shen *et al.*, 2015). Global report on small-scale mining estimated that 13 million people are engaged directly in small-scale mining activities throughout the world, mainly in developing countries, and the livelihoods of a further 80-100 million people are affected by it (Hilson & Maconachie, 2017). The report further provided estimates of the number of people working in the Mining, Minerals and Sustainable Development (MMSD) research countries (Table 1.1). From a local and regional perspective, Alliance for Responsible Mining, (2018) while conducting a study to understand the impact of SSM operations on economies and livelihoods in low to middle income countries, explored the implications for three case study countries in East Africa (Kenya, Uganda and Rwanda) where they estimated employment figures for the SSM sector in the range of 40 million miners to be 140,000 for Kenya 65,000 for Rwanda and 300,000 for Uganda. However, mining is a generally renowned precarious occupation and more often than not, where reliable statistics exist, ranks first among occupations responsible for fatal accidents (Vingård & Elgstrand, 2013; Gowrisankaran *et al.*, 2015; Geng & Saleh, 2015).

Mining operations vary and therefore can include a highly mechanized operations in large-scale mines with appropriate work environment and adequate safety for the miners as well as small-scale mines with extremely dangerous work environment (Verbrugge, 2016; Bansah *et al.*, 2016). According to Byizigiro *et al.*, (2015), Small-Scale Mining (SSM) is the extraction of a wide range of minerals in small quantities by individuals or companies with limited technological knowledge usually denoted by the use of rudimentary tools and techniques. It has been rampant within the gold mining sector especially among individuals with little capital investment and yield or output (UNEP, 2014).

In spite of experiencing its share of environmental and safety related problems that adversely impact human quality of life, SSM has made enormous contributions to the economy of host countries worldwide by contributing significantly to national revenues and foreign exchange earnings (World Bank, 2013; Wilson *et al.*, 2015; Amankwah *et al.*, 2015; Marin *et al.*, 2016; Hilson & McQuilken, 2014). About half of the world's estimated 30 million small-scale miners are dedicated to gold extraction. For example; Alliance for Responsible Mining, (2018) while conducting an overarching synthesis to understand the impact of SSM operations on economies and livelihoods in low to middle income countries, explored the implications for three case study countries in East Africa (Kenya, Uganda and Rwanda) where they found out that SSM have made a significant contribution to economies of these countries. For instance, SSGM at the assessed mining village Osiri in Migori County, Kenya inject USD 1.9 million per year into the local economy. While at the Migori district level, ASM gold mining generates USD 37 million per year and at the national level USD 225 million per year. Gemstone mining in Taita Taveta generates a production value of USD 120 million per year, of which roughly USD 50 million per year is spent locally. It is estimated that SSM gold and gemstone mining nationwide together generate a foreign exchange influx into the country in the range of USD 500 million per year. In Rwanda it was estimated that small-scale miners contributed approximately USD 39.5 million in the form of expenditures to the local economies in 2015. Similarly, in Uganda in one of its poorest region, Karamoja, small scale gold mining provides 22,500 miners with an annual income that is significantly above the Gross National Income (GNI). Gold production in Karamoja is conservatively estimated at 845 kg per year, representing a London Bullion Market Association (LBMA) market value of USD 36 million.

Despite being economically viable, the conventional concept of the work environment in SSM is that the work is not only wearisome but is also unsafe as a result of precarious underground structures and great accident risks (Hilson & McQuilken, 2014; Elgstrand *et al.*, 2017). Besides, many SSM workings are said to be deficient in implementation of mine safety requirements, access to better mining equipments, recognition of the hazards inherent in mining as well as the safety regulations (Hilson *et al.*, 2017). The most common methods of mining are therefore; underground mining and surface mining (Gibowicz & Kijko, 2013). The SSM work often takes place underground. Underground mining involves mining of hard rock from usually those containing metals. It places workers at risk of workplace accidents due to rock falls from roofs and side walls, lack of ventilation, entrapment, drowning, gas or dust explosions, gas and fuel fires, workers stumbling/slipping/falling and heavy manual work (Kurnia *et al.*, 2014; Elgstrand *et al.*, 2017; Bansah *et al.*, 2016).

Table 1.1: Total number of workers in thousands employed by SSM in MMSD research countries across Africa, Asia and Latin America.

#	Country	Total Number of Workers in thousands
1.	Bolivia	72
2.	Brazil	10
3.	Burkina Faso	100 to 200
4.	China	3 000 to 15 000
5.	Ecuador	92
6.	Ghana	200
7.	India	500
8.	Indonesia	109
9.	Malawi	40
10.	Mali	200
11.	Mozambique	60
12.	Peru	30
13.	Philippines	185.4
14.	PNG	50 to 60
15.	South Africa	10
16.	Tanzania	550
17.	Zambia	30
18.	Zimbabwe	350

Source: Hilson & Maconachie, (2017).

Despite these safety issues, SSM is a vital activity in developing countries, especially in regions where economic substitutes are insubstantial as demonstrated by the situation in China, India, Indonesia, Brazil, Peru, Papua New Guinea, Bolivia, Ecuador, Congo (DRC), Mali and Ghana whose large populations are employed in the SSM sector (Hilson *et al.*, 2014; Steckling *et al.*, 2017). Additionally, digging of shafts with little coordination between different mining teams, running deeper than before and closer to each other, often result in cave-ins or collapse of mine structures/tunnels (Sasaoka *et al.*, 2015). This coupled with non-compliance with the Occupational Safety Standards has resulted in poor occupational safety conditions as well as increased mine related accidents and injuries (Hilson *et al.*, 2017; Basu *et al.*, 2015).

1.1 Statement of research problem

Small-Scale Mining (SSM) has been categorized as high risk occupation worldwide. This has been largely attributed to the nature of the work and lack of effective occupational safety compliance (Wilson *et al.,* 2015; Vingård and Elgstrand, 2013). It brings with it a myriad of occupational safety hazards pertaining to those directly involved in the mining process (Smith *et al.,* 2016). The knowledge base of safety requirements is minimal within the SSM sector and the value of using Personal Protective Equipment (PPE) is generally poorly understood (Hilson *et al.,* 2017; Buxton, 2013). SSM has been a common practice within the gold mining sector and is equally widespread in developing countries across various continents (UNEP, 2014). Small Scale Gold Mining (SSGM) is physically demanding and dangerous (Ibid). As a result, small-scale gold miners often operate under unsafe conditions and with little or no comprehensive safety measures (Smith *et al.,* 2016; Basu *et al.,* 2015). Despite these factors, SSGM still remains a crucial activity in developing countries, especially in regions where economic substitutes are inadequate.

While there is cognizance of the safety issues associated with SSGM activities, they have not been adequately addressed by regulatory structures in countries where gold mining activities are widespread. The relevant regulatory bodies have continued to pay scant attention to safety issues in SSM sector (Smith *et al.,* 2016). Therefore, this logically means that the SSGM sector is largely informal and unregulated hence much its activities occur outside the scope of legislation or enforcement on safety issues (Hilson *et al.,* 2017). The safety regulations; OSHA No. 15 of 2007 and Mining Act No. 12 of 2016 are more applicable to large scale mining sector as opposed to SSM sector hence have failed in their mandate to ensure ratification of the Convention No. 176 concerning Safety and Health in Mines, 1995 which provides for the supervision of safety and health in mines. The illegal and informal nature of most of the small-scale mines not only in Kenya but also in other developing countries was the key motivation behind this study. By exposing the safety issues and factors influencing compliance with safety regulations in small-scale mines, the study aimed to ensure legalization and normalization of small-scale mines towards improved safety compliance and improved safety conditions which up to date have not been established and addressed.

1.2 Research Questions

Specific research questions guided the study:

1. What are the occupational safety issues in small-scale mines?
2. What are the types and causes of injuries that occur among small-scale miners?
3. Which factors influence compliance with safety regulations?

1.3 Research Objectives

1.3.1 General Objective

The main objective of the study was to assess occupational safety compliance amongst small-scale gold miners in Central Sakwa Ward; Siaya County.

1.3.2 Specific Objectives

The specific objectives of the study were:

1. To profile of occupational safety issues in small-scale mines in Central Sakwa Ward; Siaya County.
2. To determine the types and causes of injuries that occur among small scale miners in the study area
3. To examine the factors influencing compliance with safety regulations.

1.4 Research Hypothesis

Small-scale mining sector is largely informal and unregulated hence much of the activities occur outside the scope of legislation or enforcement on safety issues. Besides, the knowledge base of safety issues is minimal within the SSM sector and the value of using Personal Protective Equipments (PPEs) is generally poorly understood. As a result the small-scale miners are prone to injuries since they are non-compliant with the general safety provisions in the safety regulatory frameworks. The study therefore hypothesized that.

1. **H_0:** Knowledge on safety requirements does not influence compliance with safety regulations.

   H_1: Knowledge on safety requirements does influence compliance with safety regulations.

2. **H_0:** Mine activities do not influence the types of injuries occurring among small-scale miners.

   H_1: Mine activities do influence the types of injuries occurring among small-scale miners.

1.5 Justification of the study

The study was justified from theoretical and practical perspectives: From a theoretical perspective, it has been argued that for any system to develop and evolve its body of theory and practice, an informed and evidence-led basis is required (Weinberg, 2014). This provides the insights upon which aspects of occupational safety standards that need improvement can be identified and the rationale upon which intervention in a specific manner will be grounded. From a practical perspective, global small-scale mining literature provides evidence from several contexts showing lack of effective compliance with occupational safety regulations amongst small-Scale miners (Schoneveld *et al.,* 2017; Soriano *et al.,* 2017; Mwaipopo, 2017). This logically leads to the conclusion that an evaluation is therefore necessary to determine the level of compliance and factors that have contributed to non-compliance amongst small-scale miners. Besides, with Occupational Safety Standards application in Kenya going back to 2007 and Directorate of Occupational Safety and Health Services (DOSHS) having been constituted, there is need to explore and document how compliance with Occupational Safety Standards has occurred especially in the mining sector that has for a long time been associated with non-compliance with the Occupational Safety Standards. Overall, the study will be useful in generating information and knowledge that can be used to : (i) develop a basic, easy-to-understand mining-based occupational safety guideline for SSM in support of safe work environments, improved productivity and compliance with Occupational safety regulations; (ii) develop an "i-Safe" mobile application for reporting unsafe conditions or incidences /connecting miners with help (rescue) and resources as need may arise and (iii) contribute to the global body of knowledge and practices in occupational safety.

1.6 Scope and Limits of the Study

The study focused on Small-Scale Gold Mining activity in Central Sakwa Ward, Siaya County and was grounded within the contextual domains of occupational safety compliance pertaining to general mining processes and basic safety towards the implementation of Occupational Safety Standards as advocated in Occupational Safety and Health Act No. 15, 2007 (GoK, 2007) and Mining Act No. 12, 2016 (GoK, 2016). Unlike other studies which tend to look at the trickle-down effect of non-compliance with safety standards especially on the miners households and the community at large, this study particularly focused on those directly involved in the mining process. However, the study did not address the health impacts of gold mining.

1.7 Operational definition of terms and concepts

a) **Safety** – refers to a condition of preventing and protecting humans from being injured or harmed due to hazards in their workplaces (Friend & Kohn, 2018). The word safety has been contextualized in this case to imply any physical hazards with the potential to inflict physical pain.

b) **Small Scale Mining** – refers to the extraction of a wide range of minerals in small quantities by individuals with limited technological knowledge usually denoted by the use rudimentary tools and techniques (World Bank, 2013). In this case small scale mining implies informal or illegal mines.

c) **Small Scale Gold Mining** – refers to the gold mining activity carried out by persons with little capital investment and yield (UNEP, 2014). In this context the quantity of gold does not exceed 10.5 grams per day.

d) **Safety Regulations** – are formal requirements prescribed by a regulatory body that must be adhered to in order to minimize chances of getting injured or harmed (Black, 2017). Safety regulations in this context implies OSHA, 2007, Mining Act, 2016 and Convention concerning safety and health in mines, 1995.

e) **Safety Compliance** – refers to following rules in core safety activities (Guo *et al.,* 2016). Compliance has been used in this context to mean acting in accordance with a formal requirement such general safety provisions in both OSHA, 2007 and Mining Act, 2016.

1.8 Structure of the report

The reporting in this study adhered to the regulations of the University of Nairobi governing the award of Masters of Arts in Environmental Planning and Management. The study have five main sections proceeded by list of references and appendices. Chapter one sets the agenda for the research and answers all important questions 'why the research?' amongst other concerns. Chapter two presents a survey of relevant literature and further identifies the research gaps which form an integral part of the research. The chapter also gives an elaboration of both the conceptual and theoretical frameworks. Chapter three provides an elaborate description of the study area and a detailed description of the research methodology. Chapter four forms the core of the research since the research findings are presented, interpreted and discussed in these section. Lastly, chapter five gives the summary of findings, conclusions & recommendations of the research as well as recommendations for further research. In brief, this study is divided into five chapters. Figure 1.1 shows the diagrammatic presentation of study structure

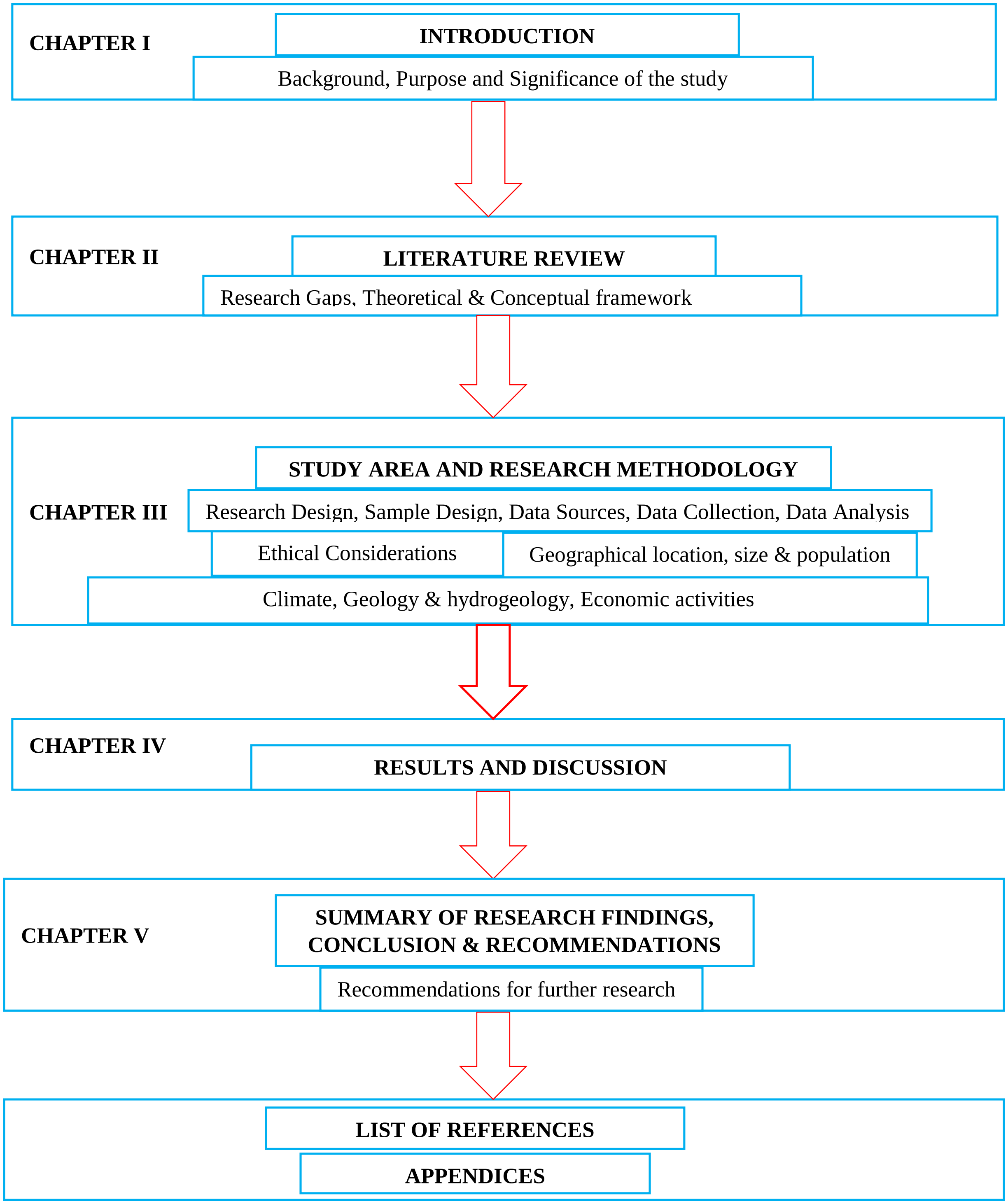

Figure 1.1: Structure of the report
Source: Researcher, (2018).

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Occupational safety have become firmly established in International Frameworks on OSH. Many conventions have been held to deliberate on OSH issues across various sectors and discipline including agriculture, manufacturing industries, extractive industries, health sector among others. For instance the operations of the health sector has been guided by Convention concerning Occupational Health Services (1985), manufacturing industries on the other hand has carried out their operations in close consideration of the provisions of Convention concerning Safety in the use of Asbestos (1986) and Conventions concerning the prevention of Major industrial accidents (1993). The provisions of Convention concerning Safety and Health in agriculture (2001) have been closely followed in the agricultural sector to ensure workers health and safety.

Of importance in this study is ILO Convention No. 176 concerning Safety and Health in Mines, 1995. This convention applies to all mines whether small-scale or large scale and provides for the supervision of safety and health in mines, the procedure for reporting and investigating fatal and serious accidents, the inspection of mines by inspectors designated for the purpose by the competent authority and the compilation as well as publication of statistics on accidents and dangerous occurrences. The convention entered into force on 5th June 1998 and was adopted in Geneva. Kenya has been a signatory to ILO conventions on OSH since 13th January, 1964 and has made tremendous efforts in developing policy, legal and institutional frameworks towards the ratification of the convention provisions. For instance formulation of National OSH Policy, 2012, OSHA, 2007 and DOSHS are all the outcome of ILO Conventions on OSH. Despite all the efforts towards safe work environment, a lot of safety issues are still experienced especially in small-scale mines. This warrants a detailed assessment to ascertain the actual issues. This section therefore provides a review of relevant works from scholarly papers, legal documents as well as unpublished documents on occupational safety compliance in SSM sector. It pays particular attention to the occupational safety issues in SSM, the types and causes of injuries that occur in SSM sector as well as the factors influencing compliance with safety regulations. A summary of the existing knowledge and research gaps emerging from the reviewed literature is made as further justification of this work. Finally, a detailed description of both theoretical and conceptual issues of the study are presented.

2.1 Occupational safety issues in small-scale mining

A considerable number of studies both at global and regional scale have been conducted in the past to establish occupational safety issues in the SSM sector (Long *et al.*, 2015; Smith *et al.*, 2016; Calys-Tagoe *et al.*, 2015; Basu *et al.*, 2015; Human Rights Watch, 2011; Song & Mu, 2013; Elenge *et al.*, 2013; Wilson *et al.*, 2015; Marriot, 2008). Occupational safety issues such as rock falls from roofs and side walls, improper use of explosives, entrapment, drowning, gas or dust explosions, collapsing of mine structures/tunnels, miners stumbling/slipping/falling and heavy manual work and lack of safety facilities have become firmly established in the academic literature (Calys-Tagoe *et al.*, 2015; Kyeremateng-Amoah & Clarke, 2015; Kundu *et al.*, 2016; Song & Mu, 2013; Human Rights Watch, 2011; Wilson *et al.*, 2015; Marriot, 2008).

