School of Mining and Metallurgical Engineering

# A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya

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**This Thesis is presented for the Degree of Doctor of Philosophy**
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# DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

The research presented and reported in this hybrid thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2015. The study also conforms to all recognized standards mentioned in Strathmore University and Helsinki Declaration as revised in 2013. The proposed research study received ethics approvals from Curtin University Human Research Committee (HRE2017-0534) and Strathmore University – Institution Ethics Review Committee (SU-IRB 0163/18) as well as research clearance permit from National Commission for Science, Technology and Innovation of Kenya (Permit No. NACOSTI/P/18/13815/21845). Copies of the approvals have been included as appendices F, G and H.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature

Date ……………. 01/06/2020

# ABSTRACT

Across the globe, millions of men, women, and children are employed in Artisanal and Small-Scale Mining (ASM) operations. Despite the significant employment capabilities, this occupational activity is perceived to be of problematic disposition. Correspondingly, there is a consensus amongst the policymakers and scholars that ASM demonstrates a complex web of problems and is more dangerous than Large-Scale mining (LSM).

This research focused on investigating the recordable injuries, as well as post-injury consequences suffered by severely injured miners and their families while working in the Osiri Gold Mine in Migori County of Western Kenya. The research examined (i) the nature of recordable injuries, (ii) bodily location of recordable injuries, (iii) mechanism of causation, as well as (iv) the risk factors that influence the likelihood of recordable injuries, likelihood of severe injuries and number of the sustained injuries (frequency of occurrence). The research explored, within the paradigm of mine safety, the concept that work-related safety is a complex system, which entails mine safety issues, as well as the economic and social challenges faced by severely injured miners and their families.

This research was conducted using an embedded mixed method approach which was implemented in two phases to answer the research questions and achieve the research aims. Herein, in the first phase, an assisted and self-administered structured survey questionnaire was used to capture information related to injury history and associated risk factors. The survey results were analysed using the combination of descriptive statistics, as well as binary and multinomial logistic regression as dictated by the outcome variables of interest.

In the second phase, face-to-face interviews were conducted using handwritten field notes to understand the economic and social consequences. Following the completion of the survey, the respondents with severe injuries were purposively identified and selected. Subsequently, a face-to-face interview was conducted with the identified respondents, wherein, the researcher interviewed a total of 33 severely injured miners. The interview results were subjected to thematic analysis to capture recurring themes

and sub-themes about the mine safety, as well as the resultant economic and social challenges faced by the miners.

This hybrid research is composed of unpublished and published chapters. The results of this research have been published as three discrete articles and presented in the thesis as Chapters 4, 5, and 6. The findings of this research inferred that most of the miners suffered injuries, ranging from minor to major. The research revealed the most frequently occurring injuries were lacerations and contusions of the hands and wrists and were predominantly caused by dropped objects and equipment. The classification of the injuries and frequency showed that most of the injured miners had severe injuries and suffered at least one injury incidence during their employment period in the mines.

The research examined the relationship between the various risk factors and the likelihood of recordable injuries using binary logistic regression. Results revealed that the injured workers were most likely to fall within the age limit of 18-34 years old, were male miners, and had less than 3 years of mining experience, worked for more than 8 hours/day, were high-risk drug users. These respondents stated work in poor working conditions, poor management and supervision, and in the work environment of job dissatisfaction and job stress. The research further analysed and compared the risk factors for the likelihood of recordable injuries and the likelihood of severe injuries. The results suggested that some predictors of the former are also associated with the likelihood of severe injuries. These risk factors were identified as: employees who were male miners, less than 3 years of mining experience, working for more than 8 hours/day; and agreement to poor management and supervision, job dissatisfaction, and job stress.

Following the above analysis, the number of times miners have been injured was classified into single, multiple, and no injury. Following this, the associated risk factors for each category were determined with no injury as a reference group using multinomial logistic regression. The aim was to understand why some employees suffered multiple injuries as against one or no injury. The results of multinomial logistic regression showed that single miners (i.e., unmarried), low-risk drug users, and dissatisfied workers were most likely to experience multiple injuries while single-injury event was associated with male workers, less than 3 years of mining experience, working for more than 8 hours/day, poor perception of working condition as well as poor management and supervision, and job stress.

The thematic analysis of interview results showed that injured miners and their families had experienced a financial crisis, as well as social health and lifestyle changes post-injury. The results revealed that huge medical bills, lack of mine management and government support had also pushed some injured miners and even family members to deplete their savings, borrow money and sell their assets, resultantly leaving them economically destitute and poor. The combination of injury and dire economic situation cumulatively resulted in social challenges, wherein, the common issues cited by miners were the mental and emotional impact of a work-related injury, abuse of substances, and negative social support.

The recommendations of this research emphasize the need for proper injury prevention and post-injury consequences management. Policymakers, mine owners, and local officials should adopt diverse frameworks that target safe mining practices, positive safety culture, hazards identification, and risk control. It is equally imperative to decrease the long working hours, manage and reduce miners' substance abuse through monitoring and regulations, and take cognizance of the consider post-injury miners' livelihood, health, and lifestyle supervision.

Research recommendations will help the government, local, and international agencies, as well as researchers to tailor policies that prevent injuries and improve the livelihood, lifestyle, and clinical health of injured miners and their associates. It will also enhance the understanding of the occupational health and safety (OHS) issues faced by miners.

# ACKNOWLEDGEMENTS

The completion of this thesis would have been impossible without direct and indirect support from others. First and foremost, I would like to acknowledge the contributions of my Supervisors: Dr. Apurna Kumar Ghosh and Associate Proffessor Janis Jansz. Also, I knowledge the assistance provided by Curtin University and Australian Government Research Training Program Scholarship. The undertaking of this study would have not been possible without permission from Strathmore University of Kenya, Greater Lake University of Kisumu, Rieko Kenya, Association of Artisanal and Small-scale Mining (ASM) operation in Migori County and Government. These bodies issued necessary permits and security to visit sites and conduct data collections.

Lastly and importantly, I am thankful for the love and sacrifices of my family. Asunta Agot Ayuen (wife), Savannah Achol Mayom (daughter) and Andrew Ajith Mayom (son) for allowing me to pursue my dream.

# LIST OF PUBLICATIONS

The following is the list of publications from this research:

## Published Papers

1. **Ajith,** M, Ghosh, AK, & Jansz, J 2020, 'Risk Factors for Number of Sustained Injuries in Artisanal and Small-scale Mining Operation', *Safety and Health at Work*, vol. 11, no. 1, pp. 50-60, https://doi.org/10.1016/j.shaw.2020.01.001. Impact factor of 1.431. The paper is presented as Chapter 5 of this thesis.
2. **Ajith**, MM & Ghosh, AK 2019, 'Comparison of parameters for likelihood and severities of injuries in artisanal and small-scale mining (ASM)', *Safety Science*, vol. 118, pp. 212–220, https://doi.org/10.1016/j.ssci.2019.04.010. Impact factor of 3.619. The paper is presented as Chapter 4 of this thesis.
3. **Ajith**, MM & Ghosh, AK 2019, 'Economic and social challenges faced by injured artisanal and small-scale gold miners in Kenya', *Safety Science*, vol. 118, pp. 841–852**,** https://doi.org/10.1016/j.ssci.2019.05.058. Impact factor of 3.619. The paper is presented as Chapter 6 of this thesis.

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# TABLE OF CONTENTS

ABSTRACT i
ACKNOWLEDGEMENTS iv
LIST OF PUBLICATIONS v
LIST OF TABLES x
LIST OF FIGURES xii
1. INTRODUCTION 1
1.1 Background of ASM in Kenya ---------------------------------------------------- 1
1.2 Statement of the Problem--------------------------------------------------------- 3
1.3 Available Knowledge on the Research Topic ------------------------------------ 5
1.4 Research Aim and Questions --------------------------------------------------- 7
1.5 Research Scope --------------------------------------------------------------- 8
1.6 How to Fill the Current Knowledge Gap----------------------------------------10
1.7 Research Significance---------------------------------------------------------11
1.8 Research Limitations---------------------------------------------------------12
1.9 Reflection on Research Challenges --------------------------------------------14
1.10 Thesis Chapters Layout ------------------------------------------------------14
2. LITERATURE REVIEW PART ONE - SIGNIFICANCE AND HEALTH DANGERS OF ASM 17
2.1 Introduction-------------------------------------------------------------------17
2.2 Employment Generation Capability of ASM Activity ---------------------------17
2.3 Fundamental Motivations for ASM Operation ----------------------------------18
2.4 Complex Webs of Health Problems in ASM Operation -------------------------21
2.5 Summary----------------------------------------------------------------------42
PART TWO - THE CONTIBUTING EFFECTS OF INDIVIDUAL CHARACTERISTICS, BEHAVIOURAL AND JOB-RELATED ON OCURRENCE OF MINING-RELATED INJURIES: A SYSTEMATIC REVIEW 45
2.6 Overview---------------------------------------------------------------------45
2.7 Abstract ---------------------------------------------------------------------45
2.8 Introduction------------------------------------------------------------------46
2.9 Materials and Methods--------------------------------------------------------47

2.10 Results -------------------------------------------------------------------------- 50

2.11 Discussion-------------------------------------------------------------------- 69

2.12 Summary ----------------------------------------------------------------------- 76

3. RESEARCH METHODOLOGY 78

3.1 Introduction------------------------------------------------------------------- 78

3.2 Mixed Methods Approach------------------------------------------------------ 78

3.3 Research Design --------------------------------------------------------------- 82

3.4 Summary------------------------------------------------------------------------ 95

4. COMPARISON OF PARAMETERS FOR LIKELIHOOD AND SEVERITY OF INJURIES IN ARTISANAL AND SMALL-SCALE MINING (ASM) 96

4.1 Overview----------------------------------------------------------------------- 96

4.2 Abstract ------------------------------------------------------------------------ 96

4.3 Introduction-------------------------------------------------------------------- 97

4.4 Materials and Methods---------------------------------------------------------- 99

4.5 Results--------------------------------------------------------------------- 106

4.6 Discussion ----------------------------------------------------------------- 112

4.7 Discussion on Limitations and Future Research Directions------------------- 117

4.8 Conclusions--------------------------------------------------------------- 117

5. RISK FACTORS FOR THE NUMBER OF SUSTAINED INJURIES IN ARTISANAL AND SMALL-SCALE MINING OPERATION 118

5.1 Overview------------------------------------------------------------------ 118

5.2 Abstract ------------------------------------------------------------------ 118

5.3 Introduction--------------------------------------------------------------- 119

5.4 Materials and Methods--------------------------------------------------- 123

5.5 Results-------------------------------------------------------------------- 131

5.6 Discussion ----------------------------------------------------------------- 137

5.7 Conclusions, Limitations, and Future Research Direction -------------------- 142

6. ECONOMIC AND SOCIAL CHALLENGES FACED BY INJURED ARTISANAL AND SMALL-SCALE GOLD MINERS 145

6.1 Overview------------------------------------------------------------------ 145

6.2 Abstract ------------------------------------------------------------------------ 145

6.3 Introduction------------------------------------------------------------------------ 146

6.4 Materials and Methods------------------------------------------------------------ 154

6.5 Results---------------------------------------------------------------------------- 157

6.6 Discussion ----------------------------------------------------------------------- 172

6.7 Limitations, Conclusions, and Recommendations ------------------------------ 178

7. GENERAL DISCUSSION AND RECOMMENDATIONS 180

7.1 Introduction------------------------------------------------------------------------ 180

7.2 Key Findings and Conclusions Related to the Research Questions. --------- 180

7.3 Conclusions Related to the Research Aim -------------------------------------- 184

7.4 Recommendations --------------------------------------------------------------- 185

7.5 Areas for Further Study---------------------------------------------------------- 187

7.6 Research Summary -------------------------------------------------------------- 188

BIBLIOGRAPHY 189

APPENDICES 222

**i.** Appendix A. Word Cloud ------------------------------------------------------- 222

**ii.** Appendix B. Research Questions Exploratory Diagram ----------------------- 223

**iii.** Appendix C. Authors Statement of Contributions ------------------------------ 224

**iv.** Appendix D. Safety Science Permission ---------------------------------------- 225

**v.** Appendix E. Safety and Health at Work Permission --------------------------- 226

**vi.** Appendix F. Curtin University Human Research Committee Ethics Approval ----------------------------------------------------------------------------------------227