Globally, there are a handful of quantitative studies across Asia particularly from China and Philippines that emphasize the scanty safety conditions in SSM, Song & Mu, (2013) while assessing the injury risks in Small Scale coal mining in China, pointed out that every year, several miners are killed and many more get injured while undertaking coal mining operations. Song & Mu argued that mining under difficult geotechnical conditions within extensive mines is a key contributing element for the increased mine accidents and injuries. The duo found out that between April 2001 and May 2004, at Caijiagou Mine, Xinjian mine, Gangzi village mine and Chengjiashan mine a number of small-Scale coal miners were killed and several others injured at this small private village mines due to gas and coal dust explosion/outbursts, blasting, electrical sparking, and poorly designed ventilation system or conditions. Other recent studies from the same region discovered that coal dust and methane explosions in small coal mines, often leads to the death of at least 6000 miners annually (Wang *et al.*, 2015; Chu & Muradian, 2016; Kundu *et al.*, 2016; Zhang & Ma, 2015; Chen *et al.*, 2018). Besides, the study likewise pointed out misuse of explosives, poor ventilation, electrocution and poor lighting as safety issues of great concern.

In other similar studies from the same continent; Leung & Lu, (2016) provides an extensive analysis of the safety situations in small scale gold mine sites in their work titled “Environmental health and safety hazards of indigenous small-scale gold mining using Cyanidation in the Philippines”. The study employed participant observation technique to ascertain the occupational safety issues with the help of data collection checklists where they found out that the five most frequently cited safety issues were: tripping or falling, effects of shafts/tunnel subsidence, insufficient ventilation, inappropriate blasting operations, rock falls as well as being hit by an object. Similarly, Smith *et al.*, (2016) while providing an analysis of the work of Institute for Occupational Health and Safety and Development (IOHSAD), an institute based in Philippines, highlighted the leading safety issues in the mines as; use of improperly maintained mining equipments, non-compliance on using PPEs, gas and dust outburst, suffocation from toxic chemical fumes, entrapment, drowning, blasting, being hit by objects, falling, rock falls and shafts subsidence.

Regionally from across Africa studies have found some statistically significant occupational safety issues experienced in the SSM sector. For example, Human Rights Watch, (2011) while assessing the prevailing safety issues at Baroya, Kéniéba and Worognan SSM sites in Bamako; in the mining areas in Western and Southern Mali interviewed 150 miners including 41 children, from where they established that; being hit or struck by moving/falling rock, carrying heavy loads (heavy buckets full of ore/bags of ore), rudimentary working tools or machinery and falls and trips were the main safety issues of concern among the respondent and were equally responsible for injuries including swellings, fractures, back injuries and bruises. For instance, the group noted that sledgehammers used in pounding rocks are very heavy hence can often led to back, chest and arm injuries. This injuries were reported to be common among the children miners and can sometimes be severe to an extent of causing death. In the three mine sites; shafts and tunnel collapse resulting into entrapments was the leading causes of fatal accidents. For instance in Worognan mines, shafts and tunnel collapse often cause death of miners every month. This is the same case at Baroya and Kéniéba mine where 7 miners died from head and neck injuries caused by shaft collapse. Apart from shafts collapse, falls and trips were reported to be another major safety issue especially among children when ascending or descending into the shafts. The study equally revealed that the deaths might be many as opposed to the provided figures as those responsible for safety often tends to downplay the accidents. The outcome of this study however might have not been conclusive considering that almost 27.1% of the respondents were children whose level of comprehension is still low and therefore might be compromised when assisted to respond to the questionnaires. Further, interpreting the questions for children miners might have resulted in loss of meaning of the initially intended question thereby resulting into inconclusive outcome.

Providing further evidence on the prevailing safety issues in small-scale mining is a study by Mwaipopo, (2017) and Dalu *et al.*, (2017) on sustainable mining operations strategies in Tanzania and Zimbabwe respectively where they qualitatively analysed the causes of mine injuries and fatalities amongst Small-Scale gold miners. In this study it was noted that in Tanzania, severe injuries and fatalities were occurring due to collapse of mine structures/tunnels (Zvarivadza & Nhleko, 2017). It was further estimated that approximately 1- 5 mortalities occur every year, with many other mortalities going unreported. Casualties among small-scale gold miners in many parts of Zimbabwe have equally been linked to miners working under confined spaces within shafts and burrowing into uncompact driver beds hence becoming vulnerable to entrapment due to tunnel collapse and poor ventilation (Hilson & McQuilken, 2014; Dalu *et al.*, 2017). Zimbabwe has been reported as one of the countries with unreasonably high number of deaths among gold miners. These findings are comparable to the conclusion of a retrospective cross-sectional study involving the analysis of records of injuries presented between 2006 and 2013 in a hospital in the upper Eastern Ghana where high risk operations including; improper use of explosives, drilling without dust control mechanisms, poor ventilation, effects of overexertion, inadequate workspace, inappropriate equipment, collapsing of mine structures/tunnels and workers stumbling/slipping/falling at site were cited to be the major safety issues responsible for mine accidents and injuries with explosive blasts injuries topping the list (Long *et al.*, 2015; Kyeremateng-Amoah & Clarke, 2015; Wilson *et al.*, 2015). Similarly Marriott, (2008) emphasized the causes of mine accidents and injuries, in her assessment involving two small scale gold mines in Kwa Zulu Natal; South Africa, Marriott cited lack of safety facilities, collapse of mine structures/tunnels, improperly used mining equipment, gas or dust explosions and rock falls as the most prevalent safety issues responsible for accidents and injuries in gold mine sites in South Africa. Finally, Elenge *et al.*, (2013) while examining the causes of injuries and accidents among small scale gold miners of the Katanga mining region in DRC, quantitatively demonstrated that improperly used/maintained mining equipment or tools, heavy manual work and falls and slips accounted for 51.1%, 32.9% and 15.5% of the accidents and injuries.

2.2 Types and causes of injuries that occur among small-scale miners

Small-scale miners use crude techniques for mineral extraction and processing and usually work under overly disorganized, dangerous, labour-intensive and unlawful conditions hence are prone to injuries (Hilson & McQuilken, 2014). Globally, quantitative studies have been carried out to establish the forms of injuries and body parts injured. The injuries occurring among small-scale miners such as cuts (lacerations), fractures, burns, bruises (contusions), neck injuries, back / chest injuries has been well documented in the literature (World Health Organization, 2016; Long *et al.,* 2015; Calys-Tagoe *et al.,* 2015; Kyeremateng-Amoah & Clarke, 2015; Perfect, 2017; Cuvelier, 2014; Elenge *et al.,* 2013). There are a handful of studies from across Latin America and Asia that have been conducted to determine the injury types as reported in SSM sector. A recent cross-sectional study in Benguet, Philippines by Leung & Lu, (2016) involving the use of interviewer-guided questionnaires and observation of work processes among the small-scale gold miners focused on establishing types of injuries occurring among miners revealed that a substantial number of miners were injured during the mining activity recording up to 35%. Leung & Lu, (2016) reported that prolonged digging, bending over /sitting in awkward positions as well as carrying awkward loads great distances can result in excruciating, persistent injuries such as lower back pain. Notably, miners experienced sprains 25%, lower back pain (23%), contusions 3%, chest pains (23%), cuts (12%); fractures (11%) and swellings of joint (3%). Similar to Leung & Lu's research in Philippines, Salman *et al.,* (2015) provides further evidence of the injury types and location as reported by small-scale miners in many Latin America with a particular focus on San Simon mining region in Bolivia. In this study Salman and his colleagues highlighted commonly reported injuries among the miners to be back injuries, neck injuries and fractures respectively with upper limbs being the most injured body parts.

Regionally, similar studies have been conducted in West and Central Africa in a bid to determine the injury types and causes as reported in SSM sector. Long *et al.,* (2015) while assessing injuries occurring among small-scale gold miners in Ghana conducted a retrospective cross- sectional study involving the analysis of records of injuries reported between 2006 and 2013 to a certain hospital in the upper Eastern Ghana. Long and his colleagues found out that fractures (30.5%) and bruises (contusions) (29.1%), were the most commonly occurring types of injuries followed by back injuries (18.0%), while the rest were cuts (lacerations) 12.0%, and burn/scald (10.4%). The study indicated that most prevalent injury location was lower limbs (feet & legs), mostly occurring due to falling, which would consequently cause a cut or laceration. The study further revealed that almost 3% of the injuries resulted in death. However, the findings of this study might have been compromised by a number of factors including; reliance on secondary data only, difference in medical seeking behaviours among miners and lastly the types of injuries the miners are willing to seek medical attention for. On the contrary, studies conducted by Kyeremateng & Clarke, (2015) on SSGM in Ghana quantitatively demonstrated that cuts / lacerations are most common types of injury sustained by miners at 53.8% of recorded injuries. This is followed by bruises at (24.7%), fractures at (10.3%), traumatic amputations at (4.9%), burns at (3.2%), and multiple injuries at (2.6%). Similarly, Calys-Tagoe *et al.*, (2015) while assessing the types of injuries occurring among small-scale miners in Tarkwa mining region of Ghana; conducted cross-sectional survey involving 406 small-scale miners where they found out the most common injury types to be cuts / lacerations (56.9%) while the most frequently injured body parts being upper limbs (hands, arm and finger) followed by lower limbs (legs, knee and feet). In another recent survey of occupational injuries and accidents in Ghana's Upper Eastern Region involving 195 miners (Long *et al.*, 2015; Kyeremateng-Amoah & Clarke, 2015) likewise pointed out that cuts/lacerations were the most frequently occurring injury types, with the lower limbs (leg and knee) reported to be the most commonly injured body parts. Similarly accentuating the status of occupational safety in small scale mines Human Rights Watch, (2011) provided a comprehensive analysis of the types and nature of injuries sustained by miners in four mine sites namely; Baroya, Tabakoto, Sensoko and Worognan in Bamako and in the mining areas in Western and Southern Mali. In this study involving 150 miners including 41 children, Human Rights Watch explored the prevailing safety drawbacks at each mine site, miner's perceptions about these drawbacks, and the existing opportunities and limitations for miners to improve the safety conditions especially the children miners. Human Rights Watch's analysis demonstrated that digging shafts and working underground, hand pulling the rope with a bucket full of ore out of the shaft, bagging for storage or crushing, grounding, and panning often lead to injuries. The most commonly reported forms of injuries were therefore back injuries, cuts, neck pain, fractures, bruises, swellings and other injuries respectively. In some instances the injuries has led to death. According to this research injuries are highly reported on upper limbs, head with lower limbs being the least injured body part.

Moving away from West Africa, Elenge *et al.,* (2013) & Perfect, (2017) provides an in-depth analysis of injuries in small-scale mining in Central Africa with a particular focus on small-scale copper and cobalt mines at Lupoto site in the mining area of Lubumbashi in Katanga Province DRC. The duo conducted workplaces safety analyses involving 180 miners where they quantitatively demonstrated that bruises (contusion) are the most common type of injury at 50.2% followed by cuts at 44.4% with fractures being the least type of injury sustained by miners at 5.4%. In their study, both Elenge and Perfect highlighted injury by body location where they found out that upper limbs (arms and hands) are the most commonly injured body parts at 50.5%, followed by lower limbs (legs, knee and feet) at 29.3%, Head 12.8% while others parts of the body constituted 7.4% of the injuries. In another study from the same region, Cuvelier, (2014) reveal that the most common injury location are lower limb consisting of leg and feet. Similarly, a study involving small-scale copper mining workers across the neighbouring region; Southern Africa in Zambia reported common types of injuries among miners to be cuts, lacerations and back/ chest injuries (Mikesell, 2017; Elgstrand *et al.,* 2017). However, the injuries were reported to be non-fatal unlike in Eastern region of Ghana where the injuries were reported to be severe and at times would result into death.

2.3 Factors influencing compliance with safety regulations

The underlying factors influencing compliance with safety regulations especially by the targeted group are well documented in literature (Howe, 2015; Durant & Fiorino, 2017; MacEachen & Kosny, 2016; Grabosky, 2013; Salihu *et al.,* 2016; Kalidin, 2017; Dupuis, 2016; Small *et al,* 2017; Chan *et al.,* 2016; Lyon & Maxwell, 2016; Malesky & Taussig, 2017). Salihu *et al.,* (2016) published a very comprehensive review of factors affecting facilities compliance to safety regulations as relates to lack of regulatory knowledge or comprehension, willingness, and ability to comply by the target group. Salihu *et al.,* (2016) pointed out that when requirements of a regulation are too complex to know and understand then the target group are likely to resist compliance on grounds of failure to understand the law. Providing similar sentiments, Durant & Fiorino, (2017) after conducting a regulatory analysis argued that more often than not, the design and development processes of regulations more so those targeted towards delivering new rules and procedures or expanding the existing ones to cater for any eventualities or circumstances or to address any new issues cumulatively affect the simplicity of the law hence leading to the loss of ability in the targeted group to comprehend the compliance requirements in the resulting regulatory structure. For instance, amendments to Occupational Safety and Health (OSH) regulations initiated in England with the main objective of substituting many complex rules with few basic, flexible and easy to understand conventional OSH rules, ended up being too complex and voluminous with continuous inclusion of detailed codes of practice, consequently affecting the ultimate goal of facilitating OSH compliance since the regulation become incomprehensible for most businesses in Britain (MacEachen & Kosny, 2016). Studies by MacEachen & Kosny, (2016) on regulatory burden and rule of law further indicated that the compliance rates with safety regulations amongst small businesses is largely affected by inaccessibility of the regulation as well as the ability to comprehend the regulatory requirements. Generally small businesses always find it difficult to keep up with the volumes of regulatory guidance that are constantly reviewed, amended and produced by regulatory authorities or agencies (Kalidin, 2017).

A study on OSH compliance by Howe, (2015) in Hong Kong &Australia found out that large firms/corporations with adequate safety personnel in place had no difficulty in understanding and using information regarding the requirements of such a regulations. As a result large firms were in a better position to ensure regulatory compliance as opposed to their counter parts in the small firms / corporations without adequate safety personnel and where resources in terms of time to read and comprehend the voluminous regulatory material on safety issue was found to be lacking. Providing further evidence Dupuis, (2016) while assessing safety regulation awareness amongst company directors and or managers in England and Wales found out that majority of company directors or managers possess little or no basic knowledge of their responsibilities under Companies and Securities Acts which acts as a subsidiary law to OSH regulations. Studies on non-compliance with safety regulations as relates to the willingness to comply by those targeted has identified the costs of compliance and incapacitation on the part of those regulated as the key contributors to non-compliance (Chan *et al.,* 2016; Small *et al,* 2017). Chan *et al.,* (2016) studied costs of compliance with safety regulations in relation to the benefits of compliance amongst Small and Medium-sized Enterprises (SME's) and found out that voluntary compliance is usually very low when the costs of complying with rules in terms of time, money and effort are considered to be high. Similarly, the complex nature of rules and the general regulatory structure essentially raise compliance cost. As such, SME's often tend to unfairly bear the burden of costs of compliance based on their size and turnover consequently affecting their compliance rates (Kalidin, 2017). Similar studies from majority of the OECD countries have concluded that the cost of compliance is usually higher for SME's, thus are at a higher risk of experiencing compliance failure (Lyon & Maxwell, 2016). Consequently, such unmanageable costs have pushed micro-firm owners to adopt operation mechanisms not requiring regulatory compliance such as relying on unpaid family members instead of hiring wage-earning labour and avoiding fixed sites. (Ibid).

Finally studies by Grabosky, (2013) and Malesky & Taussig, (2017) on non-compliance with safety regulations on grounds of inability to comply by the target group pointed out administration incompetence resulting from poor governance as the major contributor to non-compliance. He argued that the levels of voluntary compliance may be compromised and in many instances may be very poor if governments do not put in place effective implementation strategies or mechanisms. This may include provision of necessary information and other support such as training and awareness creation as need may arise. The two authors concluded that the policy makers must not only publish the rules but must also ensure that the new rules are accompanied by information campaigns with an aim of making it feasible for the target group. It is worth noting that this was a very comprehensive study combining the three factors influencing compliance with safety regulations in one study.

2.4 Theoretical Framework; Domino theory of accident causation

The study was based on Domino Theory of Accident Causation which states that one undesirable condition in the workplace will lead to others, and eventually to an accident. The theory was invented by Herbert Heinrich an early pioneer of industrial safety and accident prevention. He came up with the theory after studying 75,000 accident reports obtained from industries in the 1920s where he arrived at a conclusion that 88 % of accidents were caused by undesirable acts, 10 % by undesirable conditions while 2% were inevitable, that is, Domino theory places worker's actions at the centre of accidents. Hebert's theory serves as a standard model used by health and safety professionals worldwide. However, one key weakness of this theory is that it only focuses on manufacturing industry's safety issues, yet safety hazards or unsafe conditions can equally be experienced in other workplace environments other than the industries alone. The theory was partly adopted in the formulation of the conceptual framework mainly to illustrate that accidents and injuries that cannot be eliminated can only be minimized taking into consideration the that fact that the theory also acknowledges some accidents /injuries to be inevitable.

2.5 **Conceptual framework**

The conceptual issues in this study included the occupational safety compliance amongst small-scale gold miners. Non-compliance with occupational safety regulations in this case was the independent variable, poor occupational safety conditions are the dependent variable whereas legalization and normalization of the mine's operations serves as the intervening variables. Non-compliance with occupational safety standards implied the failure to act in accordance with a formal requirement such as the use of PPEs, mining permits and machinery guards, whereas the poor occupational safety conditions were the resultant hazards due non-compliance. Finally, legalization and normalization of the mines helps to improve occupational conditions through inspections, training and safe work procedures which ensures that safety issues are better managed. Figure 2.1 shows the conceptual application in the study.

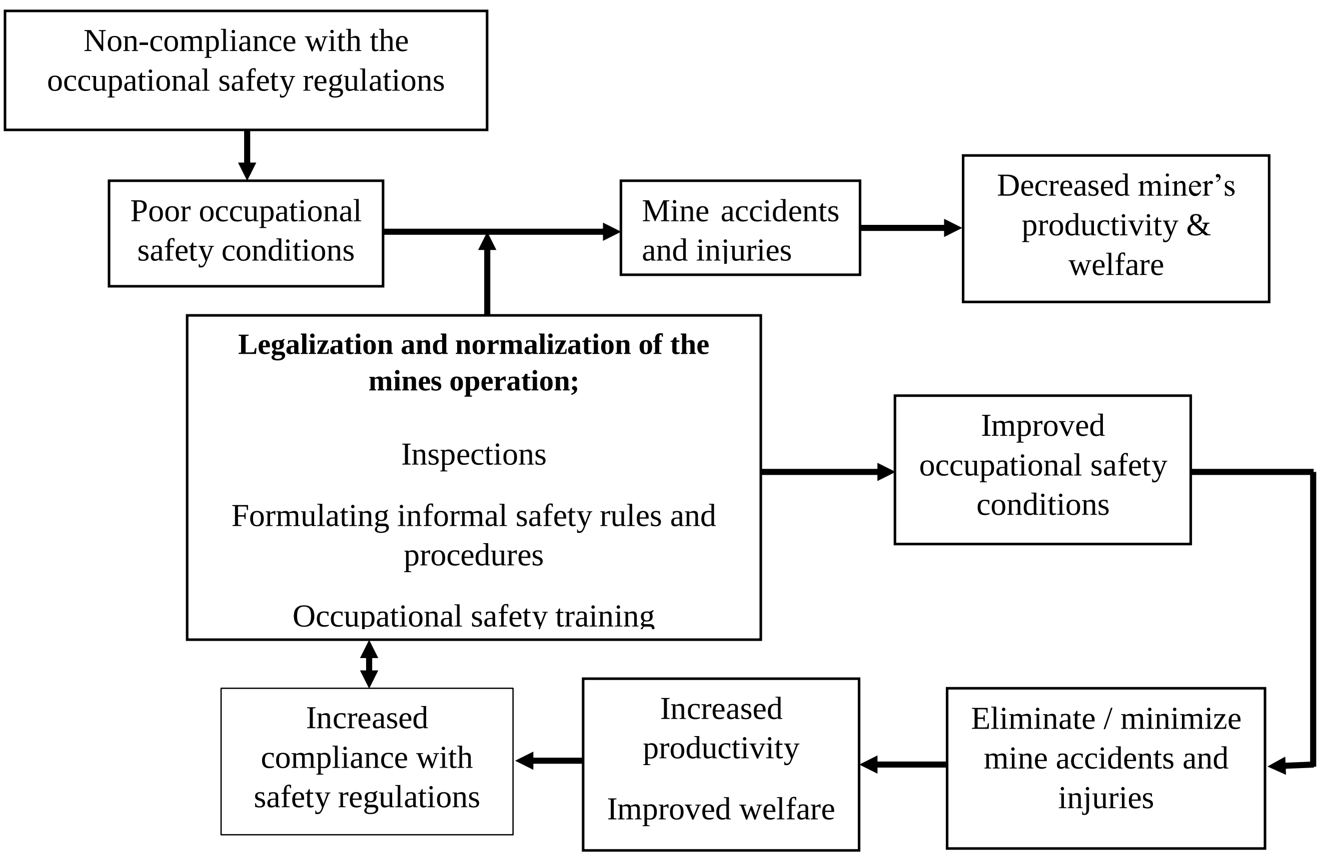

Figure 2.1: Conceptual Framework
Source: Researcher, (2018).

The figure explains the link between non-compliance with occupational safety regulations and poor occupational safety conditions as a cause of mine accidents and injuries which further leads decreased miner's productivity and welfare. Legalization and normalization of mine's operations involving formulation of informal occupational safety rules and procedures, inspections and provision of occupational safety training help to achieve improved occupational safety compliance. This further results into improved occupational safety conditions which contributes to elimination or minimization of mine accidents and injuries subsequently resulting into increased productivity and improved welfare. Increased productivity and improved welfare both contribute to increased compliance with safety regulations which typically means that the mine's operations have been legalized and normalized. The study measured variables such as occupational safety issues, types and causes of injuries, body part(s) injured, nature of injuries, accident handling, awareness on occupational safety regulations, use of PPEs, reasons for not using PPEs and safety training. These variables were measured using ordinal and nominal scales of measurement. Specific questions on the use of PPEs and occupational safety issues such as mine collapse, untimed explosion, falls/slips, hit by working tools and falling rocks were used to assess non-compliance with occupational safety standards whereas miner's knowledge and awareness on safety requirements, types and causes of injuries, nature of injuries as well as accident handling were used to assess occupational safety conditions. Additionally, an observation checklist with questions designed at nominal scale was used to assess was used to assess occupational safety conditions. Open ended questions and key informant interviews were key in the measurement of the intervening variable which to a lager extent entailed possible course of action towards improving miner's welfare and productivity by legalizing and normalizing the operations of the mines.

2.6 Research gap

Currently there is a remarkable concern on the environmental and socio-economic aspects of SSM. For instance, most of the current studies have been conscious of the use of mercury and its impacts on the environment as well as human health, role of small scale mining in poverty alleviation (sources of livelihood) and the role of women and children in SSM sector. For example a study by Alliance for Responsible Mining, 2018 within East Africa provided the economic potential of the SSM in Kenya, Uganda and Rwanda. Similar studies on economic and job creation potential of SSM has been conducted by UNDP in Taita Taveta focusing mainly on gemstone mining. Other studies focused on the health impacts of mercury use, for example a study which was conducted by UN Environment at small scale gold mines in Kakamega with the sole aim of championing for mercury free mining (UN Environment, 2018). To date, safety issues have not been adequately covered in the scholarly literature neither have they been addressed by regulatory structures in countries where SSM is widespread, hence the need to address this gap was the key motivation for undertaking this research.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.0 Introduction

Chapter three presents a detailed description of methodological techniques that were applied in the study towards achieving the study objectives. The methodology is presented under the sub-topics: research design, study variables, types and sources of data, target sample, sample design, data interpretation, data presentation, validity and reliability of research instruments and ethical considerations underpinning the study. Additionally, the chapter provides a detailed description of the study area under the subtopics: geographical location, size and population, topography, geology and hydrogeology, climate and rainfall as well as economic activities.

3.1 Study area

3.1.1 Geographical Location, Size and Population

The study was based on a research conducted at four gold mines in Central Sakwa Ward. The four gold mines were purposively selected because they are the only permanent mines in the ward and besides the ore deposits in these mines are economically viable. Central Sakwa ward is among the six wards forming Bondo sub-County under the current Siaya County. The ward is bordered by South- Sakwa Ward to the East; Yimbo West Ward to the West; Lake Victoria to the South, North-Sakwa Ward to the North. The ward is approximately 85.2 km2 with an estimated total population of 27,353 (KNBS, 2012), with males and females constituting 46.9% and 53.1% respectively. The average population density is 236 persons per sq. km (KNBS 2009). The mining area has an aggregate population of 1500 hence forming around 5.5% of the ward's total population. Geographically Central Sakwa ward lies between latitude 0^0 14^1 19^{11}N and longitude 34^0 16^1 09^{11}E. Figure 3.1 (a) and (b) shows the map of the study area.

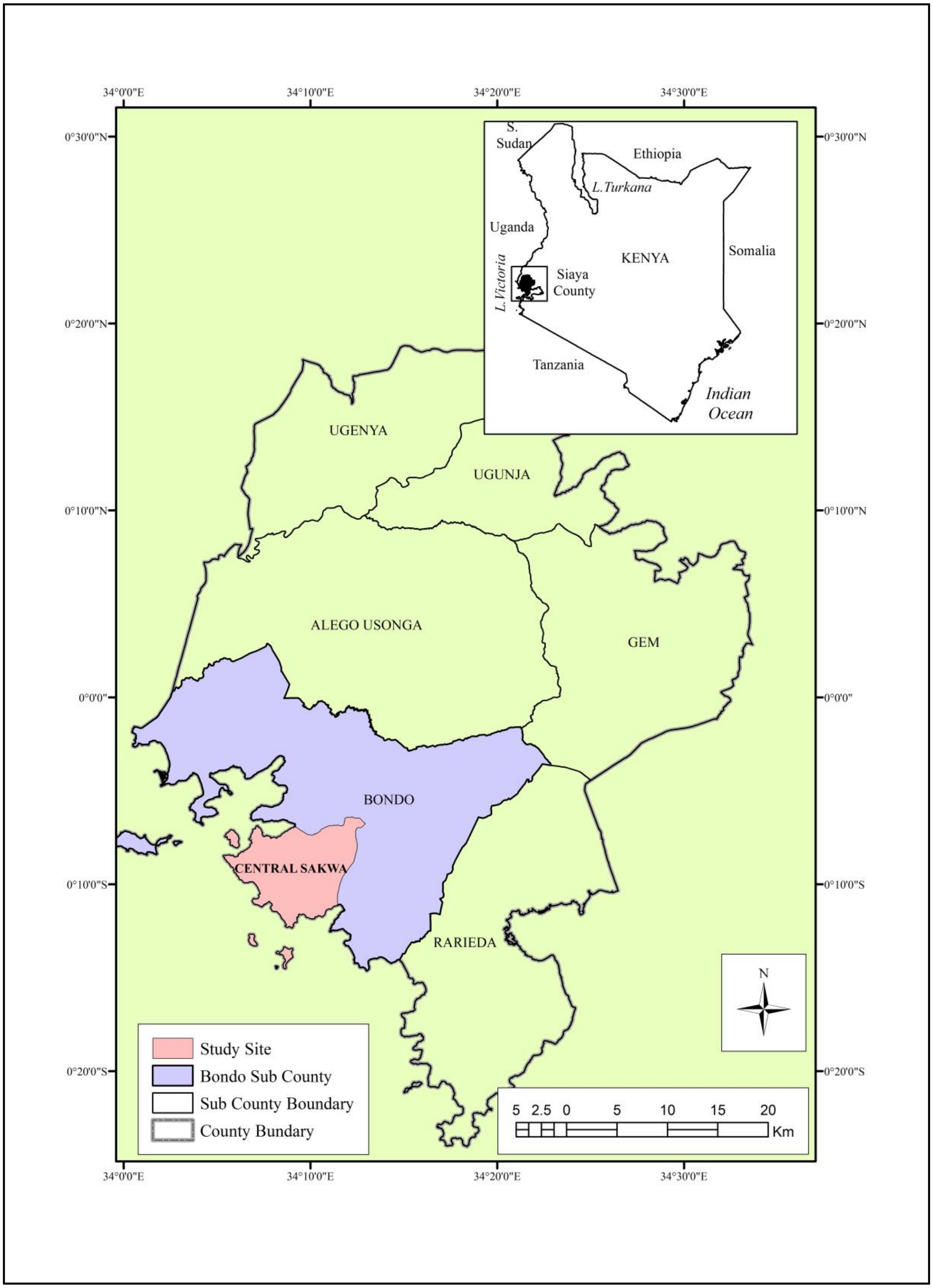

Figure 3.1a: Study Area map
Source: Survey of Kenya, (2011).

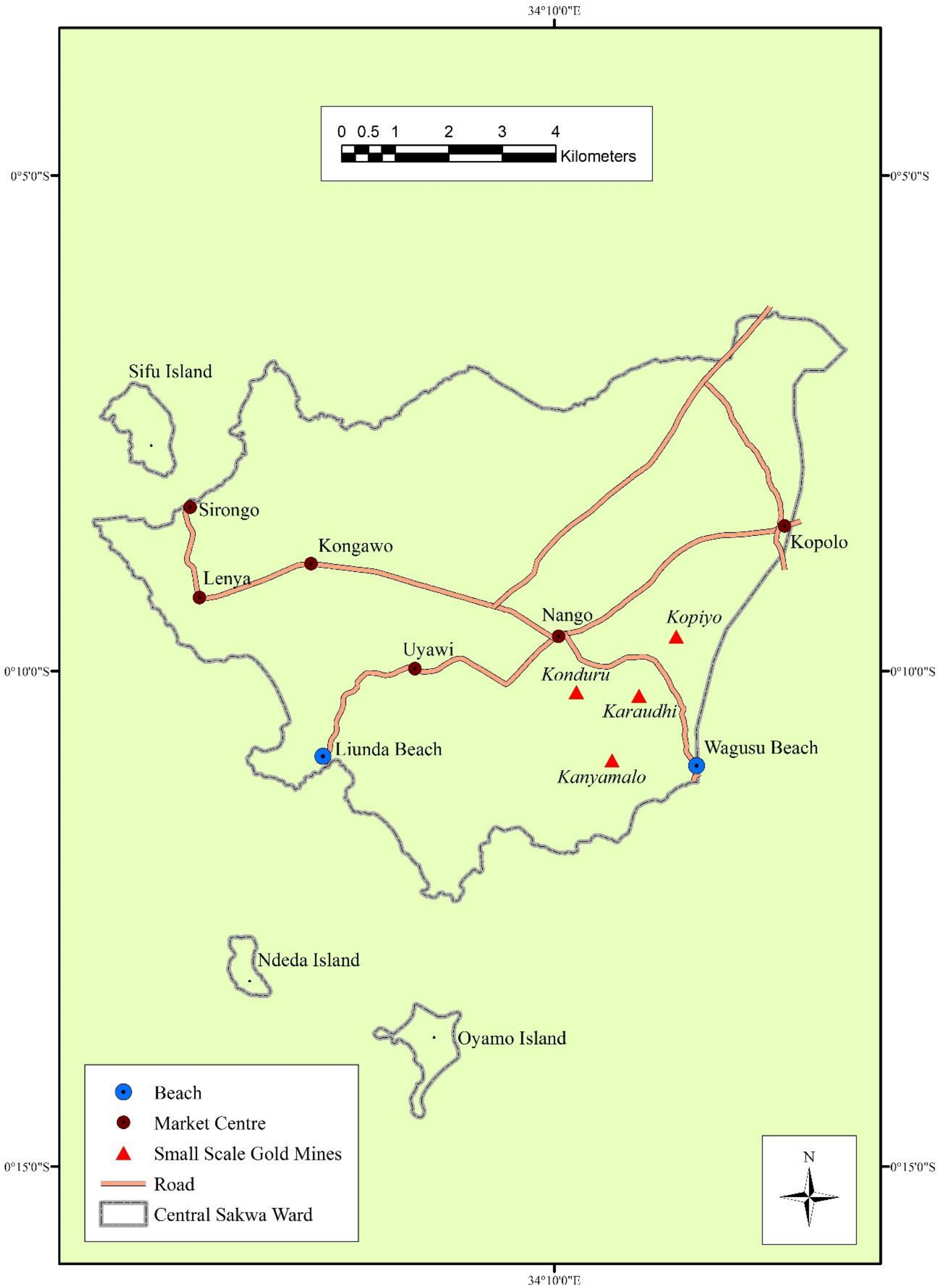

Figure 3.1b: Map of study area showing the four mine sites
Source: Survey of Kenya, (2011).

3.1.2 Topography, Climate and Rainfall

The topography of the area undulates between 50m and 70m above sea level with the main source of freshwater for the study area being Lake Victoria which has since been degraded due to the intensive operations of SSGM involving siltation and use of mercury. The lake has been a major source of water used in the gold processing. The study area is predominantly hot and humid with mean annual temperatures of 21.7^{0}C. Rainfall too vary with a mean of 1572 mm on bi-modal rainfall patterns of short rains experienced between October and December and long rains experienced between March and May (Figure 3.2). The natural vegetation of the study area is predominantly drought-resistant plants including; aloe vera species, cactus, *Lantana camara* as well as climbers. The SSM operations have gradually degraded the natural vegetation of the study area.

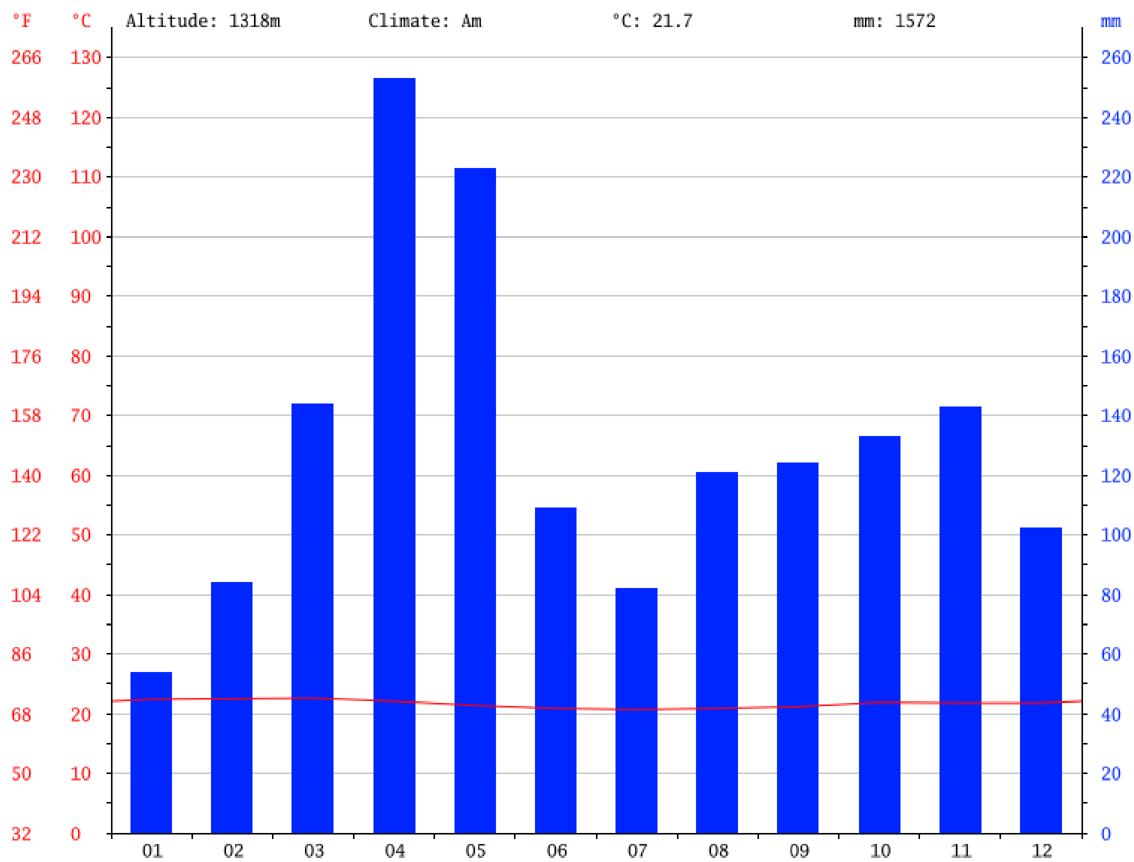

Figure 3.2: Climograph for Siaya County

Source: https://en.climate-data.org/location/11165/

3.1.3 Geology and Hydrogeology

Geologically, the study area is underlain by volcanic rocks comprising of basalt, rhyolite and elite rocks. These volcanic rocks are viewed as the as the major source of gold ore deposits, thus explains the existence of gold mining sites in the study area as well as increasing establishment of small-scale mines. Central Sakwa Ward lies over the Lake Victoria underground aquifer, and therefore the underground mine shafts often produce a lot of water and experience flooding. This necessitates continuous pumping of the water from the shafts to allow for smooth operations at the mines.

3.1.4 Economic Activities

The main economic activities in Central Sakwa Ward can be classified into three groups: agriculture, mining, and fishing. Mining is a vital economic force that drives Central Sakwa ward in terms livelihood sources for the ward residents. Central Sakwa ward is endowed with minerals; such as ballast, building stones and gold. Mining serves as a major source of income for a number of households in Central Sakwa Ward. Gold has been mined in Central Sakwa ward for a considerable time on subsistence basis in shallow and deep excavations hence resulting into establishment of four underground gold mining operations sites namely; Konduru, Kopiyo, Karaudhi and Kanyamalo. Together, these mines employ approximately 100 - 150 individuals. The gold is small-and-high-grade requiring high selectivity through manual work hence the application of crude and manual mining methods. The four mines are permanent mines that operate throughout the year, hence are not affected by seasons. However, during the long rains the mines can be more prone to collapse/subsidence as prolonged rains tend to weaken the soil and the rocks. Apart from mining activities the locals also engage in agricultural activities. In most cases the agricultural activities are concentrated along the shores of the lake, this has led to water quality degration especially due to agricultural runoff as evidenced by increased invasion of the lake by water hyacinth. Besides farming, the locals also practice livestock keeping. In addition, the presence of Lake Victoria in the study area has made fishing another source of income generation amongst the locals. Despite the availability of other sources of livelihoods majority of the ward residents have chosen to work in the mines. This profile of the study area best exemplify the decision to conduct the research in the area.

3.2 Research Methodology

3.2.1 Research Design

This was a case-study research carried out at small-scale gold mines in Central Sakwa Ward; Siaya County. In order to ascertain occupational safety compliance amongst small-scale gold miners, this study adopted mixed methodology strategy. The research questions were particularly suited for mixed methods approach as more data sources provided more relevant data to answer all the research questions.

3.2.2 Study Variables

The study comprised of several variables which were measured using ordinal and nominal scales of measurement. The variables included; occupational safety issues, types and causes of injuries, body part(s) injured, nature of injuries, accident handling, awareness on occupational safety, use of PPEs, reasons for not using PPEs and safety training.

3.2.3 Types and Sources of Data

Both primary and secondary data were applied in the study. Primary data was obtained from the respondents (gold miners) and field observation. The secondary data on the other hand was obtained from both unpublished and published documents e.g. legal documents.

3.2.4 Target Population

The study targeted a total of 128 miners who perform a variety of roles in the four selected mines including excavation and blasting, removal of ore from shafts and crushing and washing. The units of analysis therefore was gold miners. As per the literature review, most occupational safety issues were experienced in the above stated activities and therefore were ideal areas for assessing the occupational safety compliance in the SSM sector.

3.2.5 Sample Design (sample size and sampling procedure)

The researcher used probability sampling techniques to select the research sample. Therefore the study was based on a random sample of 97 miners drawn from a total of 128 miners. In order to select sample size for data collection, three steps were followed:

Firstly, the sample size was computed using formula for Creative Research Systems (2012) as shown below;

$$SS = \frac{Z^2 * (P) * (1 - P)}{C^2}$$

Where;

SS- Sample Size

Z - Z value; 1.96 for 95% confidence level

P - Population proportion expressed as decimal 0.5

C - Degree of accuracy /confidence interval (margin of error), expressed as 5% (0.05).