**vii.** Appendix G. Ethics Approval from Strathmore University in Kenya ------- 228

**viii.** Appendix H. Research Permit ------------------------------------------------- 229

**ix.** Appendix I. Participants Information Sheet ------------------------------------ 230

**x.** Appendix J. Consent Form ----------------------------------------------------- 234

**xi.** Appendix K. Recruitment Materials ------------------------------------------- 235

**xii.** Appendix L. Structured Questionnaire ----------------------------------------- 236

**xiii.** Appendix M. Semi-structured Questionnaire------------------------------------- 245

# LIST OF TABLES

Table 1. 1 Summary of catastrophic mining accidents in last five years that have attracted the attention of Kenya national media groups. .......................................... 4

Table 2. 1 Summary of the studies explicit to ASM Operation that have investigated occupational injuries. ........................................................................................ 26

Table 2. 2 Results of the critical appraisal for cross-sectional studies....................... 51

Table 2. 3 Results of the critical appraisal of the case-control studies. ..................... 52

Table 2. 4 Below showed individual characteristics and risk of mining-related injuries. ............................................................................................................... 54

Table 2. 5 Below showed behavioural factors and risk of mining-related injuries.... 60

Table 2. 6 Below showed job-related factors and risk of mining-related injuries. .... 62

Table 3. 1 Types of mixed methods designs as dictated by the four criteria (Creswell, 2003). ....................................................................................................... 81

Table 3. 2 Rigorousness of qualitative research........................................................ 94

Table 4. 1 Participants' response to risk factors for both likelihood of injuries and severity injuries (N= 236). ....................................................................... 103

Table 4. 2 Participants' responses on job performance, bodily pain and medical attention.................................................................................................. 109

Table 4. 3 Hosmer and Lemeshow test of likelihood of recordable injuries. .......... 110

Table 4. 4 Hosmer and Lemeshow test of likelihood of severe injuries. ................. 110

Table 4. 5 Risk factors that predicts likelihood of injuries in ASM operation. ....... 110

Table 4. 6 Risk factors associated with likelihood of severe injuries. ..................... 111

Table 5. 1 Goodness-of-fit. ...................................................................................... 131

Table 5. 2 Participants response to number of injuries sustained (N= 236). ........... 131

Table 5. 3 Cross tabulation of number of times miners have been injured and lost workdays (n=236 participants)................................................................ 133

Table 5. 4 Association of risk factors with single injury and multiple injuries keeping no injury as reference category. ............................................................ 134

Table 5. 5 Type of injuries sustained by miners. .................................................... 135

Table 5. 6 Miners' perception with regard to work conditions. .............................. 136

Table 5. 7 Miners' perception about management and supervision. ....................... 137

Table 6. 1 Demographic characteristics of the interviewed participants (n = 33). .. 156

Table 6. 2 The cognitive and motivation bias drive from the thematic analysis of qualitative data (adapted from Komljenovic et al., (2017). .................................... 169

# LIST OF FIGURES

Figure 1. 1 The Migori area indicating Osiri Minesite (Laura, 2018). ........................ 8

Figure 1. 2 Visual representation of concurrent embedded mixed method approach.. 9

Figure 2. 1 Epidemiological triad model for causes of occupational injury. ............. 33

Figure 2. 2 Flow diagram for the selection of literature review articles related to risk factors in the mining industry. ..................................................................... 50

Figure 2. 3 Results of studies that have investigated risk of various individual characteristics on injuries. ......................................................................... 69

Figure 2. 4 Distribution of studies that have evaluate role of substance usage and risk of mining–related injuries. ........................................................................ 73

Figure 2. 5 Distribution of job-related factors studies based on the significance with occurrence of mining injuries....................................................................... 73

Figure 3. 1 Flow diagram of research methodology. ................................................ 78

Figure 4. 1 Nature of injuries. .................................................................... 106

Figure 4. 2 Body parts injured..................................................................... 107

Figure 4. 3 Causes of injuries...................................................................... 107

Figure 4. 4 Injuries based on number of lost workdays ........................................... 108

Figure 6. 1 ASM working areas in Osiri Gold Mine................................................ 148

Figure 6. 2 Anatomy of an event as modified by Komljenovic et al. (2017)........... 151

Figure 6. 3 Complex model for causes and consequences of injuries. .................... 154

# 1. INTRODUCTION

## 1.1 Background of ASM in Kenya

Mining has been established as a contributor to the global economy as it positively contributes to poverty alleviation and local economic development (International Council on Mining & Metals [ICMM], 2014). However, in countries where other sectors of the economies are well developed, the vital role played by the mining industry tends to be overlooked. Similarly, in Kenya, agriculture, tourism, services, and manufacturing industries are considered the only backbones of the economy despite their rich mineral wealth. This view, however, has recently been shifted with the country aiming to achieve certain development goals by 2030. Which, in turn, has led to mining being identified as one area that would propel the economic growth and help attain Vision 2030. The Vision 2030 is a national long-term development strategy planned to transform Kenya into the industrialized and middle-income country, which will provide its citizens with high-quality life (Ministry of Mining [MoM], 2016).

As a step toward reinvigorating the mining sector, the 1940s Mining Act (that was out-of-date and restricted investment) was substituted with a revised and more progressive act in 2016 (MoM, 2016). The new legislation required different organs of government and relevant institutions to develop various frameworks towards addressing deficiencies in the mining industry and leveraging its potentials (MoM, 2016). The mining sector's contribution to the country's gross domestic product (GDP) is estimated to increase from 0.8% in 2015 to 10% in 2030 (Laura, 2018). This projected GDP is aimed to be reached through increased mining investments and improved operational discipline. Companies or individuals that are engaged in this activity are required to abide by good mining practices focusing on environment protection, as well as mining safety (Mwakumanya et al., 2016).

The most significant part of the new legislation was recognition of the ASM sector, which, is a complete departure from the 1940s Mining Act that prohibited the activity (International Labour Office [ILO], 2016). The provision of the new law requires that all ASM operators must obtain mining permits before undertaking any mining and mining-related activities. Surprisingly, several organizations have been unable to completely comply with this requirement due to multiple bureaucratic issues. On examining the challenges being faced by women miners in Mukibira Mines in the Vihiga District of Kenya, it was found that issuing of ASM permits was a selective process that preferred individuals bribing the system (Amutabi & Lutta-Mukhebi, 2001). A similar challenge was observed in other sub-Saharan African countries, where this activity has developed into a formal practice (Banchirigah, 2008; Hilson et al., 2017; Ledwaba & Mutemeri, 2018; Van Bockstael, 2014). As a result, the majority of artisanal and small-scale miners have started to operate illegally, thereby, posing a threat to human health and safety, as well as the environment (Bansah et al., 2018).

Because of challenges related to obtaining permits, lack of rules and enforcement regulations and the remoteness of ASM sites, millions of men, women, and children continue to work in these illegally operating mines. As a result, mining safety is compromised, which subsequently exposed miners to accidents and injuries. Similar to the situation in many other developing countries, the ASM activities in Kenya fail to meet the stipulated standards and regulations defined in the Occupational Health and Safety Act of 2017 (OSH, 2017) and safe work practices outlined by the Directorate of Occupational Safety and Health Services (DOSHS). In their study on the significance of ASM activities in the Taita Taveta region of Kenya, Mwakumanya et al. (2016) revealed the rudimentary nature of the equipment, lack of expertise, and presence of numerous OHS hazards, which often lead to accidents. The corresponding study conducted in the same region found miners to be subjected to health and safety hazards due to the lack of basic protective equipment. Correspondingly, this research identified a lack of positive safety culture, finance, and sufficient support by mine owners and local officials as major contributors (Bernard, 2014). These findings were collaborated by the miners' representatives, Civil Society Group (CSG), local government officials, Public Health Officer (PHO) and Health and Safety Advocacy Group (HSAG) who mentioned their concerns about increased accidents in Migori County and other mineral-rich regions of Kenya during the first consultative meeting with the researcher.

## 1.2 Statement of the Problem

The gold rush in Migori County has resulted in several health problems among the miners and residents (Ogola & Mitullah, 2002). In October of 2019, the Government of Kenya (GOK) shut down about 40 artisanal and small-scale gold mines after identifying adverse health and safety conditions (Mbula & Byron, 2019). Reports indicate that dozens of miners have been buried alive while working in unsafe working conditions in mines subsequently leading to severe injuries and fatalities, as seen in Table 1.1. Lawfully, the Kenyan Mining Act of 2016 calls for sustainable mining, whereby the health and safety of miners and nearby communities, as well as environment protection is paramount (MoM, 2016). However, the existing rules and regulations are hardly followed by the miners and mine owners (Mbula & Byron, 2019). Thus, resulting in complex ASM operations including frequent accidents and injuries.

Artisanal and Small-scale Gold Mining (ASGM) is the main income-generating activity in several sub-counties in Kenya (Barreto, 2018). However, the extraction of gold and other commodities through ASGM is a ‘matter of life and death’, especially in Migori County (Daily, 2018). The miners enter underground workings, where the tunnel is nearly 50 meters long and can reach up to 50 meters in depth. The tunnels are supported by wooden structures and have limited lighting and ventilation (Daily, 2017). While on-site, I observed miners entering the underground shaft using wooden made ladders and with no personal protective equipment (PPE). In this activity, “an incident-free day means a lot to county gold miners” (Otieno, 2015).

It was reported that due to the high risk associated with the activity, some of the miners were choosing to opt-out to engage in farming and fishing (Daily, 2017). However, for others, safety challenges were not to be of priority, in case, the results procured the workers sufficient money to sustain their livelihood. Before the commencement of this research and validated during the fieldwork, 192 of 610 gold miners were reported by the workers' representatives and mine owners to have experienced physical injuries of varying degrees. This information was gained through self-reporting due to a lack of proper and mandatory recording mechanisms.