The substitution of this function gives 384.16, i.e.

$$SS = \frac{1.96^2 * (0.5) * (1 - 0.5)}{0.05^2}$$

$$= 384.16$$

Since the target population (128) was less than 384, Correction Formula for finite population was used to arrive at the sample size.

$$\text{New SS} = \frac{SS}{1 + \frac{SS - 1}{N}}$$

Where,

SS - Sample Size,

N - Target population

$$\text{New SS} = \frac{384.16}{1 + \frac{384.16 - 1}{128}}$$

$$= 97$$

Secondly, the researcher used proportionate stratified random sampling to proportionately assign samples to the 4 mine sites which are treated as strata. Table 3.1 shows the results of stratification of the sample size using a sampling fraction of 1.3196 (N/n i.e. 128/97). For example Site 1: 47/1.3196 =36 Miners.

Table 3.1: Sample size per site

Site Name	Target population		# of Miners Selected into the sample	
	N	%	n	%
Site 1: Kopiyo	47	36.7	36	37.1
Site 2: Karaudhi	32	25.0	24	24.7
Site 3: Kanyamalo	23	18.0	17	17.5
Site 4: Konduru	26	20.3	20	20.6
Total	**128**	**100**	**97**	**100**

Source: Researcher, (2018)

Thirdly, using simple random sampling, actual members of the sample were selected from mine site list of workers obtained from the site manager by assigning consecutive numbers to all workers of each mine site. The researcher then used RANDBETWEEN function in Ms Excel 2016 to generate random numbers. A gold miner to whom a random number was generated automatically became a member of the sample for that particular Mine Site and with whom was administered with questionnaire.

3.2.6 Data Collection

The data was collected using instruments namely: questionnaires, interviews, observation checklists and document reviews.

a. Questionnaires

The questionnaires were used to seek the perception and opinions of small-scale gold miners concerning occupational safety and to assess their compliance (Appendix II). As such, questions were divided into a few categories such as general information about the miners, occupational safety issues, types and causes of injuries that occur in small scale mines as well as factors influencing compliance with safety regulations thus the questionnaire was designed to identify variables that could be coded for final analysis. The questionnaires were packaged with a good cover letter explaining the purpose of the research (Appendix I). A total of 97 questionnaires were administered through face-to-face interviewer technique so as to increase response rate and avoid incompleteness. One research assistants was selected and trained to help with data collection. On average the administration of questionnaire took about 6 minutes. Completed questionnaires were promptly collected by the researcher for data entry and analysis.

b. Key Informant Interviews

The key informants whom were interviewed included: County Director of Environment (CDE), County Occupational Safety & Health Officer (COSHO) and the Mine Site Managers (MSMs). CDE and COSHO were interviewed to gain valuable insight into their thoughts, perceptions, and concerns about occupational safety compliance amongst small-scale gold miners. The MSMs on the other hand were interviewed to gain valuable insights into their experience on the types of injuries and their primary causes, factors influencing safety compliance as well as their opinion on what kind of measures can be taken to improve occupational safety compliance. The researcher scheduled an interview with the key informants and administered it on agreed day. On average, each interview lasted about 10 minutes. To conduct the interviews the researcher used interview guides throughout the process (Appendix III). Besides, field notes were also taken to capture additional data during the interviews and to ensure effective transcribing and coding of data afterwards.

c. Observation checklist

The researcher systematically observed occupational safety issues at the selected mine sites and identified activities or conditions that are likely to cause harm. Since the researcher wanted to understand and obtain sufficient information about occupational safety compliance amongst small-scale gold miners, the researcher spent more time in the mine sites. In this way the researcher collected much information regarding the occupational safety conditions and compliance at the mine site. As a result, observations were made by making randomized visits in order to observe the activities that can occur in the mine sites during the range of shifts; Early Morning, Mid-Morning, Afternoon and Evening. The observation were conducted with the aid of a checklist which was designed to reflect occupational issues relating to the study setting, miner's interaction, the use of PPEs, Equipment / Machinery, Shafts, Lighting systems, Blasting operations, and Warning signs (Appendix IV). The checklist was based on general safety provisions as stipulated in OSHA. No. 12 of 2007. The checklist had a section for Comments to enrich some of the findings. The additional use of a field notebook and a camera made the data collected more efficient and comprehensive. Finally, the underground workings of the mines were accessed for first-hand information about the operations. The findings were recorded in form of photographs.

d. Documents Review

Documents reviews entailed scrutinizing reports at the county OSH office, OSHA No. 15 of 2007 (GoK, 2007) and Mining Act No. 12 of 2016 (GoK, 2016) to identify the types and causes of injuries that occur among miners and number of incidences reported and safety provisions concerning mining activities respectively. Figure 3.3 provides the diagrammatic presentation of data sources and data collection instruments.

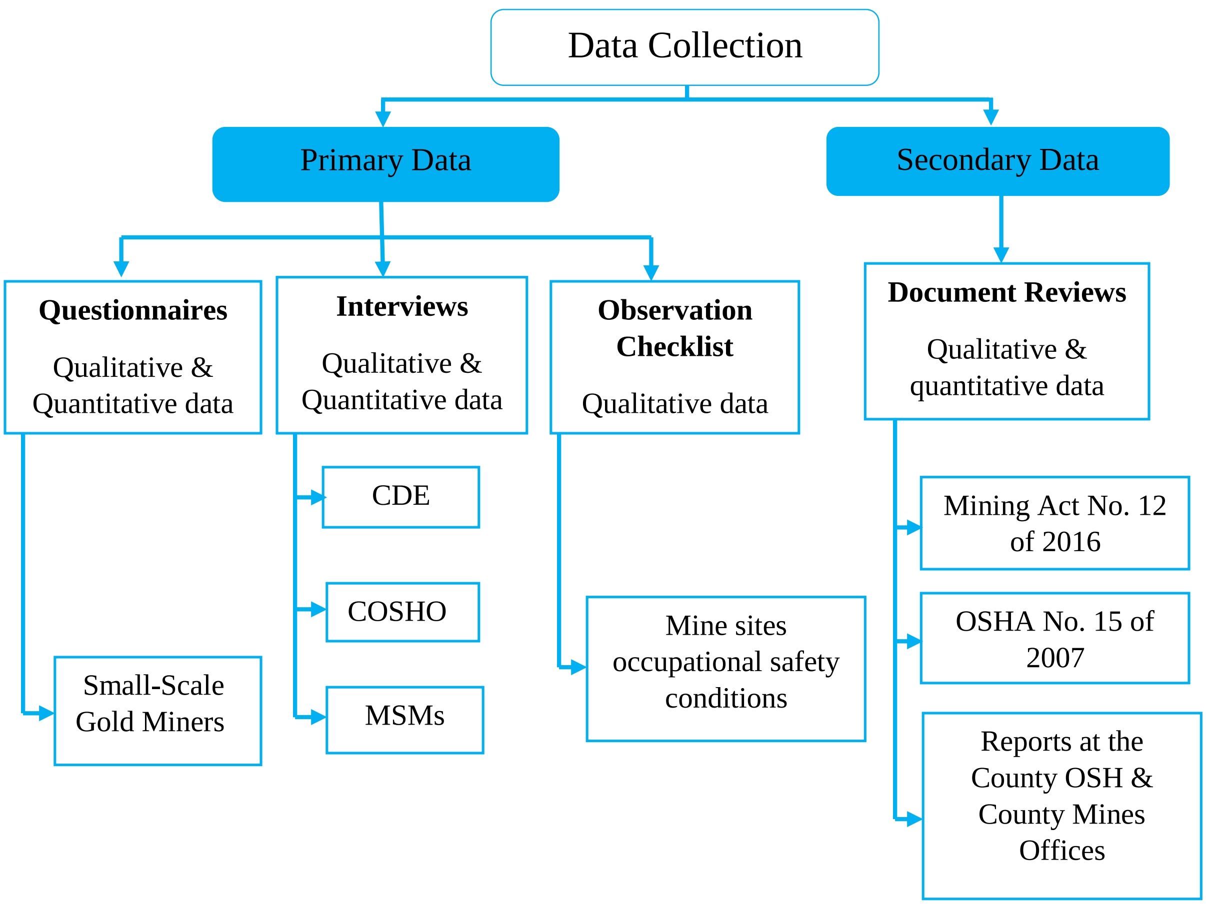

Figure 3.3: Data Collection Method's Structure
Source: Researcher, (2018)

3.2.7 Data Analysis

Qualitative and quantitative analytical techniques were used to analyse the preliminary data obtained from the field. These analytical techniques allowed the researcher to make appropriate discussions and conclusions by evaluating the data with secondary information.

a. Qualitative Data

In analyzing qualitative data all voice-recorded interviews were carefully screened, transcribed into English and divided into preformed categories based on the interview guide (Appendix III). In addition all the interview notes and transcripts were reviewed for comprehension. Observed events were translated as soon as they were collected from the field. Content analysis was used to identify recurring themes and to find the differences and interconnections between and within the themes. The predominant themes that emerge from the data were thematically coded, categorized and analyzed through content analysis method. Additionally, direct quotations from the key informants; CDE, COSHO and MSMs were used to support the findings.

b. Quantitative Data

Quantitative data was analyzed statistically using bivariate methods of analyzing data. After data collection, the questionnaires and data collection checklists were crosschecked for any errors and missing data and corrected accordingly with respect to the pre-formed data categories (Appendix II & IV). The data were cleaned and then coded and entered into the SPSS Version 21.0 where it was summarized using descriptive statistics such as means, modes, medium, percentages and frequencies and subsequently analyzed statistically using bivariate data analysis method. Variables were compared with the past studies in the literature review to establish the differences or similarities of outcomes of SSM. These correlations informed the study's recommendations.

3.2.8 Hypothesis testing

The null hypotheses was tested using Pearson's Chi Square (X^2) Test. Pearson's Chi Square (X^2) Test was suitable for hypothesis testing since the study was trying to test independence of one variable from the other. The hypothesis testing followed six steps;

Step 1: Formulation of null and alternative hypotheses.

Step 2: Rejection level; 0.05 significance level

Step 3: Statistical test: Pearson's Chi Square (X^2) Test was used.

Step 4: Calculation of test statistic

Step 5: Determination of critical value

Step 6: Comparison of calculated and critical value followed by either rejection or failing to reject the null hypotheses.

3.2.9 Validity And Reliability of research instruments

The face and content validity of the research instruments were ascertained by subjecting the instruments to thorough scrutiny and examination. For face validity, each question in the instruments were assessed by experts (supervisors) with regard to the clarity of wording, language and readability, level of difficulty in reference to the targeted audience and the layout and formatting style used. Based on the comments from the experts, the questions were examined and revised to achieve face-validity. To achieve content validity, the experts independently assessed the validity of the instruments and further determined which contents were favourable and which ones were not. These results were used to evaluate and refine the instruments in order to achieve content validity. The next step that was undertaken was determination of the reliability of the instruments. Internal Consistency reliability of the instruments was ascertained by conducting a pilot study with a group of selected small-scale gold miners. This helped to reframe questions and effect changes in the data.

3.2.10 Data Presentation

The study adopted diagrammatic, tabular, graphical and pictorial data presentation techniques. This entailed the use of Microsoft Excel 2016 to present overall findings along with SPSS mainly inform of graphs, tables and charts.

3.2.11 Ethical Considerations

The researcher adopted the acceptable research ethics as articulated in literature, (Neuman and Robson, 2014). As a result, a range ethical issues were considered before commencing the field survey. The researcher obtained a field introductory letter from the University of Nairobi, Research Permit and Research Authorization Letter from NACOSTI, Research Authorization Letter from Siaya County Commissioner and Research Authorization Letter from Siaya County Director of Education prior to data collection (Appendix VI, VII, VIII, IX & X). While in the field the researcher presented cover letter to each participant in the study informing them of the significance of the study. The respondents were informed of the fact that their participation was voluntary and they would not be forced to participate in the study, neither would there be any monetary compensation. Additionally, they were made fully aware of their rights to withdraw from the study without fear of consequence. In addition, the researcher ensured that the confidentiality of data, anonymity and privacy of participants were observed and maintained. Finally the researcher ensured that all cited work were adequately acknowledged and the report subjected to plagiarism test (Appendix XI).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

Chapter four presents, analyses, interprets and discusses the relevance of the data to the growing need for more research on safety compliance in small-scale mining sector. Based on the aforesaid approach, the chapter begins with the questionnaires response rates and the demographic characteristics of gold miners in Central Sakwa; Siaya County followed by the key findings that are thematically presented based on the research questions of the study, namely a) occupational safety issues in small-scale mining, b) types and causes of injuries that occur among small-scale miners and c) factors influencing compliance with safety regulations. Lastly, the chapter provides a detailed testing of the null hypotheses.

4.1 Response Turnout Rates

From a total of 97 questionnaires which were administered, 95 were returned representing a 97.9% return. Table 4.1 presents the number of questionnaires administered, questionnaires returned, and questionnaires not returned.

Table 4.1: Response Rate to Questionnaires per Mine Site

Site Name	No. of questionnaires administered	No. of filled questionnaires returned	No. of questionnaires not returned	Response Rate (%)
Site 1: Kopiyo	36	36	0	100
Site 2: Karaudhi	24	24	0	100
Site 3: Kanyamalo	17	16	1	94.12
Site 4: Konduru	20	19	1	95.0
TOTAL	**97**	**95**	**2**	**97.9**

Source: Fieldwork data, (2018).

4.2 Demographic characteristics of gold miners.

Table 4.2 delineates the demographic features of the gold miners by gender status for those who were administered with the questionnaires. The socio-demographic analysis shows that more than half (58.9%) of the respondents were females while the males were (41.1%) with the majority (52.6%) being within the age group of 18 – 35 years. This typically implies that the small-scale mining is a female dominated sector unlike the common stereotype that has since linked small-scale mining sector with males. The large percentage of the youthful miners was unavoidable due to the energy-intensive nature of the activities in this sector. About (60.1%) of the miners were married with (44.2%) having achieved primary education as their highest level of education while (3.2%) did not have any formal schooling. Only a small portion of the respondents (12.6%) had attained tertiary education. This justifies the use of interviewer-administered questionnaire method as opposed to self-completion questionnaires as majority would not be in a position to appropriately fill the questionnaires. A total of (20.0%) of the respondents had worked in the mining sector for less than 1 year with only (2.1%) of respondents having a work experience of more than 15 years. At the time of the study majority of the male miners (31.6%) worked in the excavation & blasting department while female miners were mainly working in the removal of ore from shafts and crushing and washing. However, no female miner was involved in excavation and blasting operations. This could be attributed to a taboo that has been held for a long time among male miners that women are bad omen. As a result women are not allowed get into the shafts for this might lead to the loss of fortune among the miners.

Table 4.2: Characteristics of study participants by gender

		Gender		
Variable	**Category**	**Female n (%)**	**Male n (%)**	**Total N (%)**
Mine Site	Kopiyo	24 (25.3%)	12 (12.6%)	36 (37.9%)
	Karaudhi	18 (18.9%)	6 (6.3%)	24 (25.3%)
	Kanyamalo	8 (8.4%)	8 (8.4%)	16 (16.8%)
	Konduru	6 (6.3%)	13 (13.7%)	19 (20.0%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**
Age of the gold miners	<18	4 (4.2%)	4 (4.2%)	8 (8.4%)
	18 - 35	30 (31.6%)	20 (21.1%)	50 (52.6%)
	36 - 50	18 (18.9%)	13 (13.7%)	31 (32.6%)
	>50	4 (4.2%)	2 (2.1%)	6 (6.3%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**
Education level	No fomal schooling	2 (2.1%)	1 (1.1%)	3 (3.2%)
	Primary	28 (29.5%)	14 (14.7%)	42 (44.2%)
	Secondary	22 (23.2%)	16 (16.8%)	38 (40.0%)
	Tertiary	4 (4.2%)	8 (8.4%)	12 (12.6%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**
Marital Status	Single	10 (1.4%)	7 (20.9%)	17 (22.3%)
	Married	40 (25%)	29 (35.1%)	69 (60.1%)
	Widowed	6 (12.2%)	3 (5.4%)	9 (17.6%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**
Mine department	Excavation & Blasting	0 (0.0%)	30 (31.6%)	30 (31.6%)
	Removal of ore from shafts	26 (27.4%)	6 (6.3%)	32 (33.7%)
	Crushing and Washing	30 (31.6%)	3 (3.2%)	33 (34.7%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**
Work duration	< 1 Year	10 (10.5%)	9 (9.5%)	19 (20.0%)
	1 – 5 Years	26 (27.4%)	18 (18.9%)	44 (46.3%)
	6 – 10 Years	13 (13.7%)	9 (9.5%)	22 (23.1%)
	11 – 15 Years	6 (6.3%)	2 (2.1%)	8 (8.4%)
	>15 Years	1 (1.1%)	1 (1.1%)	2 (2.1%)
	Total	**56 (58.9%)**	**39 (41.1%)**	**95 (100%)**

Source: Fieldwork data, (2018)
**The item validity for each variable is 100% (95) since the respondents answered all the questions.

4.3 Findings

The findings of the study therefore are outlined objectively;

4.3.1 Occupational Safety Issues in Small-Scale Mining

The study revealed five most frequently occurring safety issues in small-scale mines to be: Shafts collapse, falling rocks, hit by working tools, falling/slipping and untimed explosion as discussed below;

4.3.1.1 Shaft collapse was the main occupational safety issue.

In the current study the miners overwhelmingly indicated that the leading occupational safety issues resulting in accidents and injuries in the mines was shafts collapse (33.7%) (Figure 4.1). Shafts collapse could primarily be attributed to unsupported tunnels and shafts, weak shafts support systems, ground failures, heavy down pour and high impact pressure within the shafts created by explosive blasts. Discussions with the MSMs revealed that the shafts are sometimes supported but sometimes not and are usually poorly lit. In the supported shafts, timber is used as the main support for the underground openings. However, timbers are left unchanged for an extended period of time hence showed significant deterioration (Plate 4.1a). This trend often results in shaft collapse thereby injuring or killing the miners in the process. It is therefore necessary to support the stopes to ensure that they are safe and accessible during the mining period.

While deliberating on safety issues in SSM with the CDE who also doubles up as the Mine Officer though in close collaboration with the Regional Director of Mines (RDM) it became apparent that shaft collapse was due to unfamiliarity with the nature of the rocks in terms of strength and stability, occasioned by lack of technical expertise more so as relates to blasting operations. He mentioned that "*the shaft collapse can be overcome by involving mining and geological engineers who have the capability and resources to operate in such precarious environments". However, he said that "*from our own assessment we noted that most of the professional engineers do not find small scale mining dignifying and therefore do not want to associate themselves with such operations".*

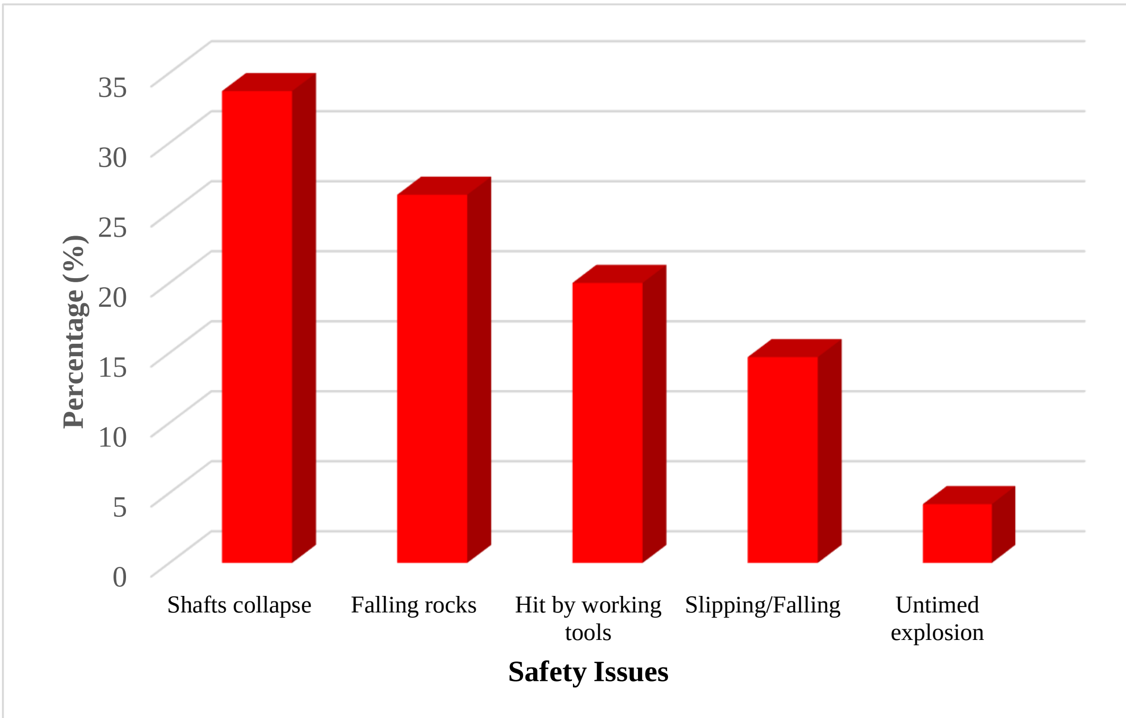

Figure 4.1: Occupational safety issues in small-scale mining
Source: Fieldwork data, (2018)

In the unsupported shafts, the voids were left open without any form of support while loose materials were found to be inadequately supported (Plate 4.1 a, b & c). The MSMs mentioned that; "*back in 2013, a shaft collapsed killing one miner instantly*". The miner was allegedly working in the unsupported shaft following a heavy down pour. However, not in all instances where there were shafts collapse, the resultant outcome were instant deaths, some miners would just sustain serious to severe injuries.