Table 1. 1 Summary of catastrophic mining accidents in last five years that have attracted the attention of Kenya national media groups.

| References, County, Country | No. of serious injuries | No. of fatalities | Causes | Reporter comments |
|---|---|---|---|---|
| Odeny (2020), Osiri Mine, Migori County, Kenya. | 15 | 4 | Mine collapse | Three miners were crushed by a rock while another suffocated after being trapped in the confined area. |
| Odeny (2019), Bukira Mine, Migori County, Kenya. | 2 | 1 | Carbon monoxide | The miners were draining the water from the mine when the accident happened. |
| Otieno (2018), Malcader Mine (Osiri Mine), Migori County, Kenya. | 0 | 6 | Tunnel cave in after heavy rain | Miners always put themselves at risk to access the precious metals. They use crude equipment. Accidents with catastrophic ends are common. |
| Kingwara (2018), Matanda Gold Mine, Migori County, Kenya. | 2 | 4 | Wall cave-in | Miners continue to operate illegally in total disregard for the law. Miners need to be familiar with the laws on safety and mining, as well as obtained permits. |
| Abuga (2018), Quarry Mine, Kissi County, Kenya. | 0 | 2 | Rockfall | Local officials were concerned about the number of unregulated quarries in the area. Quarries owners do not provide safety equipment. |
| Nandiemo (2018), Copper Hill Gold Mine, Migori County, Kenya. | 3 | 0 | Buried by rocks | Miners were working under a loose hanging wall. |
| Juma (2017), Malcader Mine (Osiri Mine), Migori County, Kenya. | 0 | 2 | Wall cave-in | Miners used poor equipment and worked in risky areas. |
| Ngechu (2015), Akala Gold Mine, Migori County, Kenya. | 5 | 2 | wooden ladder | A total of 22 miners have lost their lives in Migori Gold Mines. |
| Ndungu (2015), Mukuro Gold Mine, Migori County, Kenya. | 1 | 1 | Gas suffocation | Miners pump water into the mine to soften the rocks. |
| Adinsai (2014), Malcader Mine (Osiri Mine), Migori County, Kenya. | 7 | 2 | Mine cave-in | The landslide was caused by heavy rains. |

While the ASM-related accidents are well-known in Kenya, particularly in Migori County, there is no single academic work that was found to have explored or determined the high-prevalence, nature of injuries, severity of injuries, injured body parts, or the causes of injuries. This can be attributed to the fact that the ASM activities are carried out in rural villages and are largely illegal. Also, miners engaged in this activity continually move from one site to another depending on work opportunities, or how mineralized and accessible the minerals or metals are in their current work areas. Moreover, mine owners typically do not maintain meticulous records and loosely capture and report accidents including the severe events. Therefore, making credible and reliable data difficult to obtain and performed scientific analysis.

Similarly, despite the severity of ASM-related injuries, the post-injury impacts have never been studied. Apart from the physical body trauma, the injuries also inflicted economic and psycho-social problems. Miners in this activity are always employed on a casual basis with minimum wages and are not provided any health cover. As a result, injured miners are often laid-off without compensations or necessary assistance. Consequently, forcing miners to fend for themselves. As such, to cover the medical and pharmaceutical costs, as well as daily upkeeps, injured miners primarily rely on their savings, loans, and selling of personal belongings. In some cases, families, friends, and communities also have been observed to provide economic and social support. The challenges faced by injured miners and their families are worsened by insufficient government supports.

## 1.3 Available Knowledge on the Research Topic

The search of literature outside Kenya has returned few studies that were conducted recently (Babatunde, 2013; Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015; Nakua et al., 2019b). In agreement, these studies firmly established that injuries in ASM are a frequent phenomenon and often vary in nature. The studies also identified several physical hazards that increased the susceptibility of the miners to occupational injuries. Notwithstanding the significance of these studies, little attention has been paid to injuries that cause lost workdays, as well as lead to functional limitations and medical care. These injuries are important to be understood as they hugely impact the livelihood and lifestyle of injured miners and other stakeholders.

Due to the prevalence of injuries in ASM operations, in recent years there has been a significant global increase in interest in understanding the mechanisms of injury causations, as well as risk factors. However, the latest research furnishes conflicting analyses of the role played by individual characteristics and behavioural factors.

Moreover, none of the studies has attempted to scientifically explore the consequences of job-related factors, such as job dissatisfaction, job stress, shift hours, poor leadership and poor working conditions on the injury.

Risk factors that influence occupational injuries have been published in other industries and include age group (Breslin et al., 2003; Pransky et al., 2005; Santana et al., 2012; Stojadinović et al., 2012), gender (Bhattacherjee et al., 2003; Breslin et al., 2003; Long et al., 2015; Santana et al., 2012), marital status (Aderaw et al., 2011; Calys-Tagoe et al., 2015), level of education (Boniface et al., 2013; Stojadinović et al., 2012), mining experiences (Bena et al., 2013; Boniface et al., 2013; Calys-Tagoe et al., 2015; Margolis, 2010), shift hours (Boniface et al., 2013; Chimamise et al., 2013; Dembe et al., 2005; Salminen, 2010), alcohol consumption and drug usage (Bhattacherjee et al., 2003; Elenge et al., 2013; Kaestner & Grossman, 1998; Khashaba et al., 2018), poor work conditions (Amponsah-Tawiah et al., 2013; Burgard & Lin, 2013; Chimamise et al., 2013; Cui et al., 2015; Ghosh et al., 2004), poor management and supervision (Burgard & Lin, 2013; Chimamise et al., 2013; Ghosh et al., 2004), job dissatisfaction (Chimamise et al., 2013; Ghosh et al., 2004; Nakata et al., 2006) and job stress (Amponsah-Tawiah et al., 2013; Nakata et al., 2006; Long et al., 2015).

In addition to the insufficient scientific analysis of risk factors by recent studies related to ASM, this body of research has failed to establish the impacts of injuries. However, it has been demonstrated that injured worker(s) can be negatively affected in absence of adequate financial and social support (Bhattacherjee & Kunar, 2016; Boden et al., 2001; Brewin et al., 1983; Dembe, 2001). This condition is found to be worst in the circumstances, wherein, the individuals and their families cover the injury resultant and other associated medical and pharmaceutical costs by themselves (Dembe, 2001). The consequences can also "ripple out" to include family members, friends, co-workers, community, employer, and more (Boden et al., 2001). This raises a fundamental question of how injured ASM miners and their families can cope economically and socially post-injury, as the activity is a sole or complementary source of livelihood among many poverty-stricken populations in the developing countries.

## 1.4 Research Aim and Questions

Because of the evident gap in the availability of relevant information in published studies for the ASM-related injuries, this research aimed to investigate the recordable injuries and associated risk factors, as well as economic and social consequences affecting the injured miners and their families in Osiri Gold Mine in Migori County, Kenya (see Figure 1.1 for the location of Osiri mine site). The results of the analysis aim to shed more focus on increasing injury prevention and post-injury consequence management. In addition, the findings will enhance the understanding of OHS issues in ASM operation.

To achieve the above aim, the following questions were asked:

1. What are the specific recordable injuries (that is, nature, bodily distribution, and causes of injuries) experienced by miners?

2. Is there any association between: (i) individual characteristics (age, gender, marital status, education level, and experience), (ii) behavioural-related risk factors (alcohol and drug usage), and (iii) job-related risk factors (shift hours, poor working conditions, poor management and supervision, job dissatisfaction and job stress) with the likelihood of recordable injury?

3. Can the risk factors for the likelihood of recordable injuries also predict the severity of recordable injuries?

4. What are the risk factors that influence each defined category of the number of sustained injuries (frequency of injuries)?

5. What are the economic impacts suffered by injured miners and their families in Migori County?

6. What are the social impacts suffered by injured miners and their families in Migori County?


Figure 1. 1 The Migori area indicating Osiri Minesite (Laura, 2018).

## 1.5 Research Scope

The purpose of this concurrent embedded mixed method design was to answer the stated questions and subsequently achieve the research aim. In this research, the quantitative and qualitative methods were used to answer research questions **1-4** and **5-6,** respectively. This research was implemented in two stages as shown in Figure 1.2.

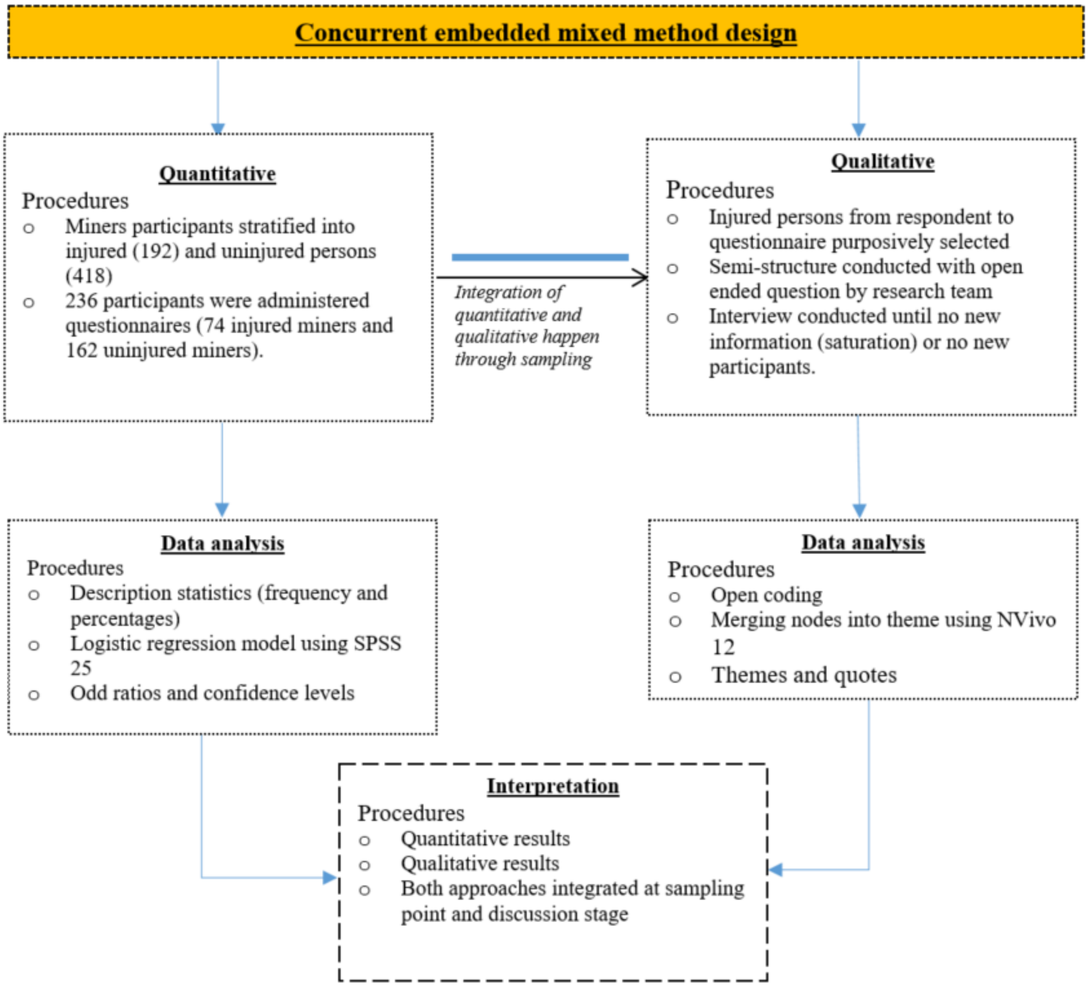


Figure 1. 2 Visual representation of concurrent embedded mixed method approach

The structured survey questionnaires were administered to 162 uninjured and 74 injured miners to capture information relating to recordable injuries history and various risk factors. The epidemiologic triad model (Centers for Disease Control and Prevention [CDCP], 2012) and anatomy of an event (Komljenovic et al., 2017) were used to guide the different phases of the study. Both models conceptualized occupational injury as a result of a complex interplay between different factors. According to the epidemiologic triad, the right environment facilitated agent-host interaction, which later leads to the occurrence of injury. The agent factors are the physical and ergonomic hazards, while host factors are the individual characteristics and behavioural related risk factors as shown in Figure 2.2 of Chapter 2. Whereas, environmental factors were job-related risk factors. This model helped in the quantitative phase to establish the association between various risk factors and the number of outcome variables of interest. The survey data was then analysed using both descriptive statistics and logistic regression to summarize the participants' responses and assess the relationship between risk factors and the response variable(s).

In the second phase, severely injured miners who responded to the survey were purposively identified and qualitatively interviewed. The researcher adopted the anatomy of an event model to understand the mine safety issues (e.g., nature of safety culture) and consequences of injuries on miners and their families as shown in Figure 6.2 of Chapter 6. The anatomy of an event shows occupational accidents and resultant consequences as a complex system. Within this system, the human, technological, and organizational components demonstrate a cumulative influence which facilitates occurrence or reoccurrence of occupational injuries. Therefore, in addition to the statistical test of association, the focus was to understand underlying fundamental and direct causes of injuries by asking "Why ASM-related injuries occurred?" and "Why they were not stopped?" as well as recognize the post-injury negative socio-economic impacts. This phase was intended to provide an in-depth insight into the livelihood and challenges faced by the selected severely injured participants. Participants were interviewed about mine safety issues, as well as their economic and social issues post-injury guided by semi-structured questions. The number of participants was not statistically determined rather it was achieved after reaching idea saturation, which was attained after interviewing 33 severely injured miners. The interview dataset was subjected to thematic analysis, wherein, recurring themes were identified from the 33 transcripts.

## 1.6 How to Fill the Current Knowledge Gap

Previously, studies related to ASM have characterized the injuries and cited the causal mechanisms. This thesis has gone further and assessed the nature, bodily distribution, and causes of recordable injuries. In addition, the thesis has scientific analyses and resultantly determined: (i) The relationship between risk factors for likelihood of recordable injuries and the likelihood of severe injuries, (ii) the predictors of single injury and multiple injuries incidents, (iii) management commitment to safety, (iv) economic impacts of severe injuries, and (v) social impacts of severe injuries.

## 1.7 Research Significance

This research has exclusively focussed on the injuries which resulted in lost workdays, medical burden, and functional limitations (on-job and off-work restrictions). The research has identified various nature of recordable injuries experienced by miners which range from a laceration to major physical trauma, such as amputation. These injuries were frequently located in the upper and lower limbs of the body and were mainly caused by falling objects or equipment.

For better comprehensiveness, the injuries were categorized based on the number of times miners were injured and the number of lost workdays. This segregation revealed that the majority of miners experienced single injury and major injuries (i.e., recordable injuries that forced miners to stay off for duration exceeding 7 days) compared to multiple injuries episode and miners (i.e., recordable injuries that has forced miners to stay off for duration less than 6 days).

In comparison to the previous studies related to ASM operation, this research for the first time implemented a comprehensive analysis of risk factors based on the likelihood, severity, and frequency. The research identified that some risk factors for the dichotomous likelihood of recordable injuries also predicted the likelihood of severe injuries after applying binary logistic regression. In this first inferential analysis, the likelihood of severe injuries resulted in a dichotomous outcome with minor injuries collapse into no injury group and major injuries classified as severe injuries. The research also showed that not all risk factors for single injury influenced multiple injuries occurrence with no injury as a reference group.

Besides the characterization of recordable injuries and related risk factors, the research has provided a first-hand account of the severe affliction of the injured miners and their families. The research identified several factors that negatively impacted the economic and social situations. Without health insurance, compensation programs, and requisite support from the mine owners, as well as government, the research revealed that miners depend on their savings, loan, and family assistance for medical care and daily living needs, which subsequently reduced their financial situation and pushed them into poverty. Furthermore, miners suffered from various psychosocial issues, such as mental and emotional trauma, substance abuse, and relationship challenges.

Besides, the research demonstrated that poor commitment of mine management to the safety of the mineworkers directly impacts the wellbeing and livelihood of workers. The evidence of poor management and supervision was cited by the injured miners and they unanimously agreed that the mine management fails to seriously consider the safety of miners. This was shown by lack of availability of personal protective equipment, hazard awareness, accidents and injuries documentation and lack of support post-injury. These findings indicated the paramount and pertinent need to ensure education, awareness, and leadership training for changing the working conditions and perceptions.

This research enhanced understanding of injuries that happened in ASM operation beyond simple characterisations. It also collaborated with the idea that ASM activities are dangerous to the health and wellbeing of the miners, as the associated economic and social burden invariably precipitates to the family members. Therefore, a proper approach needs to be adopted to increase OHS standards and consequently, safe work practices and positive safety culture. The research provides recommendations for the government and non-governmental organisation (NGO) stakeholders to develop informed and sustainable policies that do not only target environmental impacts but also focus on injury prevention and post-injury consequences management. These policies should target the likelihood of injuries occurrence, which will subsequently stop major injuries and negative economic and social impacts.

## 1.8 Research Limitations

In this research, I have illustrated the existence of recordable injuries and relative level of severity, as well as the number of times miners have been injured (frequency of occurrence) and accompanying risk factors. I have also identified the negative impacts of severe injuries on individual miners and their families. Although the findings from this research have widened the perspectives on the problematic nature of ASM operation, the course of the study presented few limitations.

- ✓ The first limitation noted in this research was the adopted sampling approach, whereby participants were systematically selected after stratification. In this form of sampling, particularly in the injured stratum, each participant was given the number, and during the survey, the first random number (first selected participant) was identified followed by systematic choosing of successive participants. This introduced the possibility of biasing the number of miners who suffered single injury incidences and severe injuries (major injuries) compared to those multiple injuries event and less severe injuries (minor injuries).

- ✓ In the comparison of risk factors for likelihood of recordable injuries and the likelihood of severe injuries, minor injuries (i.e., less than 7 lost workdays) were added into no injury group. However, a 0 lost workday injury should be used as a foundation for preventive efforts. The analysis of the minor injuries' category (depending on the definition) could be carried out to understand the effect of risk factors and limitations.
- ✓ Although the research considered some key risk factors, individual traits, such as impulsivity, compliance, etc., as well as job-specific factors (that have been previously studied with mixed results) were excluded. However, these need to be included to provide a comprehensive picture of the role played by various risk factors.
- ✓ Due to how participants responded to some of the 5-Likert scale questions, measures related to alcohol and drug usage, the categories of these risk factors were reorganized. All the respondents 'to strongly agree' were combined into agreed while 'neutral' and 'strongly disagree' into 'disagree'. The riskiness of alcohol and drug with the occurrence of occupational injuries were classified into high-risk user, low-risk users, and non-users. The effects of risk factors measured through 5-Likert scale items and measures of alcohol and drugs on occupational injuries cannot be generalized. This left the need to understand the contributing effects of individual items or measures under defined risk factors on the occurrence of occupational injury, unaddressed.
- ✓ This research used both the binary and multinomial logistic regression to evaluate the role of various risk factors on different outcomes variables. Therefore, the analysis is limited from comparing the odd ratios of risk factors for several injuries sustained with those of the likelihood of recordable injuries and the likelihood of severe injuries although the contributing effects of the same predictors were measured.

- ✓ The reliability and credibility of the information related to economic and social challenges faced by injured persons and their families were concerning. This is because the study analysis relied on the first-hand account of the participants due to a lack of compensation claim reports, medical documentation, and other related documents. This 'hearsay' methodology raises the concern about the completeness and accuracy of the data. Therefore, further analyses of the post-injury impacts could be implemented using the government documented data (if available) to augment study robustness.

## 1.9 Reflection on Research Challenges

This research presented several challenges before and during the data collection.

- ✓ It took approximately over a year to obtain necessary permits to travel to Kenya and conduct data collection.
- ✓ The second challenge was gathering and convincing miners to participate in the study. ASGM sites in this study area are run by individuals, families, and communities. Therefore, the researcher had to undertake several consultations before data collection. The first consultation was conducted with the local government officials, followed by the operation heads (site owners) and lastly with all 610 miners.
- ✓ The third challenge was eliciting responses during the face-to-face qualitative interview. In the initial phase of the interview, some participants were somewhat hesitant to explain how injured occurred and the issues they were currently facing. However, they opened-up during the interview may be due to the gradual development of trust in the interviewer.
- ✓ The last challenge was at the analysis stage, whereby some categories of risk factors were devoid of sufficient participant responses and therefore were required to be collapsed into another group to achieve a more stable statistical model.

## 1.10 Thesis Chapters Layout

### Chapter 1

The introduction chapter provides the background to the research and states the research problem. This chapter also presents the research gap identified from the previous work, research aim and questions, significant and limitation associated with the current research.

**Chapter 2**

The part 1 literature review discusses the relevant research available in the context of the current research and study aim. The chapter provides insight into the motivations for engaging in ASM operation, sector hazardousness, and occupational injuries in ASM operation, as well as post-injury consequences.

The part 2 literature review presents the peer-reviewed studies that are specific to mining-related accidents and injuries for the period – 2004 to present (2020). Publications that have investigated the role of various risk factors for injuries that occurred in mining industries were reviewed and discussed. Specifically, the chapter discusses findings on individual characteristics, behavioural factors, and job-related factors.

**Chapter 3**

This chapter provides information on the research methodology. The chapter focuses on the rationale for adopting mixed method research, the underpinning paradigm, adopted mixed method typology, research design approach, as well as research questions. The sampling, data collection, and analysis procedures are discussed in Chapters 4, 5 and 6.

**Chapter 4**

This chapter presents published paper one, which answered research questions one to three. The paper investigates injury history and the risk factors associated with the likelihood of recordable injuries and the likelihood of severe injuries using both descriptive statistics and binary logistic regression.

**Chapter 5**

This chapter presents publication two, which answered research question four. This chapter aimed to determine the risk factors for the defined categories of number of injury incidences suffered by the miners (number of injuries sustained – frequency of injuries). The injured miners were categorized into those who suffered a single injury and multiple injuries episodes, respectively. The risk factors tested in paper one were again assessed with these groupings using multinomial logistic regression instead of binary logistic regression. The aim of Chapter 5 was to understand why some miners are likely to be injured single time while others got injured multiple times within the same working environment. Thus, completing the gap left unresolved in Chapter 4.

**Chapter 6**

This chapter presents published paper three, which answered research questions five and six. This focuses on the relevant entities left unexplored as the first and second papers identified injury history and various risk factors without assessing the post-injury impacts. The researcher was interested to determine the economic and social challenges experienced by some of the severely injured miners. This chapter confirms that most injured miners in ASM operations became economically and socially vulnerable post-injury, particularly those with insufficient support.

**Chapter 7**

This chapter provides general discussion and recommendations for the government towards facilitating informed decision-making and for future work.

The next chapter in this report is the Literature Review Part 1.

# 2. LITERATURE REVIEW PART ONE - SIGNIFICANCE AND HEALTH DANGERS OF ASM

## 2.1 Introduction

This chapter provides a brief overview of both the significance and perils of ASM operations. It is notable that the preceding literature review part 2 comprehensively reviewed and explicated peer-reviewed published papers on specific individual characteristics, behavioural, as well as job-related factors that are attributed to occupational injuries in mining sector. After discussing the span of ASM activity in terms of its employment generation capability, the current chapter then extrapolates on the complex web of problems and the ramifications of injuries.

## 2.2 Employment Generation Capability of ASM Activity

According to Labonne (1996), ASM operation is considered as the foremost approach, as regards the extraction of both metal and non-metallic minerals. As a matter of fact, ASM has been utilised extensively in barter trade and development of traditional crafts throughout human civilisation and the industrial revolution. In addition, the World Bank (2013) reports that regardless of the century-old prevalence of the concept, the sector retains its noteworthy status of livelihood-related activity until to-date, with particular reference to impoverished people. Furthermore, the report adduces that the concept of ASM exhibits strong reliance on both business-minded individuals and the government, particularly in the mineral-rich developing countries situated across Africa, Oceania, Asia, Central and South America. However, the clearly deficient evidence and an ineffectual monitoring system, coupled with the largely unproductive mechanism of documenting, renders the estimation of the maximum extent of ASM socio-economic potentials problematic. This predicament is exacerbated by the illegal operations and palpable absence of a universal definition (Hentschel, 2003).