Plate 4.1: Underground workings; (a) deteriorated timber support, (b) inadequately supported stopes, (c) a miner lifting heavy load while bending over hanging rocks & (d) miners sitting in an awkward position while excavating the rocks.

Source: Research Field Visits, (2018)

Other than shaft collapse, there were other safety issues that continue to pose safety threats among the miners. These were; falling rocks (26.3%), hit by working tools (20.0%), slipping/falling (14.7%) and untimed explosion (4.2%) (Figure 4.1). These safety issues have resulted in several fatalities and severe injuries among miners. Generally the nature of the injuries occurring as a result of these occupational safety issues ranged from minor injuries to instant deaths (Figure 4.2).

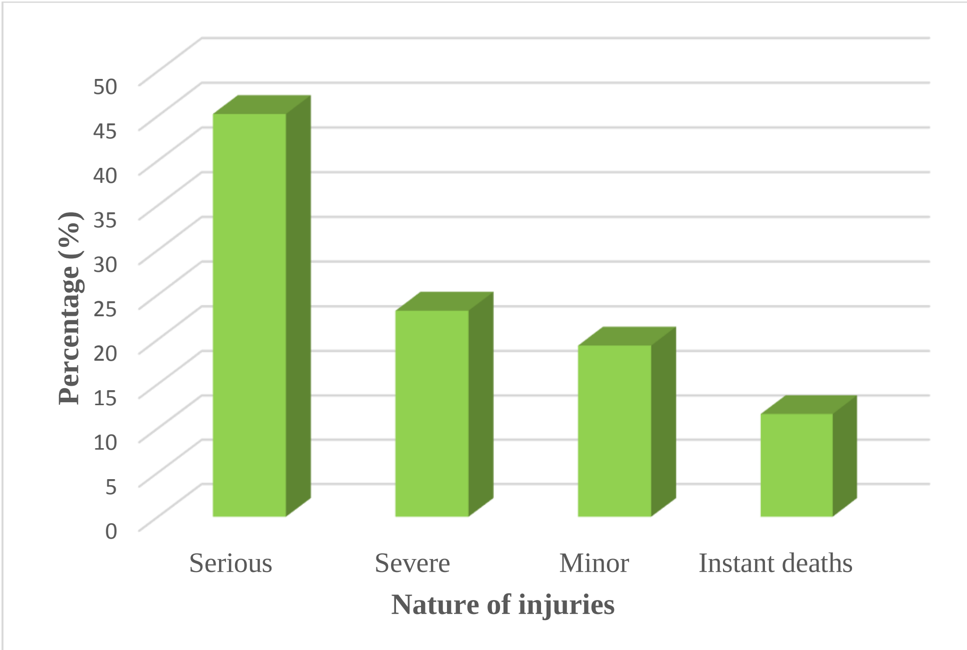

Figure 4.2: Nature of injuries
Source: Fieldwork data, (2018)

Despite the high potential magnitude of harm, miners invariably do not report accidents that occur at the mines because of fear of drawing public attention except for accidents whose resultant outcome is fatal. The miners overwhelmingly indicated that incidents resulting in fatalities (instant deaths) are usually reported to the area chief who always act by ordering temporary mine closure (Table 4.3). The operations would always resume upon burying the departed miners. Usually, non-fatal accidents are kept hidden from the general public. This could be attributed to the fear of hefty penalties and fines associated with non-compliance with the OSH regulations and non-conformance with best practices, sanctions and permanent closure of mine sites upon reporting incidences pending investigations.

Table 4.3: Accident handling based on the nature of the injury

Action Taken	Nature of injury	Accident handling				Total	
		Reported to area chief		Not reported			
		N	%	N	%	N	%
Temporary mine closure	Instant deaths	11	11.6	0	0	11	11.6%
None	Severe injuries	0	0.0	22	23.2	22	26.2
	Serious injuries	0	0.0	43	45.2	43	47.7
	Minor injuries	0	0.0	19	20.0	19	19.3
	Total	**11**	**11.6**	**84**	**88.4**	**95**	**100**

Source: Fieldwork data, (2018)

These results were similar to the findings of previous studies on occupational safety issues in small-scale mining. A study by Smith *et al.,* (2016), on occupational safety issues in SSMs highlighted the leading safety issues in the mines as; use of improperly maintained mining equipments, non-compliance on using PPEs, gas and dust outburst, suffocation from toxic chemical fumes, entrapment, drowning, blasting, being hit by objects, falling, rock falls and shafts subsidence. Accentuating similar outcomes is a study by Leung & Lu, (2016) on "Environmental health and safety hazards of indigenous small-scale gold mining using Cyanidation in the Philippines", which established the five most frequently cited safety issues to be shafts/tunnel subsidence, insufficient ventilation (suffocation), tripping or falling, inappropriate blasting operations (untimed explosion), rock falls as well as being hit by an object. A study by Human Rights Watch, (2011) on the prevailing safety issues at Baroya, Kéniéba and Worognan small-scale mines in Bamako; in the gold mining areas in Western and Southern involving 150 miners established that; shafts collapse, being hit or struck by moving rocks, rudimentary working tools or machinery and falls and trips were the main safety issues of concern among the respondent and were equally responsible for injuries including swellings, fractures, back injuries and bruises. In the three mine sites; shafts and tunnel collapse resulting into entrapments was the leading causes of fatal accidents. For instance in Worognan mines, shafts and tunnel collapse often cause death of miners every month. This is the same case at Baroya and Kéniéba mine where 7 miners died from head and neck injuries caused by shaft collapse. Apart from shafts collapse, falls and trips were reported to be another major safety issue especially among children when ascending or descending into the shafts. The study equally revealed that the deaths might be many as opposed to the provided figures as those responsible for safety often tends to downplay the accidents. Providing similar sentiments on the prevailing occupational safety issues in small-scale mines is a study on sustainable mining operations strategies in Tanzania and Zimbabwe which qualitatively analysed the causes of mine injuries and fatalities amongst Small-Scale gold miners. In this study it was noted that in Busia district of Tanzania, severe injuries and fatalities were occurring due to collapse of mine structures/tunnels, (Zvarivadza & Nhleko, 2017). It was further estimated that approximately 1- 5 mortalities occur every year, with many others going unreported. Casualties among small-scale gold miners in many parts of Zimbabwe have equally been linked to miners working under confined spaces within shafts and burrowing into uncompact driver beds hence becoming vulnerable to entrapment due to tunnel collapse and poor ventilation, (Hilson & McQuilken, 2014; Dalu *et al.*, 2017). Zimbabwe has been reported as one of the countries with unreasonably high number of deaths among gold miners. These findings are comparable to the findings of a retrospective cross-sectional study involving the analysis of records of injuries presented between 2006 and 2013 by small-scale gold miners to a certain hospital in the upper Eastern Ghana which cited mine structures/tunnels collapse, workers stumbling/slipping/falling, improper use of explosives (untimed explosion) and inappropriate equipment as the major safety issues responsible for mine accidents and injuries, (Long *et al.*, 2015; Kyeremateng-Amoah & Clarke, 2015; Wilson *et al.*, 2015). Finally, emphasizing similar outcomes is Marriott, (2008) whom in her assessment of two gold mine sites in Kwa Zulu Natal; South Africa concluded that collapse of mine structures/tunnels gas or dust explosions rock falls and improperly used mining equipment and lack of safety facilities were the most prevalent safety issues responsible for accidents and injuries in gold mine sites in South Africa.

Despite a handful of similarities, other studies found contradicting results. Unlike in the current study; a study by Song & Mu, (2013) on safety issues experienced in small-scale coal mines at Caijiagou Mine, Xinjian mine, Gangzi village mine and Chengjiashan mine in China found out that gas and coal dust explosion/outbursts was the main occupational safety issue followed by blasting, electrical sparking and poorly designed ventilation system. Song & Mu argued that mining under difficult geotechnical conditions within extensive mines is a key contributing element for the increased mine accidents and injuries. The duo found out that between April 2001 and May 2004, a number of small-scale coal miners were killed and several others injured at this small private village mines. The difference in findings from this previous study could be attributed to the difference in geo-technical conditions or setting between coal mines and gold mines which makes coal miners more susceptible to suffocation due to gas and coal dust explosion/outbursts and gold miners to entrapment due to shaft collapse.

4.3.2 Types and causes of injuries that occur among small-scale miners

The study established the types of injuries occurring among miners to be cuts, fractures, bruises and back/chest injuries and causes of the said injuries to be sharp rock edges, working tools / machinery, falls and struck / hit by object as discussed below;

4.3.2.1 Back / chest injuries, cuts, fractures and bruises were the major injuries.

Various injuries were reported to be occurring among the miners. These were back / chest injuries, cuts (lacerations), fractures and bruises (contusions) (Figure 4.3). Back / chest injuries and cuts constituted the most frequently occurring types of injury accounting for (35%) and (26%) of reported injuries respectively while the leading underlying causes of these injuries were lifting heavy loads & prolonged bending (34.7%), Sharp rock edges (24.2%), Working tools / machinery (14.7%), Fall, (13.7%), Struck / hit by rock (12.6%) (Figure 4.4; Plate 4.1 c & d). Back/chest injuries were attributed to ergonomical hazards resulting into ergonomic stressors. Ergonomic stressors have been linked to physiological injuries associated with repetitive and cumulative exertion mainly in the form of prolonged bending and lifting heavy loads. Such findings reflect the state of occupational safety conditions as one that is deplorable and that require urgent intervention of the relevant agencies / authorities. The findings are equally important in shaping preventative actions and policies given that there is a paucity of studies in Kenya regarding the occupational safety issues among small-scale miners. Collectively, this evidence supports the Domino theory of Accident causation by Herbert Heinrich which concluded that that 88 % of accidents were caused by undesirable acts, 10 % by undesirable conditions while 2% were inevitable. The injuries were spread across all body parts (Figure 4.5) with hand and back / chest being the predominantly injured body parts.

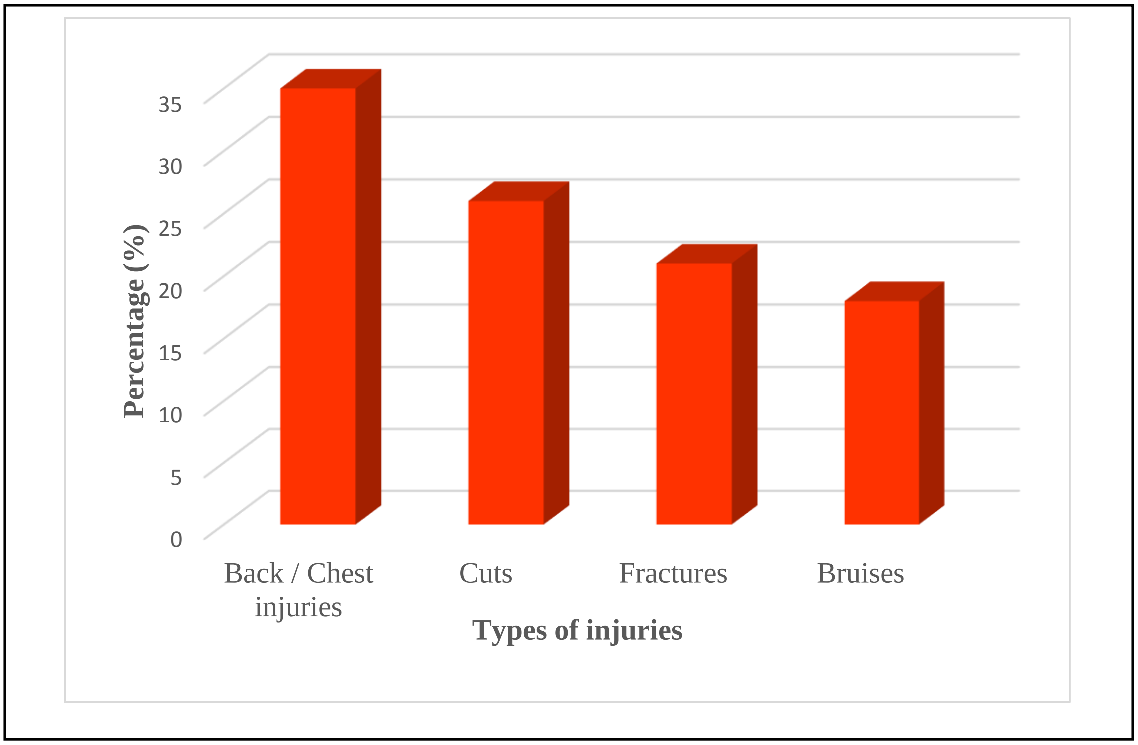

Figure 4.3: Types of injuries occurring among small-scale miners
Source: Fieldwork data, (2018).

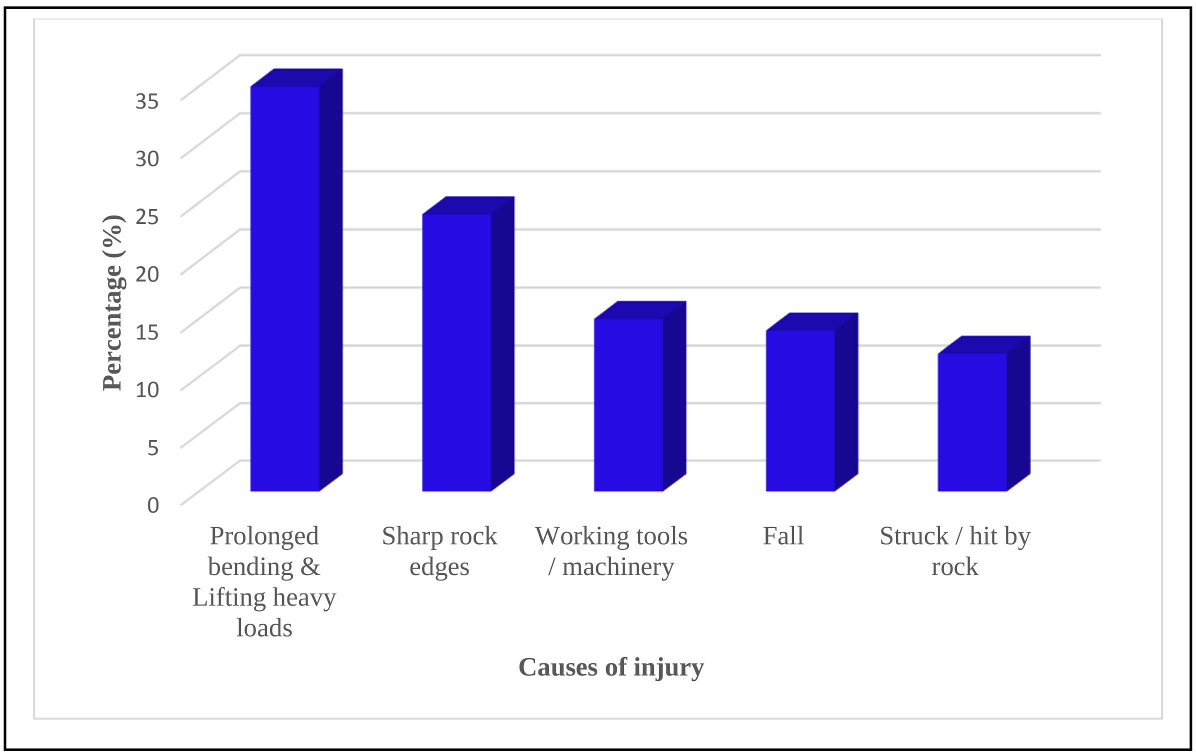

Figure 4.4: Causes of injuries occurring among small-scale miners
Source: Fieldwork data, (2018).

These results were consistent with that of a cross-sectional study on types and causes of injuries occurring among small-scale miners conducted by Leung & Lu, (2016) and Salman *et al.*, (2015) in Benguet, Philippines and San Simon mining region in Bolivia respectively. Both studies indicated that prolonged bending /sitting in awkward positions as well as carrying awkward loads can result in excruciating, persistent injuries such as lower back pain and chest pain. Therefore lower back / chest pains were recorded as the most occurring injuries. In the Leung & Lu study back/chest injuries (46%) were followed by sprains (25%), cuts (12%), fractures (11%), bruises/contusions (3%) and swellings of joint (3%) with upper limbs being the most injured body parts whereas Salman *et al.*, showed that back/chest injuries were followed by neck injuries and fractures respectively. Another available study with similar results was a study by Human Rights Watch, (2011) which was carried out in Bamako and in the mining areas in Western and Southern Mali. After a comprehensive analysis of the types and nature of injuries occurring among miners (150 miners including 41 children) in four gold mine sites namely; Baroya, Tabakoto, Sensoko and Worognan the study demonstrated that digging shafts and working underground, hand pulling the rope with a bucket full of ore out of the shaft, bagging for storage or crushing, grounding, and panning often lead to injuries. Like in the current study, the most commonly reported forms of injuries were back injuries followed by cuts, neck pain, fractures, bruises, swellings respectively with most injuries are highly reported on upper limbs and head with lower limbs being the least injured body part.