The latest report from the World Bank (2019) revealed that about 40 million people are employed in ASM sector, thereby indicating a significant rise from the statistics hitherto informed by international labour office (ILO) of 11-13 million in 1999. In addition, these reports also cited evidence from the operation's secondary or indirect sustenance benefits for millions of beneficiaries. As per the reports, an estimated 800,000 Kenyans (1.7% of population) were directly or indirectly dependant on the ASM sector in the year 2018 (Barreto, 2018). Around 70,000 artisanal and small-scale miners of this population were found to be directly engaged in non-metallic and construction minerals sector, while another 70,000 participated in gold mining activities. Therefore, it can be surmised that the sector directly employed 140,000 miners with several thousand indirect beneficiaries.

## 2.3 Fundamental Motivations for ASM Operation

The remarkable growth of ASM operation worldwide has been attributed to a number of factors. Several publications have posited that high levels of poverty and the ability to earn quick money has made a significantly positive contribution to the uptake of ASM among individuals, families, communities and small-scale cooperatives (Arthur et al., 2016; Banchirigah & Hilson, 2010; Banchirigah, 2008; Cartier & Burge, 2011; Hilson, 2011; Sara, 2012). The get-rich-quick narrative implies that miners are foraying into the sector out of choice, as opposed to necessity (Kelly, 2014). This narrative is reinforced by rushed periods, minerals fuelled conflicts as well as the presence of business-minded individuals (Cartier, 2009; Hilson & McQuilken, 2014; Jønsson & Bryceson, 2009; Ross, 2004).

Conversely, other studies have contended that people ventured into ASM primarily to escape from poverty (Andrews, 2015; Arthur et al., 2016; Banchirigah & Hilson, 2010; Cartier & Burge, 2011; Clifford, 2011; Hilson & Garforth, 2012; Hilson, 2003; Kamlongera, 2011; Kuepouo, 2017; Ouoba, 2017). This viewpoint postulated that ASM is a necessity but not a matter of choice for millions of men, women and children, particularly in developing countries. In fact, it was in Washington DC, during the World Bank-hosted International Roundtable on ASM, that the intersection between ASM and poverty saw the light of day (Barry, 1996). In this forum, the delegates acknowledged that economic hardships and the absence of viable alternative opportunities are catalysing the growth of ASM activity. Correspondingly, poverty has been defined, with reference to specific needs, as the 'vulnerability' and 'marginalization' of the population. Widespread marginalization attributed to the paucity of basic needs, coupled with economic travails, render the individuals vulnerable (Hilson & Garforth, 2012).

Similarly, with the passage of time, myriad activities are adopted by individuals or households, when faced with economic hardships, to fortify provisions as well as to advance their standards of living (Loison, 2015). It is this adaptability that is the key principle evidenced in the ASM activity, given that ASM offers a 'complete alternative' to those fraught by impoverishment, or serves 'as income diversifiers' (Hilson 2010). Notably several studies have recognised ASM as a viable mechanism of livelihood diversification, the genesis of which is attributed to the cessation of their traditional forms of living (Aderaw et al., 2011; Andrews, 2015; Hilson & McQuilken, 2014; Kamlongera, 2011; Kamlongera & Hilson, 2011; McFarlane et al., 2016; Spiegel, 2009). In his study, Fisher et al. (2009) revealed that the Tanzanian ASM miner population demonstrated heightened economic stability as compared to the rural population subsisting on non-ASM activities. Subsequently, the local population commonly referred to the ASM sector as "*The ladder that sends us to wealth*." Analogously, Arthur et al. (2016) conducted a related study with an emphasis on the people in Ghana's Prestea mining region. The findings of this study revealed multiple beneficial contributions of the ASM sector upon an assessment of the nexus between ASM activities and livelihoods of the population. These included the following: enhanced subsistence, improved welfare and asset attainments, reduced susceptibility, and assistance for students to start their own business, among others.

Meanwhile, several researchers have concluded that ASM is essentially adopted by the poor as a complementary or alternative strategy of livelihood diversification (Arthur et al., 2016; Banchirigah & Hilson, 2010; Banchirigah, 2008; Hilson, 2016; Hilson & Banchirigah, 2009; Kamlongera, 2011; Kamlongera & Hilson, 2011). Moreover, extant research corroborates that most of the rural population in sub-Saharan Africa countries is involved in agrarian activities (Weng et al., 2015), due to which periodic weather alterations adversely affect the sustenance potential. This, in conjunction with inadequate alternative subsistence support, impels several thousands of populations to participate in the ASM, which, in turn, serves as a supplementary source of income (Hilson, 2011; Hilson & Banchirigah, 2009). Congruently, Cartier and Burge (2011) and Okoh and Hilson (2011) conducted studies in Ghana and Sierra Leone, respectively. Their findings underscored the intersection of ASM and small-scale agriculture, also positing that the choice of ASM is enforced upon farmers due to poor agriculture performance that renders them incapable of meeting their financial needs. Correspondingly, Kouame and colleagues et al. (2017) recently conducted a study in the Boore region of Ivory Coast. According to their findings, ASM contributed a significant share to the income of local community members, in addition to their primary income source. This underlines the concurrent pursuit of ASM as a complementary strategy of livelihood diversification in addition to their traditional income sources (Hilson & Garforth, 2012).

Conversely, according to the alternative livelihood diversification approach, ASM contributes to the individuals' livelihood as the sole source of income (Banchirigah, 2008; Hilson, 2010; Hilson, 2003; Hirons, 2014; Siegel & Veiga, 2009). Studies show that this approach is ascribed to the paucity of profitable alternative employment opportunities as well as inadequate government policies (Hilson, 2010; Hilson & Banchirigah, 2009; Kouame et al., 2017). Proponents of this approach suggest that advantageous factors like non-viability of other options and sector profitability have led to a complete abandonment of the traditional livelihood means for ASM (Banchirigah & Hilson, 2010). For instance, the Structural Adjustment Program (SAP) implementation and enforcement of economic liberalisation policies, rendered numerous public servants and rural farmers jobless in the majority of developing countries. Thus, these jobless individuals had no alternative but to adopt ASM as their singular livelihood source (Mabhena, 2012; Spiegel, 2009).

Hilson and Garforth (2012) posit that the argument is more nuanced and indicate that many ASM communities are neither driven by 'push factors' nor by 'pull factors', but rather by a hybrid combination of both. In their study, it was revealed that the initial stage of ASM was abounding with financially driven individuals, while at a later stage, it was largely populated by poverty-driven individuals in Mali. Similarly, Clifford (2011) disagreed with the concept of a singular reason in their study and suggest that the initial transition of financially-motivated individuals towards ASM activities was later gradually replaced by the poverty driven individuals. It was observed that the initial composition left for profitable avenues after exhausting and examining the role of ASM in Guyana.

In addition to the allure of quick riches and poverty narratives, researchers have also identified other factors. For example, Bakia (2013) conducted another study covering six locations in the east region of Cameroon; they assessed the ASM sector in the region to reveal that economic reasons did not essentially underpin the induction of miners in the ASM sector. In fact, the ineffectual infrastructure and neglect on the part of the government catalysed the movement of miners to ASM.

Furthermore, Aizawa (2016) conducted a study to examine the underpinning factors for the exodus of individuals towards ASM, other than the previously studied factors of economic hardships and improved financial allure. The research identified additional motivating factors of social benefits in addition to economic factors, for sustained ASM activities.

The author opined that in the Geita gold mining area of Tanzania, the ASM miners obtain support from the other workers towards sustenance of livelihood during challenging times such as economic adversities. According to Werthmann (2009), marginalised women in communities do not deliberately conform to specific norms, and in fact, frequently encounter social family problems, whereby they are impelled to work for ASM gold mining, which provides these women with an opportunity to safeguard their financial future.

## 2.4 Complex Webs of Health Problems in ASM Operation

Although ASM industry has been demonstrated to impart socio-economic benefits, the sector poses a risk to millions of miners along with nearby communities. According to ILO (1999), ASM is infested with numerous occupational and community hazards that frequently cause illnesses and injuries. The most cited hazards include chemical, biological, psycho-social and physical/ergonomic related hazards (Bakia, 2013; Lu, 2012; Ngure et al., 2014; Ogola et al., 2002; Shen & Gunson, 2006; Tomicic et al., 2011; Tschakert & Singha, 2007). This is because miners as well as mine owners are often ignorant about good mining practices and safety culture (Elenge et al., 2011). It is notable that Smith et al. (2016) and Bansah et al. (2016) corroborate this viewpoint, after revealing that ASM sites are characterised by lack of safety measures, insufficient OHS training and capacity building, inept policies and procedures, cultural perceptions, unenforced regulations if legislated, illegal and informal nature of activities, poor equipment as well as lack of expertise.

While the overarching objective of this research is to investigate the recordable injuries that occurred during ASM operation, contributing risk factors and the accompanying ramifications suffered by injured persons and their families, the researcher briefly succinctly discussed other hazards and related health risks. This is intended to increase the understanding that ASM is indeed important, but it has also negatively affected the wellbeing of miners and surrounding communities. The information is critical for sustainable policy development that protects the miners, communities and even the environment.

#### 2.4.1 Chemical risks

The use of chemicals in processing of mineral or metal mined through ASM technique has been shown to cause various health problems (Charles et al., 2013; Gardner et al., 2010; Male et al., 2013; Pegg, 2006; Van Brussel et al., 2016). Potential Harmful Elements (PHE) such as mercury, arsenic, lead, cyanide etc., are commonly employed during the mining process. Congruently, an unsafe use of these PHEs exposes miners and nearby communities to contaminated levels, thereby resulting in neurological, autoimmune, kidney and respiratory impairments (World Health Organisation [WHO], 2016). In the Migori County of Kenya, Ogola et al. (2002), Odumo et al. (2011) and Ngure et al. (2014) analysed human health-related problems associated with the ASGM chemical used in the processing, by collecting soil/water samples as well as by conducting visual observation and interviews. These researches found elevated level of PHEs, which eventually led to various health problems.

Even though several chemicals are available and utilised during ASM activities, a lot of sites tend to prefer mercury. Over 50 developing countries are known to use mercury for the amalgamation process involving gold (Tschakert & Singha, 2007). The preferential adoption of mercury attributed to its simplicity, inexpensiveness, effectiveness, and ease (Hinton et al., 2003). These authors acknowledged that mercury does not require specialised skills, thus rendering it an attractive option. On the negative side, mercury contributes significantly to atmospheric emissions (i.e., 37% of global emissions) and causes a number of health problems to miners and surrounding communities (Basu et al., 2015). Correspondingly, biological mediated reactions transformed mercury into poisonous methylmercury, which can then be transported into aquatics systems, and if consumed, lead to health problems (Arifin et al., 2015; Baeuml et al., 2011; van Straaten, 2000; Webster, 2012). Mercury can be inhaled, absorbed or consumed from contaminated food sources by humans (Ogola et al., 2002; Bose-O'reilly et al., 2016).

In his studies, Tomicic et al. (2011) found that when humans are exposed to mercury, they exhibit several symptoms such as headaches, sleep disorder, dizziness, wounds/irritation of mouth, walking difficult, vision disorder, trembling, persistent cough, thoracic pain and rhinitis. Correspondingly, Yard et al. (2012) identified symptoms that were comparable to those of Tomicic et al. (2011) in addition to kidney dysfunction among gold miners in Madre de Dios. The findings of another study conducted by Gibb and Leary (2014) reveal that individuals have suffered from neurologic effects such as tremor, memory problems, and vision disorder after conducting a comprehensive review of mercury-related health problems in ASGM communities.

### 2.4.2 Biological risks

The risk of infectious, waterborne, and vector-borne diseases in mining has been well documented in several literatures (Eisler, 2003). Correspondingly, Douine et al. (2018) assessed the quality of life and health problems confronted by illegal gold miners in French Guiana. This research used survey questionnaires to collect information on quality of life on mine site, health problems, as well as medical history. This study only included participants who were over 18 years old, worked in illegal gold mining activity, and had being at site for at least seven days. The collected dataset was analysed using descriptive statistics and bivariate analysis. The results of the analysis revealed that illegal gold miners suffered from serious non-communicable and communicable diseases such as malaria, leishmaniasis, dengue or chikungunya, digestive disorders as well as high blood pressure (HBP) that spread beyond mining area.