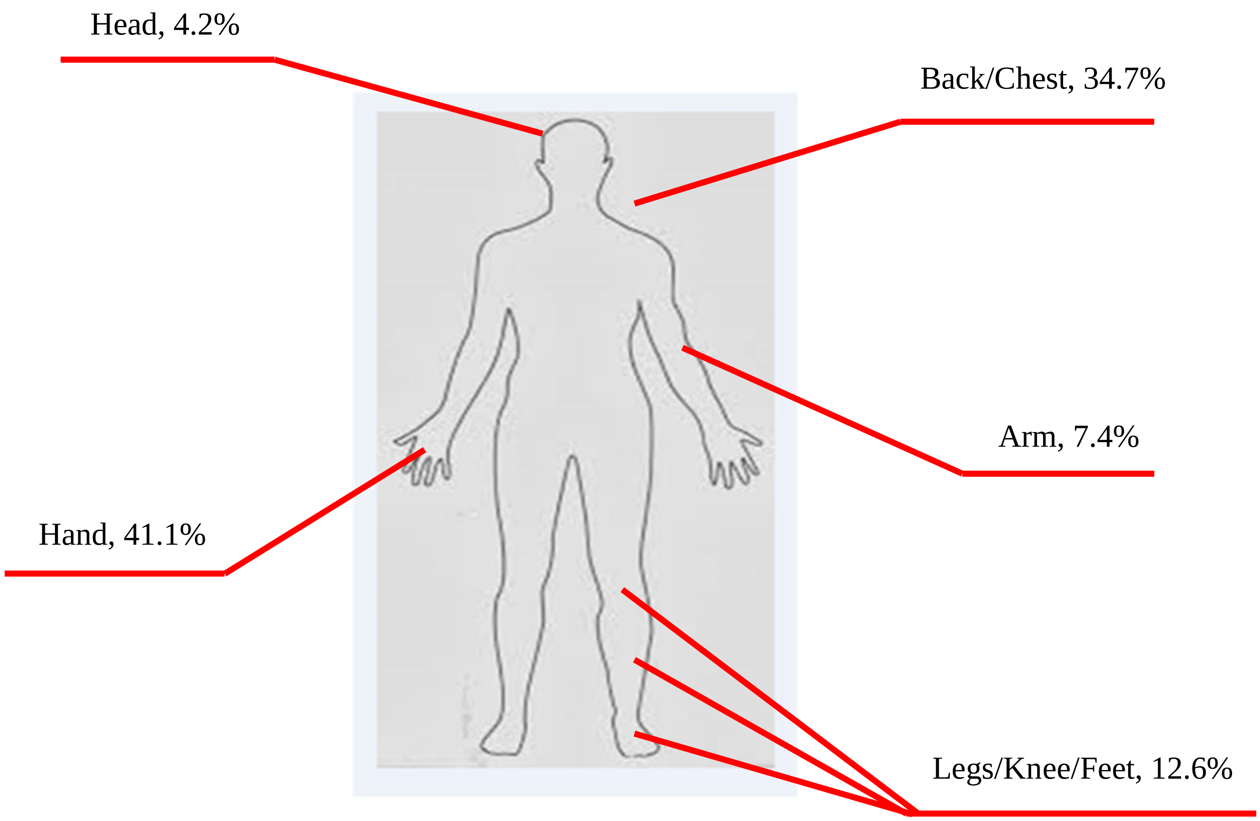

Figure 4.5: Body parts injured
Source: Fieldwork data, (2018).

While this study indicated that back/chest injuries were the most occurring types of injuries among miners, there were other studies that found fractures to be the most occurring types of injuries. For instance a retrospective cross- sectional study in the upper Eastern Ghana on the types of injuries occurring among miners which involved analysis of hospital records for the period 2006 to 2013 by Long *et al.*, (2015) found out that fractures (30.5%) and bruises (contusions) (29.1%), were the most commonly occurring types of injuries followed by back injuries (18.0%), while the rest were cuts (lacerations) 12.0%, and burn/scald (10.4%). The study indicated that most prevalent injury location was lower limbs (feet & legs) unlike in the current study which found out upper limbs to be the most injured body parts. The injuries in the lower limbs in this study were attributed to being hit by an object and falling respectively. The difference in the findings from this previous study could be attributable to three factors which include; the healthcare seeking behavior of the small-scale miners, the types of injuries that they may be willing to seek medical attention for and the fact that the assessment in this study was limited to the hospital records as opposed to going to the sites to engage the miner on a one-on-one. In another contradicting study; bruises /contusion were the most common type of injury at 50.2% followed by cuts at 44.4% with fractures being the least type of injury occurring among miners at 5.4%. This was a study by Elenge *et al.,* (2013) & Perfect, (2017) which involved an in-depth analysis of injuries in small-scale copper and cobalt mines at Lupoto site in the mining area of Lubumbashi in Katanga Province DRC. The difference in the finding from this previous study could be attributed to the varying degree of safety risks inherent in the copper and cobalt mines compared to the gold mines which was the epicentre of the current study. Despite the striking differences in the findings, this two studies however recorded similar results relating to the body part injured which was the upper limbs (arms and hands) are the most commonly injured body parts at 50.5%, followed by lower limbs (legs, knee and feet) at 29.3%, Head 12.8% while others parts of the body constituted 7.4% of the injuries.

4.3.2.2 **Inadequate knowledge on the use of machinery and failure to use PPE.**

Machinery on the four sites were mainly rock crushers, generators, compressors and water pumps. The site managers indicated that the machineries especially rock crushers were dangerous and miners had sustained injuries whilst operating them because they did not know how to use them properly. Besides most of the rock crushers were unguarded (Plate 4.2). This explains the astoundingly high rates of fractures and cuts among miners in the crushing activities (Table 4.4). The site visits established that stirring slurry without gloves was the leading cause of cuts on the hand as expressed by the miners in the questionnaires (Plate 4.4 c).

Table 4.4: Types of Injuries as reported from mine activities

Mine Activities	**Injury type**								**Total**	
	Cuts		Fractures		Bruises		Back/Chest injuries			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**(%)**	**N**	**%**
Excavation & Blasting	4	4.2	4	4.2	4	4.2	18	18.9	30	31.6
Crushing & Washing	13	13.7	8	8.4	8	8.4	5	5.3	34	35.8
Removal of ore from shafts	8	8.4	8	8.4	5	5.3	10	10.5	31	32.6
Total	**25**	**26.3**	**20**	**21.1**	**17**	**17.9**	**33**	**34.7**	**95**	**100**

Source: Fieldwork data, (2018).

Plate 4.2: Unguarded crusher at mine site 3
Source: Research Field Visits, (2018).

There were noticeable problems with equipment management and application at the mines. While on site one of the crusher operator was seen attempting to repair a damaged crusher whilst it was still operating while another was observed operating a winch without relevant PPEs (Plate 4.3a & b). Additionally, no female miners were seen in an appropriate PPE (Plates 4.4a, b, c & d). The few male counterparts who were wearing PPE were only having gum boots while the rest were seen in sandals. This further explains the role of gender in relation to regulatory compliance.

Plate 4.3: Equipment Use; (a) A miner repairing a crusher whilst it is operating and without relevant PPEs and (b): Miners operating a winch without appropriate PPEs

Source: Research Field Visits, (2018)

The site managers were unable to comment on whether they provide the workers with PPE or whether wearing it was enforced on site. In brief discussions it appeared very few miners on site had safety training and none had been given to workers regarding tools or mining techniques used on site. Throughout the study period and on each site visit both children and adult miners were present and working on site without appropriate PPEs, (Plate 4.5 a, b, c & d). This therefore logically explains the level of violation of the provisions of Occupational Safety and Health Act No. 15 of 2007 and Employment Act (Cap 266), 2007 which regulates employment of children.

In addition, the discussions with the MSMs revealed that there was no proper procedure for reporting and investigating mine accidents and injuries. Instead they preferred not to talk about it. This confirmed the overwhelming response in the questionnaire on accident handling where all fatal accidents were reported to area chief whereas non-fatal accidents went un-reported and hence no action taken.

Plate 4.4: Female miners and the use of PPEs; (a) Female miners breaking rocks on site without appropriate PPEs, (b) A female miner carrying rocks on her head without appropriate PPE, (c) A female miner stirring slurry without protective gloves & (d) Female miners sluicing and panning soil without relevant PPEs.

Source: Research Field Visits, (2018).

Plate 4.5: Non-compliance on the use of PPEs; (a) & (b) Children miners working on site without appropriate PPEs and (c) & (d) adult miners working on site without relevant PPEs
Source: Research Field Visits, (2018).

These results were consistent with that of a study by Human Rights Watch, (2011) in Bamako in the mining areas in Western and Southern Mali who observed and studied 41 children miners. Human Rights Watch observed that back/chest injuries were common among the children miners and could sometimes be severe to an extent of causing death. This injuries were linked to heavy manual work involving lifting awkward loads.

4.3.2.3 Lack of access to better equipments and limited understanding of potential risks inherent in mining were responsible for injuries.

During the site visits there were noticeable problems with the types of equipments used and the state of safety conditions at the sites. Observably, miners were seen using rudimentary tools such as sledgehammers to pound rocks (Plate 4.6). Sledgehammers have been linked to fractures, back, chest and arm injuries occurring among miners in rock crushing department. Limited understanding of the potential risks inherent in mining turned out to be a potential cause of injuries. Evidently majority of miners were working without proper gear seemingly oblivious to the risk they are exposing themselves to. This was also corroborated by the presence of uncovered shafts, deteriorated timber support as well as risky behaviours portrayed by the miners (Plate 4.7 a, b, c & d). This has been so since the law sidelines illegal mines in terms of inspection, auditing and training. The discussions with the CDE and COSHO confirmed the reasons for deplorable safety conditions at the sites since it came out clearly that the inspectorate are only obliged to legally operating sites. However, both the CDE and COSHO acknowledged the need to provide assistance to the small-scale mining sector to manage safety risks despite the illegality of their operations. These results were consistent with the findings of a study conducted by Human Rights Watch, (2011) in Bamako in the mining regions in the Western and Southern Mali which found out that sledgehammers used in pounding rocks are very heavy hence could often lead to arm, back and chest injuries.

Plate 4.6: Lack of access to better equipment; a female miner breaking rocks using a rudimentary too and without a relevant PPE

Source: Research Field Visits, (2018).

Plate 4.7: Deplorable safety conditions & Risky behaviours (a) Uncovered shaft, (b) Deteriorated timber support (c) A miner holding a timber with bare hand & (d) A miner hanging on a shaft while removing ore.

Source: Research Field Visits, (2018).

While the risks associated with the underground, illegal, small-scale mines are recognized, they are only addressed when a disaster occurs. This means that there is a lot of laxity on the part of the inspectorate which has adversely affected the enforcement efforts put in by the government as far as workplace safety is concerned. In addition, curbing the risky conditions and behaviours observed on sites and as displayed by miners can only be achieved if inspection are conducted as frequent as possible, and specific aspects such as ground strength, use of explosives, shafts support, and use of PPEs among others included in each inspection.

4.3.3 Factors influencing compliance with safety regulations.

Generally compliance can be categorized into four levels depending on the occupational safety class against the potential magnitude of harm. Occupational safety classes ranges from class (I – IV); Catastrophic (I), Critical (II), Marginal (III) and Negligible (IV). Catastrophic is a condition that might result into multiple injuries or deaths, critical is a condition that might result into severe / serious injuries, marginal is condition that might result into minor injuries while negligible is a condition that might not result into any form of injury. Therefore the potential magnitude of harm include; Instant deaths (A), Severe injuries (B), Serious Injuries (C) and Minor Injuries (D). Based on a foresaid approach, the compliance levels are; unacceptable, undesirable, acceptable with conditions and unconditionally acceptable. For instance, a combination of IA indicates that the occupational safety conditions are very poor therefore the level of compliance is unacceptable.

A number of factors were identified to be influencing compliance with safety regulations among small-scale miners. These were; knowledge/awareness, cost of compliance and administrative failures / incompetence;

4.3.3.1 Lack of knowledge /awareness on the occupational safety requirements has influenced compliance among small-scale miners.

A significant number of miners (78.9%) expressed lack of awareness about occupational safety requirements with only 21.1% miners indicating that they are aware (Figure 4.6). While trying to build a rapport with the miners most of them mentioned that the skills are passed from one generation to another therefore they are learning from miners who are equally unaware of occupational safety requirements. Majority of the miners indicated that of importance to them is knowing how to process the ore to obtain gold. This therefore logically means that a lot of awareness creation is needed more so through training as well as erecting safety best practices signs on site.

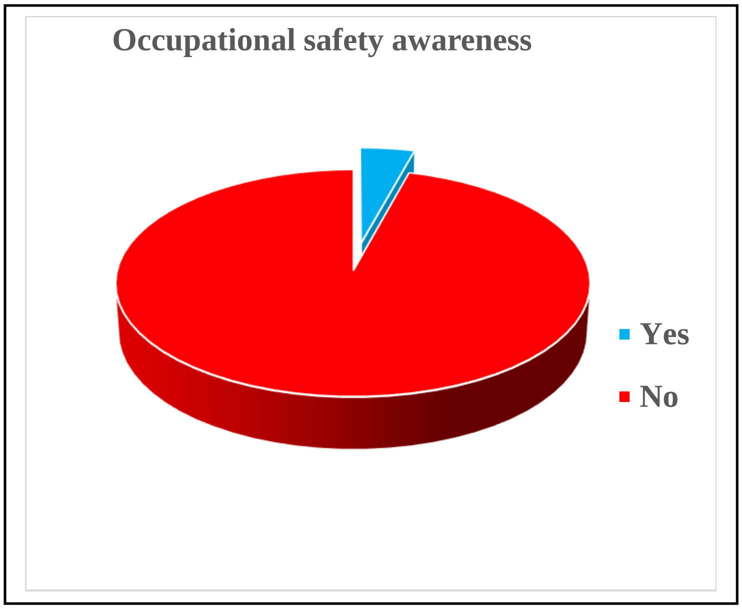

Figure 4.6: Knowledge/Awareness on occupational safety requirements
Source: Fieldwork data, (2018)

Observably, there exist a very high correlation between occupational safety knowledge and level of education. The higher the level of education the higher the chances of having knowledge, (Table 4.5). This therefore means that higher levels of education comes with some level of exposure through training and use of social media. Noticeably, awareness ranked high among miners who had attained secondary and tertiary education. In this case social media has played a key role in creating awareness and enhancing knowledge among the miners followed by radio/TV and training and family and friend. However, fellow miners and mine site managers ranked the least in awareness creation on safety requirements (Figure 4.7).

Table 4.5: The relationship between Level of Education and Occupational Safety Awareness among Miners.

Education level	Occupational Safety Awareness				Total	
	Yes		No			
	N	%	N	%	N	%
No formal schooling	0	0	3	3.2	3	3.2
Primary	1	1.1	41	43.2	42	44.2
Secondary	9	9.5	29	30.5	38	40.0
Tertiary	10	10.5	2	2.1	12	12.6
Total	**20**	**21.1**	**75**	**78.9**	**95**	**100**

Source: Fieldwork data, (2018).

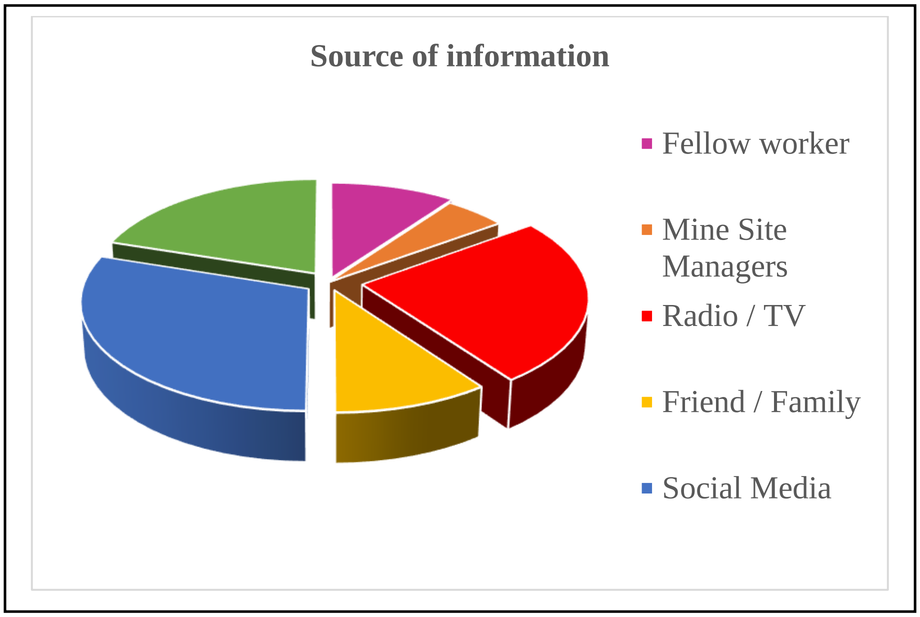

Figure 4.7: Source of safety knowledge
Source: Fieldwork data, (2018)

The study further showed that there were salient variations in the level of knowledge about occupational safety requirements between adults and children miners. This could be attributed to the significant differences in their level of comprehension about issues. The children miners who participated in the study indicated that they were not using PPEs because they are not aware of their importance (Table 4.6).

Table 4.6: Role of age on the use of PPEs

Age group	Reason for not using PPEs								Total	
	Not provided		Not required		Not affordable		Not aware of their importance			
	N	%	N	%	N	%	N	%	N	%
<18	0	0.0	0	0.0	0	0.0	8	10.8	8	10.8
18-35	3	4.1	3	4.1	34	45.9	0	0.0	40	54.1
36-50	2	2.7	1	1.4	18	24.3	0	0.0	21	28.4
>50	1	1.4	0	0.0	4	5.4	0	0.0	5	6.8
Total	**6**	**8.2**	**4**	**5.4**	**56**	**75.6**	**8**	**10.8**	**74**	**100**

Source: Fieldwork data, (2018)

Apparently, the astoundingly high levels of lack of awareness about occupational safety requirements among miners was due to limited training. 95.8% of miners indicated that they have never been trained on occupational safety requirements with only 4.2% agreeing to have been trained (Figure 4.8).

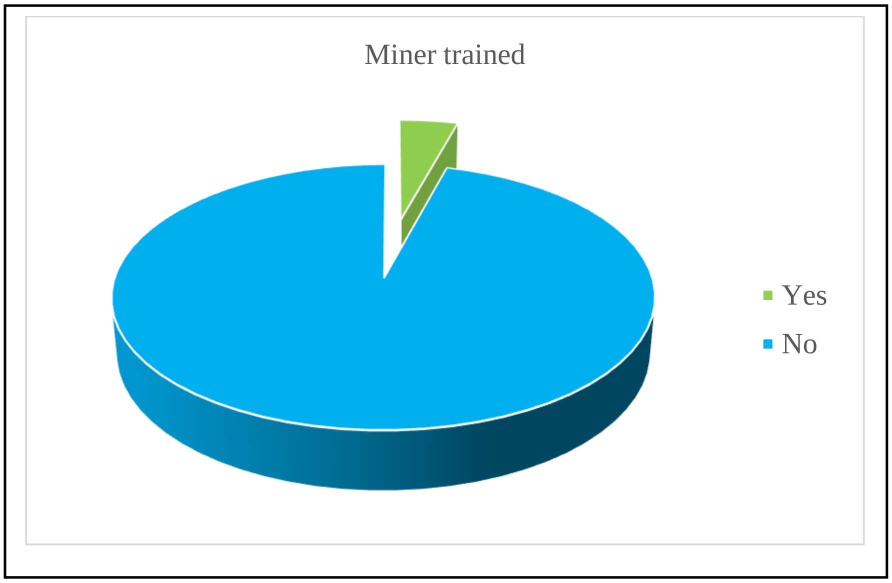

Figure 4.8: Proportion of miner's trained on occupational safety requirements
Source: Research statistics, (2018).

These results concurred with the findings from previous studies. For instance a study by MacEachen & Kosny, (2016) on regulatory burden and rule of law indicated that the compliance rates with regulations amongst small businesses is largely affected by inaccessibility of the regulation as well as the inability to comprehend the regulatory requirements. Inaccessibility directly affects awareness and knowledge thus influencing compliance. Similarly, Salihu *et al.*, (2016) in their comprehensive review of factors affecting facilities compliance to environmental regulations pointed out that when requirements of a regulation are too complex to know and understand then the target group are likely to resist compliance on grounds of failure to understand the law. This therefore means that inability to comprehend the provisions of the regulations affects awareness and knowledge. In another study on regulatory awareness amongst company directors or managers in England and Wales, Dupuis, (2016) similar results were obtained and the study concluded that that majority of company directors or managers possess little or no basic knowledge of their responsibilities under Companies and Securities Acts. Finally, a study by Durant & Fiorino, (2017) on the impacts regulatory amendments on compliance in England found out that regular reviews and amendments in the design and development processes of regulations cumulatively affect the simplicity of the law hence leading to the loss of ability in the targeted group to comprehend the compliance requirements in the resulting regulatory structure.

4.3.3.2 The perceived cost of compliance / limited economic incentives hinders compliance

Unaffordability topped the list of reasons why miners were not using PPEs at 60% especially among miners who indicated that they were not using PPEs. The perceived cost of compliance in this case has been affected by the quantities of gold obtained by miners. The gold is high grade but occur in very small quantities, therefore a lot of resources has been channelled to machinery e.g. drillers, excavators, crushers, compressors and generators gold processing equipments as opposed to PPEs. Little investment has been done on PPEs. Additionally, the study identified other factors influencing regulatory compliance apart from the issue of affordability. These include; not aware of their importance (8.4%), not provided (6.3%) and not required (3.2%) (Figure 4.9).