Congruently, Sagaon-Teyssie et al. (2017) assessed the prevalence of HIV and factors associated with HIV seropositive among the population living and working at the informal artisanal small-scale gold mining (IASGM) site of Kokoyo in Mali. The research applied quantitative survey to determine the prevalent risk factors. In addition, qualitative survey carried out to understand participants' views on sexual practices and concomitant preventions. The research found that 8% of 224 miners were HIV positive, which is relatively higher than Malian national prevalence of 1.3% estimated in 2015.

Another study by Basu et al. (2015) investigated and complied a report about the health problems faced by Ghana-based the artisanal and small-scale gold miners. This research cited numerous health problems faced by miners, which also included infectious and contagious diseases. The prevalent of biological health risks have been identified by a plethora of studies in sub-Saharan African countries (Arthur et al., 2016; Bakia, 2013; Labonne, 1996; Noetstaller, 1987; Smith et al., 2016; Zvarivadza, 2018).

#### 2.4.3 Psycho-social risks

In addition to chemical and biological hazards and associated illnesses, published literatures have also cited the widespread drug usage, alcohol consumption, and other undesirable psycho-social activities in ASM operation (Basu et al., 2015). A review of the health risks associated with gold mining in Australia, North America, South America, and Africa has found excessive use of alcohol and drugs in mining areas (Eisler, 2003). In Burkina Faso, Werthmann (2009) revealed that in particular, female miners, including young girls, were exposed to sexual harassment, exploitation, lack of schooling, violence, etc. In another study, Grätz (2009) found that societal ailments such as prostitution, thuggery, and violence were prevalent in the mining communities of Northern Benin.

#### 2.4.4 Personal injuries

Beyond occupational illnesses, the most direct imperilment of ASM operation is the risk of personal injury faced by mineworkers themselves (Casey, 2019). A number of ASM activities have a widespread presence of uncontrolled physical and ergonomic hazards, which often causes a prevalence of injuries (Buadee et al., 2018; Arthur et al., 2016; Smith et al., 2016). A study that investigates the various ASM-related health problems and safety practices in Wassa West District of the Western Region, Ghana found that 47% of 135 small-scale gold miners suffered personal injuries of varying nature and degrees over a 10 years period (Dorgbetor, 2005). Similarly, in year 2019, up to 39 ASM operators were killed in a single accident event after a copper and cobalt mine owned by Glencore collapsed in southeast Congo (Bujakera, 2019). The accident occurred after miners illegally entered the mine and the old terraces sidewall cracked, thus causing significant rock-falls.

The term injury refers to body lesion, which is caused by a sudden exposure to hazards (Gururaj, 2005). The occupational injury is distinguished from other health problems by causal factors, like, the acuteness of event, degree of severity, and potential of repetitiveness (Gururaj, 2005).

Although the occurrence of injuries is acknowledged in the literatures, only limited scholarly literature so far has focused on injuries characterisation and associated causes. The extensive search of various databases yielded only eight recent research publications outside Kenya. Table 2.1 illustrates the summaries of studies that are specifically related to ASM operation.

Table 2. 1 Summary of the studies explicit to ASM Operation that have investigated occupational injuries.

| References, Country | Aim | Material and Methods | Key Findings | Limitation |
|---|---|---|---|---|
| 1. Nakua et al. (2019b), Ghana. | This study aimed to determine the potential risk factors for injury, injury rate and miners' safety perception. | The study recruited 494 artisanal and small-scale miners between June 2015 to August 2016. This used household-based approach to select representative samples. The systematic random sampling was applied to select household and participants to be interview. The authors used the descriptive statistics to summarize the data, Chi Square test and Fisher exact test in order to test the relationship between the categorical variables, and univariate and multivariable logistic regression models to predict risk factors for injury. | The findings showed that 59% (289 per 1000 miners) suffers mining-related injuries annually. About 45.5%, 39.8% and 14.7% of injured miners had contusion, laceration and fracture injuries respectively. In addition, the commonly injured parts were leg (41.3%), arms (24.5%) and head (14.0%). These injuries were caused by machinery/tool (46.1%), followed slip and falls (32.2%). Majority of the injuries were classified as severe (37.1%), moderate (30.0% and minor (32.9%).<br><br>They also found that middle-aged miners, miners with middle and secondary school qualification were the risk factors for mining-related injuries. | Though this research attempted to provide injury history and risk factors for injury, the research design failed to support the findings. The overall target population was not stated, which raised concerns about the sample representativeness and calculated injury rate. In addition, there is no reason was provided to explain why some miners had minor, moderate and severe injuries. |

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| 2. Lu (2017), Philippines. | This research aimed to understand the safety hazards faced by small-scale miners in one of the largest operations in Itogon, Benguet. | The research recruited 93 miners from a small-scale mine in the area. The research used a combination of survey questionnaires, health physical examination guide, and work process observation tool to capture information about the hazards and associated health problems.<br><br>The data was analysed using the descriptive statistics such as frequency and percentages. | The results revealed that 31.2% of the participants involved in accident, and major physical injuries were laceration (47.8%) and fracture injuries (17.4%). | The risk factors beyond physical hazards were not examined. The bodily locations of injuries were not cited. In addition, there was no mentioned of severity of injuries. Therefore, this research results cannot be generalised. |
| 3. Calys-Tagoe et al. (2015), Ghana. | This research aimed to o characterize ASGM-related related injuries and associated risk factors in Tarkwa region so that the government can develop injury prevention and protection policies. | This research recruited 404 of miners from 5 licensed and 4 unlicensed sites. The injuries that occurred in preceding 10 years were included in the survey. Using simple random sampling for licenced sites and concept of ‘contact zones’ for unlicensed sites to select | The results showed that about 23.5% of 404 gold miners had experienced severe injuries over the last 10 years that led to lost workdays and functional limitations. The breakdown of injury frequency showed that 78.9% of 95 injured miners had single injury episode in this 10-year period. Of the recorded 121 events, 57% were laceration injuries, followed by puncture wound with | The simple random sampling approach and creation of contacts to select participants showed that occupational injuries in this study were generated by chance. This impacted the evaluation of risk factors for occupational injuries.<br><br>The research obtained information on education level, sex and alcohol consumption, but it did not elucidate |

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| | | participants, a structured, paper-based, interviewer-administered questionnaire was used to elicit information related to socio-demographic characteristics, work activities and duration, injury history as well as training and miner's perception about safety.<br><br>The survey data was analysed using both descriptive statistics and inferential statistics such as Pearson's Chi-square and ANOVAs. | 13% and abrasion with 11%. Also, 70% of the injuries were located in the upper and lower limb of the body and most of them were attributed to falling object and handling of tools/machinery. The research also showed that only 15.7% are not injuries related to lost time.<br><br>Regarding the influencing risk factors beyond physical hazards, the researchers showed that participants' gender and mining experience, and not age was associated with occurrence of injury. | whether they influence occurrence of injuries. |
| 4. Long et al. (2015), Ghana. | The study investigated artisanal and small-scale gold mining related accidents, injuries, and potentially related risk factors that occurred in a legally registered community operation in the Upper | The research divided the community into 20 clusters of about 20 households each, with all individual households assigning an identifier. Then, a random sampling approach was applied, whereby the numbers were pulled out from the bag | The research results showed that 45.5% and 38.5% of the miners suffered a single injury episode. In addition, only 25% of the injured miners had experienced work injuries relating to lost time.<br><br>The research also showed that cut/laceration (43.8%), contusion/abrasion (21.9%) and non-specific injuries such as bruises (31.2% | Because this research was household- based study, some households with higher number injured persons were potentially missed during the random selection. Thus, the number of injured was obtained by chance.<br><br>Furthermore, the research did not focus on injuries that resulted in lost workdays which |

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| | Eastern region. | randomly. A structured interview questionnaire was administered to each household. The data collection was implemented in 2011, after which a follow-up interview was conducted in 2013. The research recruited 173 participants in 2011 and 22 participants in 2013.<br><br>The collected data was subjected to descriptive statistics for frequency distribution. Meanwhile, binary logistic regression analysis was used to test association between the occurrence of injury and various risk factors. | were common among injured miners. These injuries were mostly located in the lower limb (lower limbs (legs and feet) and primarily attributed to object.<br><br>The analysis of risk factors for occurrence of injury showed that only males and smokers had a statistical association, but not the rest of demographic characteristics. | have serious post-injury impacts.<br><br>In addition, this longitude study seems to suggest that occupational did decline from 2011 to 2013. However, considering the samples that consented to participant again in 2013, the results of the research cannot be generalised. |
| 5. Kyeremateng-Amoah and Clarke (2015), Ghana. | To investigate the nature of injuries that happened in ASGM. | The author reviewed medical records of artisanal and small-scale miners that have visited one of Ghanaian’s district hospitals emergency department | The research found 72 cases of ASM-related injuries in the hospital record. Fractures and contusion injuries (67%) frequently suffered by the artisanal and small-scale miners who visited the hospital and were largely caused | The research did not specify the affected areas of the body. In addition, the research merely summarised the cases without adequate analysis. Moreover, not all cases of mining injuries were reported, as the |

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| | | from 2006-2013 and subject the data to descriptive statistics. | by falls (25%), followed by mine collapse entrapment (22.2%) and crushing (19.4%). Also, the research revealed that 10% of the patients were admitted, 59.4% treated and discharged, 27.8% referred for advanced care and 2.8% died on arrival. | activity is largely practiced in rural areas with limited health facilities. Although the research has provided a clear indication of the severity of injuries, these results cannot be generalised. |
| 6. Boniface et al. (2013), Tanzania. | Research was aimed to investigate the risk factors associated with injuries and fatalities among the miners working in the Mererani Tanzanite Mines in, Tanzania. | This research used a cross-sectional survey for those who visited the local health facility between January 2009 and May 2012. The structured questionnaire survey was face-to-face interview administered to participants, with the assistance of medical records. The data was analysed using descriptive statistics and bivariate analysis. | The research found 248 cases of small-scale mining related injuries, of which 8.1% of the patient were admitted, 19.4% medicated and discharged, 31.2% required high care and 41.3% died before reaching the hospital. Majority of them sustained multiple injuries (33.3%), cut/open wounds 19.1%, and head/neck injuries 17.9%. Causes included rock falls (18.2%), blasting (16.9%), slip/trip fall (16.1%), and suffocation (13.2%), and assault (13.2%).<br><br>The risk factors for occurrence of injury were: Young age group, working for more than 12 hours per day, and less than five years of mining experience. Level of education was significant but the descriptive showed that | Not all severe cases of injuries are reported in the hospital, as most mining sites are located in the rural villages where medical facilities are located in remote areas. In addition, there was no information about the number of ASM miners to be able to infer the prevalent levels.<br><br>In addition, the study only focused on demographic characteristic without assessing participants' perception about work conditions and mine management. |

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| | | | primary school education had high odds or fatality. | |
| 7. Babatunde (2013), Nigeria. | Study evaluated the practice of occupational health and safety among the artisanal mineworkers in the rural mining community of Ijero-Ekiti in Ekiti State, Nigeria. | The author invited an estimated total of 143 miners, of which 127 consented to participate in the research. During the data collection, only 118 mine workers met age selection criteria and were administered semi-structured quantitative survey questionnaire. | The research showed that 45.8% of 118 respondents had suffered physical injuries. | This study did not provide detailed information on the causes of physical injuries or statistically examined various risk factors. Overall, the study was predominantly descriptive. |
| 8. Elenge et al. (2013), Democratic Republic of Congo (DRC). | Study aimed to determine the rate of occupational accidents among the artisanal and small-scale miners in Katanga Region. | The research employed systematic random sampling technique to select 180 participants from the prepared listed of 394 mineworkers and administered Kiswahili translated structured survey questionnaires in the mining area of Katanga, D.R.C. Congo. The data was subjected to both descriptive statistics and Pearson | This research found that about 72.2% and 60% of the sampled population had experienced at least one and two accidents respectively in preceding 12 months. The study also revealed that about 430 lesions were reported by those that have experienced at least one accident. The frequently occurring injuries were bruise, wounds (22.7%), and were distributed in the upper limbs (25.3% and lower limbs (14.2%). The most commonly physical hazards causation | The research design did not allow for segregation of representative samples into those that have experienced accident and those who did not. As a result, they findings cannot be generalised. |

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| | | chi-square. | cited by the participants were tools handling (51.5%), handling heavy loads (32.9%) and falls (11.5%). As per this study, some injured participants were carried by the family or Red Cross Medical Units (RCMU) and analysis of lost workdays showed that some individuals with wound injuries had stopped working for three days or as more compared to contusion. | |

#### 2.4.4.1 *Risk factors for injury occurrence*

Although many accident causation theories have been propounded over the years, this research adopted "epidemiological triad framework" using the agent-host-environment model as well as "Anatomy of event" to guide the search for literatures and subsequently assess the risk factors associated with injury occurrence in ASM operation (CDCP, 2012). The concept of anatomy of event has been discussed in Chapter 6.

According to the epidemiological triad model, the susceptible host and external agent only cause injury collectively if there is an appropriate environment. This model was traditionally developed for determining the causes of infectious diseases but then evolved over time to include injury and other health problems (CDCP, 2012). William Haddon was the first epidemiologist to contend that injury can be examined within an epidemiologic framework. He insisted that the agent-host-environment interaction are key in development of injury (Songer, 2008). In this research, attention was placed on to the sector hazardousness and characteristics of miners. As a result, the physical and ergonomic hazards were identified as agents, while host factors were classified as individual characteristics and behavioural risk factors. Meanwhile, environmental factors were highlighted as job-related risk factors, as conceptualised in Figure 2.1

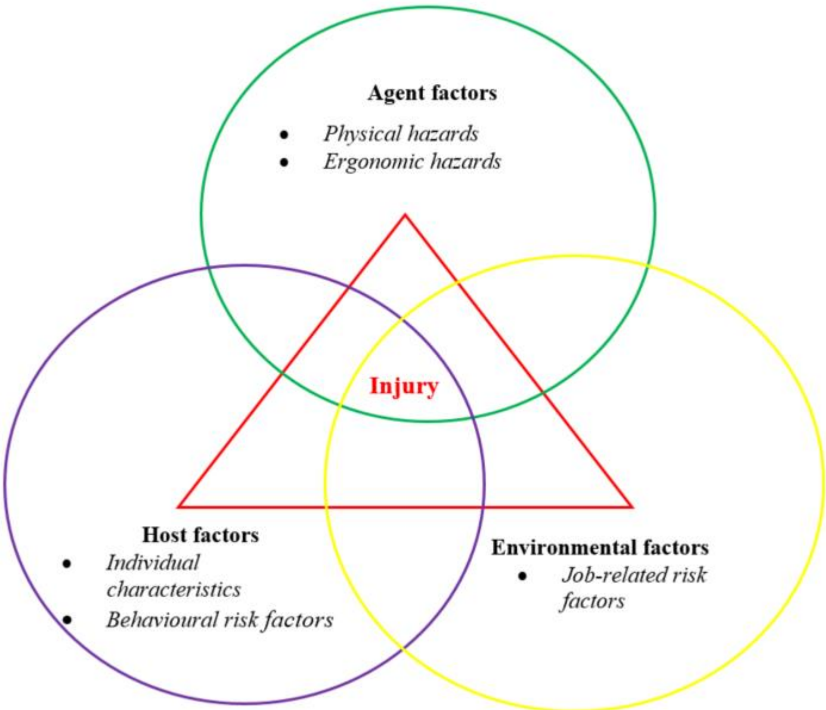


Figure 2. 1 Epidemiological triad model for causes of occupational injury.

#### *2.4.4.1.1 Agent Factors*

In the traditional epidemiologic triangle model, the agent refers to the microorganism or pathogen that causes infectious diseases. However, over time, the concept of agent has been widened to include physical causes of injuries (CDCP, 2012). The nature of physical exposure determines both the type of injury and the relative level of severity. The exposure to agents causing physical injuries are broadly classified into two: physical and ergonomic hazards.

<u>Physical hazards exposure</u>

The narrative of physical hazards-injury fit has been well established in extant literature. ASM, like many other riskier industries in developing countries, has had its fair share of injuries. The ILO has recorded that small-scale miners have higher risk of experiencing occupational injuries as compared to their large-scale counterparts (ILO, 1999). This finding was confirmed by a recent conducted study by Nakua et al. (2019b) in Ghana, which reported increased injury risk among the informal miners. Jennings (1999) cited the common hazards that cause injury in ASM as obsolete and poorly maintained equipment, lack of training, lack of ventilation and misuse of explosives, rock falls, subsidence, lack of knowledge and violation of regulations. Additionally, Donoghue (2004) mentioned other mining-related physical hazards such as falling from height, electrocution, entrapment, and flooding of underground workings.

<u>*Ergonomic hazards exposure*</u>

The ergonomic hazards are known to be responsible for work-related musculoskeletal disorders (WMSDs). Jerie (2013) examined the ergonomic hazards associated with Southern African small-scale mining (SSM) activities. This research applied ergonomic principles that involved assessing the complex relationship between people, physical and psychological aspects of the work environment with a view to optimizing the comfort, health and safety of workers. The research reported that SSM activities are conducted in restricted areas with low ceilings wherein miners were exposed to physically demanding tasks and high thermal heat loads on a daily basis. The author also identified the presence of ergonomic disorders among the miners, which resulted from awkward working postures, plenty of manual material handling (MMH) activities, and repetitive tasks and motions. In this research, the author advocated for the load handling ability, training as well as ergonomic working redesign to prevent injuries.

In her study on ergonomic and injuries associated with SSM activity in Philippine, Lu et al.

(2017) found that miners were required to undergo the following experiences: prolonged crouching and bending, prolonged handling of tools, and carrying heavy sacks filled with mineral ores. The analysis of injuries showed that most miners reported muscle pain, thus indicating ergonomic hazards and risks. This research recruited 193 small-scale miners in one of the largest SSM area in the Philippines. The study employed a combination of survey questionnaires, health physical examination guide, as well as work process observation tools in order to capture information on ergonomic and safety hazards.

Correspondingly, Elenge and colleague et al. (2011) conducted hazards identification and analysis in order to develop a better understanding of health risks in ASM activity. As per the findings, those who worked in loading area were exposed to injury risks. These results confirmed that working in this type of mining industry exposed miners to a number of ergonomic-related risk factors.

#### *2.4.4.1.2 Host factors*

In the epidemiologic triad, the host refers to the worker or miner who is exposed to either agents or hazards. The host factors, also referred to as intrinsic risk factors, are the individual and behavioural characteristics that interact with the agent within the right environment to cause injury (CDCP, 2012). In this research: age, gender, marital status, education level, mining experience, alcohol consumption and drug usage are the host factors, and are discussed in the next literature review section.

#### *2.4.4.1.3 Environmental factors*

Environmental factors are known to cause occupational injury, commonly referred to as extrinsic factors (CDCP, 2012). The extrinsic factors are the physical working environment and organisational structure (CDCP, 2012). The review of a number of publications revealed job-related risk factors were considered as extrinsic factors that caused occupational injury, as long as there is an interaction between an agent and host (worker). The extrinsic factors of interest for this research are as follows: (i) shift hours, (ii) poor working conditions, (iii) poor management and supervision, (iv) job dissatisfaction, and (v) job stress. These extrinsic factors were chosen because of their alignment with ASM operation, and are discussed in literature review part 2.

#### 2.4.4.2 *Post-injury economic and social consequences*

The consequences of occupational injuries include medical care services, absenteeism, disabilities, death, loss of waged time, and reduced productivity (Bhattacherjee & Kunar, 2016). While occupational injuries can directly or indirectly affect several parties such as employers, communities, health insurance companies etc. (Boden et al., 2001; Camm & Girard-Dwyer, 2005, Dembe, 2001), this research narrows its focus on the experiences of injured persons as well as their families.

##### 2.4.4.2.1 *Injured person returns to work*

As discussed before, ASM activity is an alternative or complementary source of living for the most vulnerable population. The majority of these individuals worked on a causal basis, and lacked compensations/insurances. Therefore, their ability to return-to-work (RTW) quick assumes critical significance for livelihood. Several factors such as injury severity, psychological distress, personal characteristics, environmental factors, and economic situation of the injured person determined the RTW (Bhattacherjee & Kunar, 2016; Cancelliere et al., 2016; Fry, 2002; Howard, 1998; Mackenzie et al., 1998; Mackenzie et al., 1987). RTW is "the duration or extent of an inability to work due to impaired health or functional limitation" (Krause et al., 2001, p.465).

The relative level of injury severity has been associated with the ability of injured workers to RTW and perform effectively (Hepp et al., 2013). In a systematic review of 94 extant publications on RTW, Cancelliere et al. (2016) established that lower severe injuries were indeed positively related to RTW. Put succinctly, individuals with minor injuries always return to their jobs quicker than severely injured persons. Another study carried out by Bhattacherjee et al. (2016), also observed that seriously injured coal miners had a higher mean time for return to work (MTRW) (72 days) after assessing the factors for RTW among 109 injured Indian coal miners between 2000 and 2009. This is attributed to the fact that lower severity injuries do not cause high pain and disability. Additionally, they are less likely to cause activity limitation and performance restriction. As a result, employers or management are more willing to accommodate them more quickly as compared to severely injured persons.

Injured workers experiencing psychological distress eventually experience extended loss time from work and curtailed chances of RTW (Davydow et al., 2009; Howard, 1998; Mackenzie et al., 1987). Studies have shown that anxiety, depression, post-traumatic stress disorder (PTSD) and partial post-traumatic stress disorder (PPTSD) are common ramifications of occupational injuries (Chin et al., 2017; Ghisi et al., 2013; Lin et al., 2012). Most of the injured workers are sometime impelled to completely abandon working or opt for lower paying jobs with the aim of sustaining their families. Consequently, some are unable to find jobs, as witnessed in the case of the Chilean miners, where a majority of the 33 rescued miners were facing difficulties making ends meet even after the catastrophic incident (Chamber, 2015). A report by Boyette (2015) shows that the miners have had difficulties finding work opportunities and are forced to depend on government pension that pays them half the amount they used to make while working at the mine.

According to Zhang (2014), a declined psychological function among the miners significantly dilutes their interest and inclination to work. Psychological theories states that an increase in psychological stress inevitably leads to reduced psychological functions. As a result, the miners experience distracted attention and reduced levels of consciousness. The negative physiological responses have also been shown to result in reduced strength, sense, mental and memory disorders, and a stiffened body.

The personal characteristics such as age and gender of injured persons also play a crucial role in determining the duration of recovery and RTW (Bhattacherjee & Kunar, 2016). As will be discussed in literature review part 2, some studies suggested that older workers and female gender tend to suffer severe injuries, which is why their RTW duration is lengthy. Whereas, others established that younger workers and male gender tend to have high severity of injury. Irrespectively of the argument, the central point is that the individual's age and gender are directly associated with RTW.