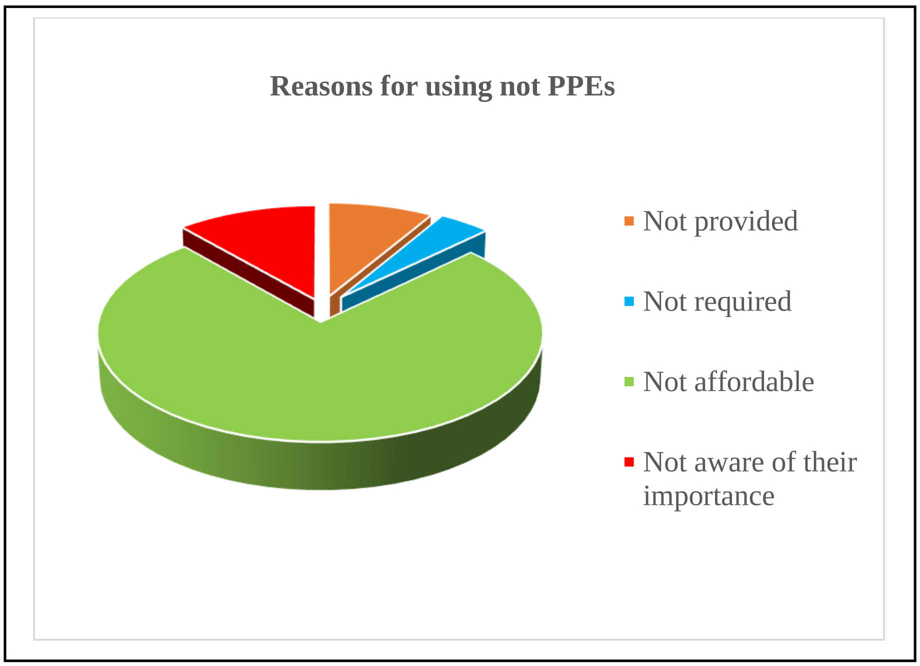

Figure 4.9: Reasons why miners were not using PPEs
Source: Research statistics, (2018).

The female miners were mostly affected by the affordability. Apparently, all female miners were not using PPEs due to issues relating to affordability, (Figure 4.10). This could be attributable to the fact that most of their earnings are channeled towards family upkeep unlike their male counterparts.

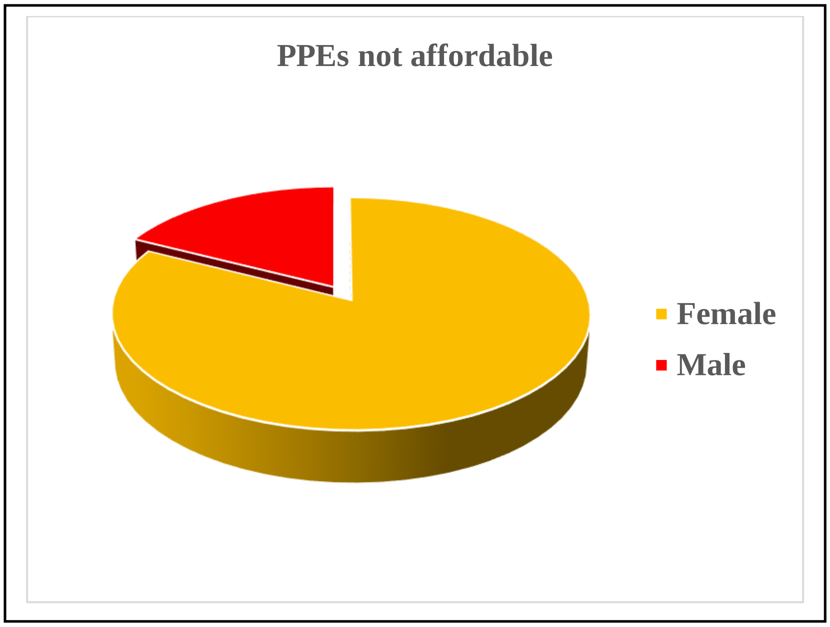

Figure 4.10: Effects of gender on cost of compliance
Source: Research statistics, (2018)

Despite the unaffordability of PPEs, small-scale mining sector has still played a significant role as a source of livelihood for many in medium and low income economies. However, the sector has remained unattractive to professional mining experts with the technical know-how to effectively and efficiently manage the operations. This has been attributed to low economic returns.

These results were consistent with the findings of a study on costs of compliance in relation to the benefits of compliance amongst Small and Medium-sized Enterprises (SME's) by Chan *et al.*, (2016) which similarly found out that regulatory compliance is usually very low when the costs of complying with rules in terms of time, money and effort are considered to be high. In another study similar study by Kalidin, (2017) the cost of compliance was found to be embedded in the complex nature of rules and the general regulatory structures. Complex nature of rules and general regulatory structure essentially raise compliance cost in relation to turnover consequently affecting compliance rates. Lastly, this study concurred with the findings of a study by (Lyon & Maxwell, 2016) from majority of the OECD countries which concluded that the cost of compliance is usually higher for SME's, thus are at a higher risk of experiencing compliance failure.

4.3.3.3 **Administrative failures / incompetence influenced regulatory compliance.**

Administrative incompetence was noted from the part of the Mine Site Managers as well as the regulators or law enforces; CDE and COSHO in relation to safety training, accident reporting inspection and licensing. The study established that 11.6% of accidents were reported to the local area chief while an 87.4% of the accidents went unreported (Figure 4.11). This shows the level of incompetence from the part of the site managers whose responsibility is to ensure that all unsafe conditions are reported to the CDE. This is in gross violation of the occupational safety requirements as been provided for in the Constitution of Kenya under Article 41; Sub- article 2 (b) and its subsidiary laws. The sub-article states that "every worker has the right to reasonable working conditions". This constitutional provision has further been regulated in the Mining Act No. 12 of 2016 and OSH Act No. 15 of 2007. Under Mining Act, 2016 Part XI, Section 178 (1) a right or entitlement conferred under a mineral right shall not operate to exempt a person from compliance with the provisions of the Occupational Health and Safety Act, 2007 concerning the safety of workers and mine operations as provided for in Part VIII, sections 75 – 77, 79 & 80. Under the law, no person shall engage in or undertake any artisanal and small scale gold mining operation unless granted prospecting or mining permits prior to meeting certain conditions. However, discussions held with the CDE, COSHO and MSMs revealed that lack of formality in the sector significantly affects worker safety.

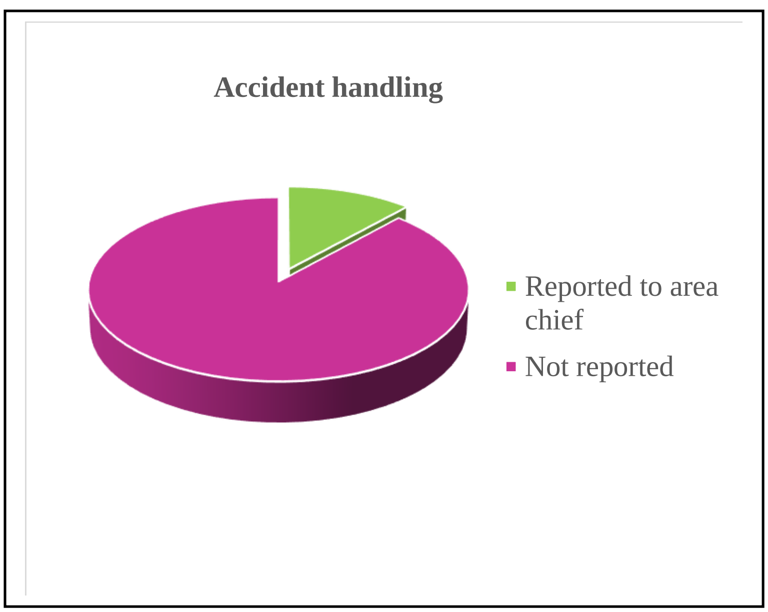

Figure 4.11: Accident handling at the mines
Source: Research statistics, (2018).

The study further revealed that only accidents whose resultant potential magnitude of harm was instant deaths were reported to the area chief whereas accidents which resulted in severe, serious or minor injuries were not reported (Table 4.3). Upon reporting the accidents the area chief would always act by ordering temporary mine closure while for other accidents no action was taken (Figure 4.12). Temporary mine closure was usually followed by resumption of normal operations without proper investigation into the cause of accident and how to avoid future recurrence. This demonstrated administrative failure on the part of site managers and COSHO and CDE for failing to report and investigate the accidents respectively. However, from a technical point of view the Mine Site Managers were justified not to report the accidents since this could amount to permanent mine closure consequently affecting the livelihoods of many households. Additionally, the ability of the OSH inspectorate to provide assistance like training and accident investigation is limited to those engaged in formal (legal) small-scale mining activity only.

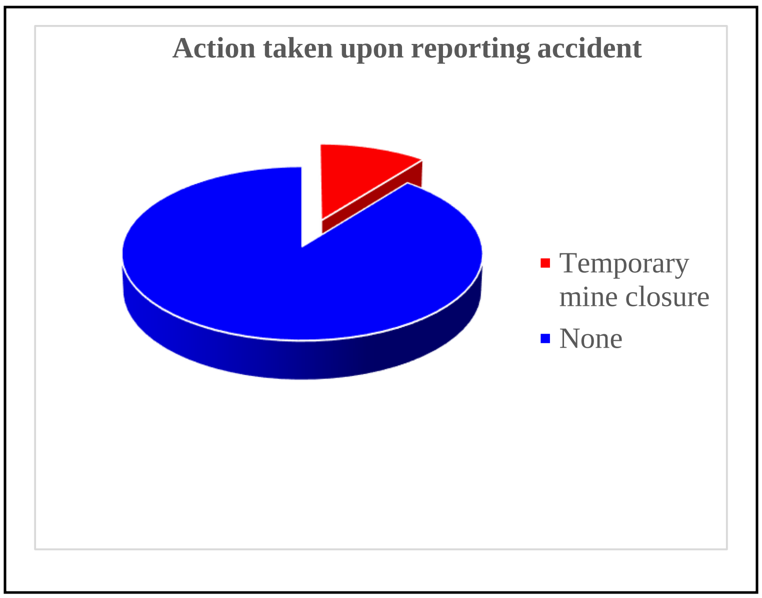

Figure 4.12: Action taken upon reporting an accident
Source: Research statistics, (2018).

In instances where it would be possible for the inspectorate to provide assistance in terms of training, inspection and accident investigation, inadequate staffing and logistics was greatly mentioned to be influencing compliance since the law enforcers are incapacitated thus affecting the level of monitoring of small-scale mining operations more so as relates to safety issues. These findings are consistent with the findings of a study by Calys-Tagoe *et al.,* (2015) on impacts of under-resourced inspectorate on the safety outcome in small-scale mine in Tarkwa Mining region of Ghana. Calys-Tagoe *et al.*, concluded that inadequate staff and a pool of highly obsolete research resources make it incapable for the Minerals Commission to facilitate sufficient safety improvement in the mining sector. The study revealed that at the Tarkwa small scale district office there were only two inspectors; the district officer and his assistant who had to conduct at least one inspection per month at each of the 15 operating mines. Additionally, the district office had only one vehicle for their activities. In other similar studies, Grabosky, (2013) and Malesky & Taussig, (2017) pointed out administration incompetence resulting from poor governance as the major factor influencing compliance. They argued that the levels of voluntary compliance may be compromised and in many instances may be very poor if governments do not put in place effective implementation strategies or mechanisms including provision of necessary resources such as adequate safety personnel, vehicles and financial support. In a nutshell, administrative incompetence coupled with illegality of small-scale mining operations together influence regulatory compliance amongst small-scale miners.

4.4 Hypothesis testing

The study was based on two hypotheses;

1. H_0: Knowledge on safety requirements does not influence compliance with safety regulations.

   H_1: Knowledge on safety requirements does influence compliance with safety regulations.

To test the null hypothesis that knowledge on safety requirements does not influence compliance with safety regulations, a provision in the safety regulation (OSHA, 2007) requiring miners to use protective gears was cross tabulated against awareness on safety requirements (Table 4.7). Using Pearson's Chi Square (X^2) Test, the test statistic (7.712) was computed (Table 4.8). The critical value at 0.05 significance level, 1 d.f was 3.84. Since the calculated value is greater than the critical value, the null hypothesis that knowledge on safety requirements does not influence compliance with safety regulations was rejected. As a result the alternative hypothesis that knowledge on safety requirements does influence compliance with safety regulations was adopted.

Table 4.7: Awareness on safety requirements vs the use of PPEs

Awareness on safety requirement	PPEs used		Total
	Yes	No	
Yes	9	11	20
No	12	63	75
Total	**21**	**74**	**95**

Source: Fieldwork data, (2018).

Table 4.8: Chi-Square test

	Value	d.f	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.712[a]	1	.005		
Continuity Correction[b]	6.120	1	.013		
Likelihood Ratio	6.889	1	.009		
Fisher's Exact Test					
N of Valid Cases	95			.012	.009

**Computed for 2×2 contingency table
Source: Research statistics, (2018).

2. **H_0:** Mine activities do not influence the types of injuries occurring among small-scale miners.

   H_1: Mine activities do influence the types of injuries occurring among small-scale miners.

To test the null hypothesis that mine activities do not influence the types of injuries occurring among small-scale miners, various mine activities were cross tabulated against the types of injuries occurring among the miners (Table 4.9). Using Pearson's Chi Square (X^2) Test, the test statistic (15.541) was computed (Table 4.10). The critical value at 0.05 significance level, 6 degree of freedom was 12.59. Since the calculated value is greater than the critical value, the null hypothesis that mine activities do not influence the types of injuries occurring among small-scale miners was rejected. As a result the alternative hypothesis that mine activities do influence the types of injuries occurring among small-scale miners was adopted.

Table 4.9: Mine Activities vs types of injuries occurring among miners

Mine activities	Type of injury				Total
	Cuts	Fractures	Bruises	Back / Chest injuries	
Excavation & Blasting	4	4	4	18	30
Crushing & Washing	13	8	8	5	34
Removal of ore from shafts	8	8	5	10	31
Total	25	20	17	33	95

Source: Fieldwork data, (2018).

Table 4.10: Chi-Square Test

	Value	d.f	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.541[a]	6	.016
Likelihood Ratio	15.931	6	.014
N of Valid Cases	95		

**Computed for 3×4 contingency table

Source: Research statistics, (2018).

The results of this study suggests that fatalities and severe injuries are common characteristics of small-scale mines. It is therefore important for this knowledge to be diffused throughout society especially among those involved directly in small-scale mining and the mine and safety regulators. For purposes of this discussion it is assumed that knowledge transfer represents positive action for society. The results are of value to industrial hygienist in conducting ergonomic analysis and modification to curb injuries, safety practitioners in providing training, to safety regulators in developing safety guidelines and regulations and to mining engineers.

Ergonomic analysis and modification entails modifying workplace based on understanding of human physiological abilities and limitations. Industrial hygienist can approach this from five perspectives; elimination, substitution, engineering controls, administrative controls and use of PPEs. Elimination involves physical removal of hazard from the workplace, e.g. removal of hanging rocks in the mines that are likely to cause injuries. Substitution on the other hand involves replacing the hazard with a substance which is less hazardous, e.g.

replacement of deteriorated timber support in the mines with steel rods. Engineering controls would basically involve machine guarding especially the rock crushers that were noted to be responsible for fractures among miners. Administrative controls which involves changing the way people work by reducing exposure time might come in handy in addressing ergonomical hazards such prolonged bending towards reduced back/chest injuries by ensuring that miners work for a shorter time. Finally, protective gears can be used as the last defence in case the hazard persists. Ergonomic analysis and modification must be followed immediately with training to enhance uptake of various changes at the mines. Safety practitioners at the County level can provide miners with knowledge and skills necessary to recognize hazards and perform their tasks safely. Recognition of hazards is key to hazard control and evaluation. The outcomes will particularly interest information and safety regulators involved in establishing safety laws and regulations perhaps to amend existing regulations and fill relevant policy gaps.

Other practical applications resulting from this study include the formulation of informal safety guides such that any other occurrence outside the set guideline and which can amount to injury is identified, recorded and reported. In a nutshell, the results of this study can contribute to a large extent in addressing safety issues and factors influencing compliance with safety regulations if the recommendations and the practical application aspects are taken into consideration.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS & RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of findings of the research within the framework of the research questions. This is subsequently followed by the research overall conclusions, recommendations and areas for further research.

5.1 Summary of findings

The study investigated occupational safety compliance by first profiling occupational safety issues in small-scale mines, then determining the types and causes of injuries occurring among small-scale miners and lastly by examining factors influencing compliance with safety regulations. Based on the aforesaid format the study demonstrated that the state of occupational safety and compliance with OSH regulations in the small-scale mines was poor. With regards to occupational safety issues in small-scale mines, the study found out five most frequently occurring safety issues in small-scale mines to be: shafts collapse (33.7%), falling rocks, (26.3%), hit by working tools (20.0%), slipping/falling (14.7%) and untimed explosion (4.2%). Only safety issues that resulted in fatalities were reported to the local area chief who in most instances acted by ordering a temporary mine closure, otherwise no action was taken on safety issues resulting in severe, serious or minor injuries. The study further established the types of injuries occurring among miners to be cuts, fractures, bruises and back/chest injuries. Back / chest injuries and cuts constituted the most frequently occurring types of injuries accounting for (34.7%) and (26.3%) of reported injuries respectively. The leading underlying cause of back/chest injuries were lifting heavy loads & prolonged bending (34.7%). Sharp rock edges (24.2%), working tools / machinery (14.7%), fall, (13.7%), struck / hit by object (12.6%) were responsible for cuts, fractures and bruises. Other mediating factors that had contributed immensely to the said injuries were; limited availability of trained human capital in small-scale mining operations, inadequate knowledge on the use of machinery, failure to use PPEs, lack of access to better equipments and limited understanding of potential risks inherent in mining. The injuries were spread across all body parts; hands 41.1%, back/chest injuries 34. 7%, leg/knee/feet 12.6%, arm 7.4% and head 4.2%.

Lastly, the study revealed that the key factors influencing compliance with safety regulations in the small-scale mines were mostly related to the perceived cost of compliance, knowledge / awareness on safety requirements and administrative failures. For instance, 78.9% of the miners expressed lack of awareness about occupational safety requirements with only 21.1% miners indicating that they are aware. Additionally, unaffordability topped the list of reasons why miners were not using PPEs at 60% especially among miners who indicated that they were not using PPEs. Finally, administrative failure or incompetence too was found to be influencing regulatory compliance. Not providing PPEs or not enforcing the use of PPEs, underreporting of accidents and incidents, lack of proper investigation into causes of accidents and operating without relevant permits and licenses. The study established that 11.6% of accidents were reported to the local area chief while an 87.4% of the accidents went unreported.

5.2 Conclusions and Recommendations

The following were the main conclusions and recommendations of the study:

5.2.1 Conclusions

Lack of knowledge about safety requirements, perceived cost of compliance and administrative failure were the primary obstacles when it comes to regulatory compliance. Majority of miners demonstrated lack of knowledge about safety requirements as a key factor that has hindered them from compliance while for those who are aware or knowledgeable about the safety requirements mentioned high cost of compliance as a key obstacle. However, the regulatory in-charge together with the mine site mangers failed big time by not training the miners on safety requirements, failing to report accidents and incidents and failing to conduct inspections. Under-staffing at the mines county offices was largely mentioned as a key hindrance to undertaking proper inspections in legally operating sites. This study shows that small scale mining sector in Kenya is marred with unsafe acts and practices which have contributed greatly to mine accidents and injuries. For instance use of explosive blasts in unsupported or weakly supported shafts were responsible for mine collapse.

Poor monitoring of the operations, improper choice of tools, absence of PPEs and working in confined and poor lit shafts were the major causes of mine accidents and injuries. Reported injuries among miners were attributed to poor monitoring of operations in the sense that majority of miners were assigned roles in areas they had no knowledge about, therefore would require constant monitoring during operations to avoid injuries. Improper choice of tools for instance heavy sledgehammers were responsible for back/chest injuries as well as fractures. Failure to use PPEs among miners equally contributed to the injuries since there are some forms of injuries that could be avoided by simply wearing the appropriate PPE. Protective hand gloves for instance could help to reduce cuts from sharp rock edges. Finally working in confined and poor lit shafts were responsible for injuries relating to hit by working tools and awkward sitting position. It became apparent that miners excavating rocks in poor lit shafts ended up hitting their hands or legs. Additionally, miners were likely to slip and fall thus injuring themselves especially when they walk along dark stopes.

Discrimination by the existing OSH policy and regulations on illegal mines in terms of inspection and accident investigation have led to deplorable safety conditions in small-scale mines. The safety provisions of the current OSH regulations are specifically targeting legal mines and large-scale mines for that matter.

Fatalities and severe injuries are common characteristics of small-scale mines. Usually mine collapse results in instant deaths or severe injuries leading to death. This has been a key feature of small-scale mines considering the scanty nature of safety conditions. Besides, the sector is marred with underreporting of accidents which further translate into non-investigation of safety incidence resulting into accidents.

5.2.2 Recommendations

The study therefore recommends:

National government

- **i.** **Technical capacity:** DOSHs should seek to address shortfalls in the labour inspection system to ensure that international safety standards are upheld in mining. The training of further inspectors would help to ensure greater coverage and therefore encourage greater compliance from small-scale mines.
- **ii.** The use of policy instruments such as sanctions, taxes, prohibitions and subsidies to influence ensure compliance with safety regulations.
- **iii.** Regular enforcement activities by the inspectorate such as inspections, sanctions, compliance audits.

iv. Introduction of policy initiatives to ensure geological data on ground and rock strength is available to prospective miners.

County Government of Siaya

i. Formulation of by-laws to streamline mining in the county and to make it safer.

ii. Formulation of small-scale mining sector specific occupational safety standards that are practical and easy-to-understand

iii. Establishment of a complete, unbroken chain of responsibility and accountability for safety by the site managers to facilitate reporting of incidents and improved safety conditions such as use of PPE'S, safety warning signs and posts at the site.

iv. Mandatory safety section in mining permits should be adopted and strictly enforced, preferably verified and referenced before being allowed to commence operation.

v. Data and statistics: The Government should continue its efforts to tackle the problem of data collection relating to occupational safety, as accurate, up-to-date statistics are required to inform the design and implementation of an effective occupational safety programme. This should include requiring all dangerous occurrences to be reported and recorded, even those that do not result in injury.

International organizations

i. To offer sensitization and training programs as well as financial assistance to aid occupational safety compliance as relates to proper use of PPE's and safe working conditions.

ii. **Knowledge and awareness**: Greater attempts should be made in relation to the education and training of miners on safety requirements. This should include introduction and integration of mandatory safety studies in post-primary curriculum.

5.3 Areas for further research

There is need for further research to determine the compressive strength of the rocks in which the miners operate. This will inform the types of supports the rocks need to make the underground mine workings stable and safe. Future area of research could also include a study to determine the link between gender and regulatory compliance. It became apparent that female miners were mostly not complying with safety requirements as opposed to male miners.

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APPENDICES

Appendix I: Cover Letter

Introduction

I am a master student at The University of Nairobi (UoN) conducting a research on "*Occupational Safety Compliance in Small-Scale Gold Mines in Central Sakwa Ward, Siaya County;* A key component of this study is obtaining important input from County Occupational Safety and Health Officer, County Director of Environment, Mine site Managers and tapping into knowledge and experience of the gold miners. Your positive response will help in determining the occupational safety conditions and the major factors influencing compliance with the Occupational Safety Standards. This can be used for future regulatory improvements and formulation of safety programmes towards improved miners productivity and life expectancy.

You have been selected to participate in this study. Your participation is voluntary and all collected data will be handled with the utmost confidentiality. Any recorded interview will be destroyed as soon as it has been transcribed. The information obtained will be used solely for educational and research purposes.

Thank you for your willingness to participate in the study.

Appendix II: Questionnaire for participants of the study

Before starting to answer the questions, please go through the instructions relevant to each question and identify the correct answer for each question. **Name is optional.** *Please put (√) in the right place.*

SECTION A: GENERAL INFORMATION OF THE RESPONDENTS

Name: .... Site name: ....

- Gender: Female [ ] Male [ ]
- Age: ≤18 [ ] 18 – 35 [ ] 36 – 50 [ ] >50 [ ]
- Highest level of education: No formal schooling [ ] Primary [ ] Secondary [ ] Tertiary [ ]
- Marital status: Single [ ] Married [ ] Separated [ ] Divorced [ ] Widowed [ ]

1. Which department do you work?
   - Excavation & Blasting [ ]
   - Crushing and Washing [ ]
   - Removal of ore from shafts [ ]
   - Other………………...
2. How long have you worked in the gold mining sector?
   - ≤ 1 year [ ]
   - 1 -5 years [ ]
   - 6– 10 years [ ]
   - 11 – 15 years [ ]
   - > 15 [ ]

SECTION B: OCCUPATIONAL SAFETY ISSUES

3. Has your mine site ever experienced any safety issue? Yes [ ] No [ ]. If yes, complete part (a), (b) & (c). If no, please proceed to the next question

a. In which department did the safety issue occur?
   - Excavation & Blasting operations [ ]
   - Crushing and Washing [ ]
   - Removal of ore from shafts [ ]
   - Other………………...

b. What was the safety issue?

- Shafts collapse [ ]
- Untimed explosion [ ]
- Falling rocks [ ]
- Slipping / falling [ ]
- Hit by working tools [ ]
- Other...

c. What was the nature of the injury

- Instant death [ ]
- Severe [ ]
- Serious [ ]
- Minor [ ]
- Other...

4. When an accident occurs how is it handled? If reported please complete question 5.

- Reported to area chief [ ]
- Reported to County Director of Mines [ ]
- Reported to County Commissioner [ ]
- Not reported [ ]
- Other ………………………………………………………………………………

5. Upon reporting the accident, what actions are normally taken?

- Investigation into the cause [ ]
- Temporary Mine closure [ ]
- None [ ]
- Other...

SECTION C: TYPES AND CAUSES OF INJURIES

6. Have you ever been injured in the course of your work? Yes [ ] No [ ]. If yes, complete part (a) & (b) below? (*You can choose more than one*). If no, please proceed to no.

a. What was the type of injury?

- Cuts [ ]
- Fractures [ ]
- Bruises [ ]

- Back / Chest injuries [ ]
- Other…………...

b. What was the cause of the injury?

- Struck / hit by rock [ ]
- Sharp (rock) edges [ ]
- Fall [ ]
- Working tools/Machinery [ ]
- Lifting heavy load [ ]
- Awkward sitting position [ ]
- Other..

c. Which part of your body was injured? (*You can choose more than one*)

- Head [ ]
- Legs / knee/Feet [ ]
- Back / Chest [ ]
- Hand [ ]
- Arm [ ]
- Other (Specify): ....

SECTION D: FACTORS INFLUENCING COMPLIANCE SAFETY REGULATIONS

7. Have you ever heard about occupational safety at your workplace? Yes [ ] No [ ]. If yes, where did you get the information? If no, please proceed to the next question

- Fellow miner [ ]
- Mine Site Manager [ ]
- Radio / TV [ ]
- Friend / Family [ ]
- Social media (Facebook / Twitter) [ ]
- Newspaper / Magazine [ ]
- Training [ ]
- Other..
....
....

8. Do you wear personal Protective Equipment (PPE) when working? Yes [ ] No [ ]. If yes, complete part (a) & (b). (*You can choose more than one*). If no, please proceed to part (c) below

a. Type of PPE
   - Protective helmets [ ]
   - Protective footwear [ ]
   - Protective glasses /Face shields [ ]
   - Gloves [ ]
   - Other...

b. How did you get the PPE?
   - Provided by site manager [ ]
   - Bought for myself [ ]
   - Given by co-worker [ ]
   - Given by a friend / family [ ]
   - Other…………...………………......

c. What is your reason of not using Personal Protective Equipment?
   - Not provided [ ]
   - Not required [ ]
   - Not comfortable [ ]
   - Not affordable [ ]
   - Not aware of their importance [ ]
   - Other..\

9. Have you ever been trained on basic occupational safety requirements? Yes [ ] No [ ]. If yes, who was the trainer?
   - County Director of Mines [ ]
   - County OSH Officer [ ]
   - Mine Site Manager [ ]
   - Safety expert/consultant [ ]
   - NGO [ ]
   - Other...
   ....

(b) Overall, what do you think about the level of safety in the mine where you work?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

....

....

(c) Which aspects of safety in the mine need improvements? Explain

....

....

....

....

Thank you for your participation

Appendix III: Interview Guide

1. County OSH Officer (COSHO)

- Do you have any records on the number & types of commonly reported SSM accidents and injuries?
- What are some of the factors that influence compliance with occupational safety standards especially amongst Small-Scale miners?
- How often do you conduct inspection / compliance audits in the SSM sector in the county?
- Does the inspectorate provide occupational safety training for the small-scale miners in the County?

2. County Director of Environment (CDE)

- Do you have any reports or other documents and information on small-scale mining activities within the County e.g. number of licensed operators
- How often do you supervise and monitor the operation and activities of small-scale gold miners.

3. Mine Site Managers (MSMs)

- Is the site legally permitted to operate?
- Do you provide PPEs to your miners?
- What are the common types & causes of accidents and injuries?
- Do you have procedure of accident reporting & investigation?
- Are those carrying out blasting operations sufficiently trained?
- Have you considered placing warning signs as a way of preventing injuries?

Thank you for your corporation.

Appendix IV: Occupational Safety Compliance Checklist

Site name..

Occupational Safety Issues	Yes	No
Mine setting & Miners interaction		
▪ Are there any aspects of the physical environment that may pose dangers to the miners		
▪ Are miner's interaction's a recipe for any injuries or accidents		
PPE		
▪ Appropriate foot ware (safety boots) worn by miners		
▪ Miners operating various machines have their gloves on		
▪ Miners wearing protective helmet		
▪ Miners going underground putting on reflective overalls		
▪ Miners operating crushers have safety glasses and earplugs on		
Equipment / Machinery		
▪ Adequate guarding mechanisms / shields		
Shafts		
▪ Opening of all shafts appropriately guarded		
▪ Shafts adequately supported by strong timber		
▪ Appropriate ladder installed within the shafts to aid movement		
Lighting systems		
▪ Adequate lighting systems provided underground		
▪ Well maintained back – up rechargeable lamps		
Blasting operations		
▪ Blasting conducted under supervision of a qualified personnel		
▪ Blasting permits available on site		
Warning signs		
▪ Warning signs have been adequately erected on mine sites		

Comments

Signature: ....   Date: ....

Appendix V: Fee Statement

University of Nairobi

A world-class university committed to scholarly excellence

Portal Home | Fee statement | Timetables | Course Registration | Results | Enquiries | Book Room | Logout

- Fee Statement
- Detailed Fee Statement

C50/5465/2017 BETH AKINYI AYOO (Nairobi Evening)

Fees Statement

Academic Year : 2016/2017 **Billing Currency :** KES

Transaction/ Receipt Number	Date	Description	Debits DR	Credits CR	Balance	Cur.Rate
2180142445	2017-01-23	FEES PAYMENTS	0.00	79,500.00	-79,500.00	KES=1
C50/5465/2017-2016/2017-SEM2	2017-04-13	FEES PAYABLE FOR SEM1	79,500.00	0.00	0.00	KES=1
		Academic Year Totals :	**79,500.00**	**79,500.00**	**0.00**	

Closing Balance : 0.00

Academic Year : 2017/2018

Transaction/ Receipt Number	Date	Description	Debits DR	Credits CR	Balance	Cur.Rate
Opening Balance					**0.00**	
2180214164	2017-11-20	FEES PAYMENTS	0.00	62,000.00	-62,000.00	KES=1
2180226997	2018-01-11	FEES PAYMENTS	0.00	27,500.00	-89,500.00	KES=1
2180241302	2018-02-21	FEES PAYMENTS	0.00	20,000.00	-109,500.00	KES=1
2180247768	2018-03-19	FEES PAYMENTS	0.00	27,000.00	-136,500.00	KES=1
2180275419	2018-06-25	FEES PAYMENTS	0.00	62,000.00	-198,500.00	KES=1
C50/5465/2017-2017/2018-SEM1	2018-04-04	FEES PAYABLE FOR SEM2	62,000.00	0.00	-136,500.00	KES=1
C50/5465/2017-2017/2018-SEM2	2018-04-04	FEES PAYABLE FOR SEM3	62,000.00	0.00	-74,500.00	KES=1
C50/5465/2017-2017/2018-SEM3	2018-08-15	FEES PAYABLE FOR SEM4	74,500.00	0.00	0.00	KES=1
		Academic Year Totals :	**198,500.00**	**198,500.00**	**0.00**	

Closing Balance : 0.00

University of Nairobi

A world-class university committed to scholarly excellence

Portal Home | Fee statement | Timetables | Course Registration | Results | Enquiries | Book Room | Logout

Refer to guide notes below

- Exam Card
- Update Profile
- request special/Supp...

C50/5465/2017 BETH AKINYI AYOO (Nairobi Evening)

C50 MASTER OF ARTS

2017/2018 May-August Semester

Registration Deadline on 23-Aug-2018

Registered Courses

	Select	Code	Course Title	Exam Type	Class/Group	Status	Amount
1	■	CGP598	PROJECT PAPER	PROJECT	Group 1	Confirmed	58,000
						Tution Charges	58,000
Administrative Charges : ACTIVITY FEES(2,000)COMPUTER LAB FEES(5,000), ID CARD FEES(500),LIBRARY FEES(3,000)MEDICAL FEES(5,000), REGISTRATION FEES(1,000)							16,500
						Confirmed Invoiced Amount : 74,500 ; Grand Total	74,500

Sorry Course Registration closed.

Consult your Faculty/School/Institute for more information.

Appendix VI: Field Introductory Letter

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Telephone: +254 2 318262
Extension: 28016
Fax: +254 2 245566
Email-geography@uonbi.ac.ke

P.O. BOX 30197-00100
NAIROBI
KENYA

July 3rd, 2018

The Director,
National Commission for Science & Technology
Nairobi

Dear Sir/Madam,

RESEARCH PERMIT: BETH AKINYI AYOO – C50/5465/2017

This is to confirm that the above named is a Master of Arts student at the Department of Geography and Environmental Studies, University of Nairobi. Ms. Ayoo is pursuing an M.A course in Environmental Planning and Management and is currently undertaking a research project on: **"An Assessment of Occupational Safety Compliance: A Case Study of Small Scale Gold Mines in Siaya County, Kenya.**

This letter is to facilitate in the application for a research permit.

Any assistance accorded to her will be highly appreciated.

Department Of Geography
and Environmental Studies
UNIVERSITY OF NAIROBI

Dr. Boniface Wambua
Chairman, Department of Geography & Environmental Studies

Appendix VII: Research Permit from NACOSTI

THIS IS TO CERTIFY THAT:
MISS. BETH AKINYI AYOO
of UNIVERSITY OF NAIROBI, 10962-400 Nairobi,has been permitted to conduct research in *Siaya County*

Permit No : NACOSTI/P/18/49566/24418
Date Of Issue : 9th August,2018
Fee Recieved :Ksh 1000

on the topic: *ASSESSMENT OF OCCUPATIONAL SAFETY COMPLIANCE: A CASE STUDY OF SMALL SCALE GOLD MINES IN SIAYA COUNTY*

for the period ending:
8th August,2019

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 19989

CONDITIONS: see back page

Appendix VIII: Research Authorization Letter from NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/18/49566/24418**

Date: **9th August, 2018**

Beth Akinyi Ayoo
University of Nairobi
P.O Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of occupational safety compliance: A case study of small scale gold mines in Siaya County,"*** I am pleased to inform you that you have been authorized to undertake research in **Siaya County** for the period ending **8th August, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Siaya County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Siaya County.

The County Director of Education
Siaya County.

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

Appendix IX: Reaserch Authorization Letter from County Commissioner, Siaya.

REPUBLIC OF KENYA

THE PRESIDENCY

MINISTRY OF INTERIOR & CO-ORDINATION OF NATIONAL GOVERNMENT

E-Mail cc.siaya@yahoo.com
When replying please quote date & ref.

COUNTY COMMISSIONER
SIAYA COUNTY
P O Box 83-40600
SIAYA

CC/SC/A.31 VOL.II/110

16th August, 2018

All Deputy County Commissioners
SIAYA COUNTY

RE: RESEARCH AUTHORIZATION – BETH AKINYI AYOO

The person referred to above from University of Nairobi has been authorized by the Director General/CEO, National Commission for Science, Technology and Innovation vide letter Ref. No. NACOSTI/P18/49566/24418 dated 9th August, 2018 to carry out research on "***Assessment of occupational safety compliance: A case study of small scale gold mines in Siaya County***" for the period ending 9th August, 2019.

The purpose of this letter therefore is to ask that you accord her the necessary support as she carries out research in your Sub County.

WILSON WACHIRA,
For: COUNTY COMMISSIONER,
SIAYA COUNTY.

Copy to: Beth Akinyi Ayoo
University of Nairobi
P.O. Box 30197 - 00100
NAIROBI

County Director of Education.
SIAYA COUNTY

Appendix X: Research Authorization Letter from County Director of Education, Siaya.

REPUBLIC OF KENYA

MINISTRY OF EDUCATION

State Department for Early Learning and of Basic Education

COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
P.O. BOX 564
SIAYA

E-mail:cdesiaya2016@gmail.com

When replying please quote
SCA. /URA/10 VOL.I/66

Thursday, August 16, 2018

TO WHOM IT MAY CONCERN

RESEARCH AUTHORIZATION: BETH AKINYI AYOO

The above named person has been mandated to carry out research in Siaya County vide an authorization letter from National Commission for Science and Technology and Innovation Ref. No. NACOSTI/P/18/49566/24418 dated 9th August, 2018. This research study ends on 8th August, 2019.

The research title is "***Assessment of occupational safety compliance: A case of small scale gold mines in Siaya County***".

Please accord her the necessary assistance in this county as she may require.

MASIBO J. KITUYI
COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY

c.c.

County Commissioner
Siaya County

Appendix XI: Anti-Plagiarism / Originality Report

ORIGINALITY REPORT

6%	3%	3%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	K.J. Bansah, A.B. Yalley, N. Dumakor-Dupey. "The hazardous nature of small scale underground mining in Ghana", Journal of Sustainable Mining, 2016 Publication	2%
2	www.blackwellpublishing.com Internet Source	1%
3	Smith, Nicole M., Saleem Ali, Carmel Bofinger, and Nina Collins. "Human health and safety in artisanal and small-scale mining: an integrated approach to risk mitigation", Journal of Cleaner Production, 2016. Publication	<1%
4	ir.cuea.edu Internet Source	<1%
5	assets.publishing.service.gov.uk Internet Source	<1%
6	ir.knust.edu.gh Internet Source	<1%

7	www.cickenya.org Internet Source	<1%
8	Submitted to Kwame Nkrumah University of Science and Technology Student Paper	<1%
9	www.distance.mak.ac.ug Internet Source	<1%
10	www.mubs.ac.ug Internet Source	<1%
11	Submitted to University of Northumbria at Newcastle Student Paper	<1%
12	muccobs.ac.tz Internet Source	<1%
13	Okonkwo, Jonathan O.. "Initiatives to combat mercury use in artisanal small-scale gold mining: A review on issues and challenges. (Report)", Environmental Reviews Publication	<1%
14	pubs.iied.org Internet Source	<1%
15	Submitted to Boise Independent School District Student Paper	<1%
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