Additionally, it has been corroborated that environmental factors such as work conditions, social support and accommodation contributed to a delay or accelerated RTW of the injured person (Brewin et al., 1983; Cancelliere et al., 2016; Hunter et al., 1998). In the qualitative analysis of prognostic environmental and personal factors supporting earlier return to work, it was found that positive perception about work conditions, social support from family members, belief that work is good for health and job accommodation/encouragement from the various stakeholders (co-workers, employers etc.,) inspired the injured person to return to work sooner than expected (Hoefsmit et al., 2014).

Regarding the economic position of the injured person, published literature have shown that economic conditions support earlier RTW. Separately, Bhattacherjee and Kunar (2016) and Mackenzie et al. (1998) observed that poverty was a strong predictor of RTW. According to this author, lower incomes are associated with limited health insurance coverage and therefore, invariably restricts access to and appropriate use of rehabilitation. Thus, the RTW duration is often long compared with those from high earning positions that are in possession of the necessary insurance.

In contrast, a poor economic situation has been shown to compel injured miners to venture back into the activity before a full recovery earlier in order to sustain living, thus rendering them more vulnerable to injury. According to Boniface et al. (2013), some of the miners resumed work immediately after getting injured. Another study conducted by Floyd and Gallagher (1997) also found many injured individuals still reported back to work after the incident that caused injury due to financial constraints. They were also found to continue working in the mines, regardless of the trauma they went through. Injured workers were found to be in a different position to undertake or resume their previous duties (prior to the injury), thus compelling them to perform simpler tasks or even opt for a change of various individual work stations, in some cases.

#### *2.4.4.2.2 Economic consequences of occupational injuries*

According to a global statistic, about 2.3 million of occupational illnesses and injuries occur every year (Takala et al., 2014; ILO, 2019). According to economic perspectives, the global burden of occupational illnesses and injuries is $1.25 trillion per year based on the calculation cost of 4% of the worldwide gross domestic product (GDP) (Camm & Girard-Dwyer, 2005). On individual and family domain, occupational injury can affect their livelihood/household income which, in turn, pushes them into financial hardships, leading to a significant risk of impoverishment (Nguyen et al., 2013).

Generally, miners in developing countries are subjected to low pay and lack insurance coverages. According to Bhattacherjee and Kunar (2016), lower income is attributed to the paucity of adequate health insurance coverages to cater for the injuries incurred. Additionally, it has a detrimental impact on their social life. Low incomes also affect the injured miners by limiting their ability to utilize rehabilitation to regain their strength, thus enabling them to go back to work. As a result, they ae subjected to physiological health issues for the rest of their lives.

A study conducted by Reville (2001) found that private and social insurance help to mitigate the financial ramifications of workplace injuries on families, albeit with limited success. Mendelson (2003) noted in their discussion that most workplace injuries are resolved within an appropriate time-frame. The discussion also pointed out that in the pain management field, the outcomes of patients who were being treated for a given problem under a worker's compensation scheme were poorer than those being treated for the same problem in a non-compensation environment.

Mine management across the globe have failed to support ex-workers following injuries. Additionally, they fail to take duly consider whether or not the needs of the injured workers have been met. In this context, there is a strong need to enhance the service delivery among mine management in regard to social, health and rehabilitation services. Additionally, there is a need to enhance access to compensation and additional social protection benefits because the lack of compensation leads to poor health outcomes among the injured individuals and their families (Bhattacherjee & Kunar, 2016). Despite the acknowledged limitation with insurance and compensation, the fact of the matter remains that these assistances provide injured miners with a means to cover for medical, pharmaceutical and living expenses post-injury.

The extended duration of RTW and lack of earnings/assistance from the management of the mines impels miners to rely on their family for health care and other support. Family members play a crucial role in the aftermath of an injury by providing support (Mock et al., 2003; Morrow et al., 2014). They alleviate the burden imposed on the injured person by engaging in tasks on their behalf. Family members also provide these patients with the much-needed emotional support. The post injury period is particularly sensitive and requires someone to talk with and listen to the injured person. In his article, Mason Ellis posited that the support system of family, friends, and caregivers after an injury is very vital to recovery and adaptation to a new life (Ellis, 2017). He also added that family relationships and support from friends was of prime importance to the financial and emotional wellbeing of the injured person (Ellis, 2017).

Strunin and Boden (2004) revealed that workers with back problems experienced challenges in participating fully or partially in some of family roles. In the instances of a married couple, the study found out that in case the husband was injured, in most cases, the wife was forced to take up the role of a care giver to the injured and meet the family's basic financial needs.  Evidently, this is found to enhance the health and function ability of the injured person. In that context, the impact of injuries on family livelihoods has been examined by a number of studies.

A study conducted by Subramanian (1991) indicated that the impacts of injuries at work were similar to those of non-work related in most cases. The study acknowledged the finance difficulty faced by the family of the injured person poses a great threat to their savings' life, which makes it difficult for these families to save some money for future expenses. Meanwhile, a study from Proctor (2001) showed that in a single parent family, the impacts of the injuries are particularly adverse as the family's earnings gets seriously stymied, thus making it difficult to meet the basic needs of the family.

The survey conducted by Kalyani et al. (2015) on the impact of injury to family properties indicated that the expenses are generally excessively high after an injury and thus, has an adverse impact on the economic condition of the injured person's family. To cover up the costs, the family, in many cases, is forced by circumstances to mortgage or even sell off some or all of its properties to help settle the expense. Morse et al. (1998) revealed in their study that large losses associated with injuries were found to lead workers to sell their cars, change their residents in a less-expensive area, or even sell their homes in order to cover up and adapt to the change in income.

Due to family's declining economic position, the quality of life is also significantly affected. Hensler et al. (2001) found that upon injuries, the families' income was found to be reduced, as a result of which family activities such as market work was also affected since the injured had to be given care. Due to the high expenses associated with the maintenance of injured persons, the family was found to be struggling with debts in most cases. The Hensler et al. (2001) study also found that large financial losses led the family of the injured worker or the worker himself/herself to borrow funds in order to help lessen the burden of expenses.

Cantor's (2001) study on the effect of injury on medical expenses revealed that family income was suffering due to reduced work. In turn, these impacts were found to be directly affecting both the injured worker and the family. This resulted in time squeezed for the family, which was then forced to sell any of its property to cater for the expenses due to reduced work time.

##### *2.4.4.2.3 Social consequences*

The economic consequence is not the only burden suffered by the injured persons and their families. A substantial body of literature demonstrates that the social consequences also affect their quality of life. In this context, Dembe et al. (2001) developed a conceptual framework for identifying and analysing "unseen" social consequences of occupational illnesses and injuries.

The model demonstrated that the investigation of the social consequences can be a complex process owing to an intricate web of relationships between different domains level (i.e., individuals, group and social institutions). The manifestation of the consequences is determined by the domain levels and processes of interaction. For example, in the domain of individuals and family, the social consequences include family breakdown, excessive use of alcohol and drugs, low self-esteem and self-confident, stigmatisation, stress, depression etc., (Boden et al., 2001; Kim, 2013; Lax & Klein, 2008).

Psychological impacts

Coping with an accident is found to have a significant inverse-ratio effect on the miner's psychological stress. Miners who were involved in accidents pointed out that this significantly affected their social and mental life. Chang (2009) observed that workers suffering from industrial accidents had significantly high levels of anxiety and depression. Correspondingly, Choi (2002) posited that the prevalence of post-traumatic stress disorder (PTSD) among individuals who were involved in accidents or injury was high, and that the symptoms persisted for a long time. The findings collected on depression were also corroborated in a study conducted by Kang et al. (2017), whereby the participants complained of feeling uneasy, having trouble sleeping, and irritability. They were also found to have recurring memories of the accident. Additionally, the study participants frequently ruminated on debilitating feelings of guilt, shock and fear.

Beedie et al. (2000) revealed that negative mood states, such as depression (feelings of hopelessness and worthlessness), fatigue (feelings of mental and physical over-exertion), confusion (feelings of bewilderment and uncertainty), anger (feelings of annoyance, aggravation, fury, and rage), and tension (feelings of nervousness, apprehension, and anxiety) have been associated with debilitated performance.

Impacts on relationship

A linkage has been drawn between occupational injuries and relationship problems. A study conducted by Kang et al. (2017) shows that a majority of those affected by the accident felt a significant disconnect from other people. Consequently, this adversely impacted their journey of recovery since one of the ways to cope with their feelings entails involves talking to friends and relatives. To that end, Somer and Szwarcberg's (2001) study on the effect of an injury on social life indicated that in some cases, the injured person often requires hospitalisation and rehabilitation. These two cases were noted to be the beginning of separation from friends and family in that the mutual relationship was found to be on a different level after the injured person was discharged from the hospital or rehabilitation centre.

Mining accidents also lead to significant effects among those affected and their family relations. While these accidents have also been found to bring families closer among survivors, there have been cases where they drive families further from each other. Chambers (2015) notes that the experience among the Chilean mine survivors took a toll on them. One of the miners in the report pointed out that his personality changed after the traumatizing experience. He defined his previous life as someone who loved socializing with friends and family. However, he now prefers to be alone. The effects of this experiences are found to affect the miner's social lives five years down the line. A majority of the 33 miners from the Chilean accident are reported to struggle with psychological scars from the entrapment that they experienced. Consequently, the experience has adversely impacted the ability of some of them to maintain jobs.

## 2.5 Summary

The literature review part 1 has provided fundamental reasons as to why millions of men, women and children are engaged in ASM activities. The sector is a livelihood strategy for poor people and a source of income for business-minded individuals. Despite these benefits, ASM poses a significant health risk to miners and proximate communities. This chapter demonstrated that ASM activity is infested with chemical, biological, psychosocial, ergonomic and physical hazards, which, in turn, poses serious occupational illnesses and injuries to miners and adjacent communities.

Amongst ASM-related health problems, occupational injury has been under-researched despite being a frequent phenomenon. In Kenya, no publication so far has been found to have examined the likelihood, frequency and severity of ASM-related injuries despite numerous reported by several media houses (Otieno, 2018; Kingwara, 2018; Ngechu, 2015; Nandiemo, 2018; Juma, 2017; Ndungu, 2015; Adinasi, 2014; Abuga, 2018). According to these news outlets, accidental injuries are common with varying degree of severities, and are mainly attributed to poor OSH.

The search of published literature outside Kenya returned a handful of publications. Although these studies have highlighted the presence of occupational injuries, their results cannot be generalised due to flaws in their methodologies. In addition, risk factors beyond physical hazards have not yet been sufficiently evaluated. It is noteworthy that some of these studies found certain individual characteristics to facilitate ASM-related injuries (Calys-Tagoe et al., 2015; Elenge et al., 2013; Nakua et al., 2019b), while others did not attempt to investigate the relationship (Kyeremateng-Amoah & Clarke, 2015; Lu, 2017). Moreover, literature review from other industries showed that agent-host-environment factors interaction facilitate the occurrence of occupational injuries (Amponsah-Tawiah et al., 2013; Burgard & Lin, 2013; Chimamise et al., 2013; Cui et al., 2015; Ghosh et al., 2004; Stojadinović et al., 2012). However, the combined effect of numerous risk factors identified from literature remained under-researched in other industries.

Another area that was explored while searching research studies was the economic and social challenges faced by the severely injured ASM miners. Surprisingly, not much literature was found on post-injury consequences and management despite the identified prevalence of ASM-related injuries. Only few studies had mentioned these issues, albeit without great attention.

Arthur et al. (2016) explored the relationship between the artisanal/small-scale mining and livelihood in Prestea Mining Region, Ghana by employing a cross-sectional mixed method survey involving random simple sampling as well as purposive sampling to recruit ASM mineworkers. The findings suggest that the driving factors that influence people to undertake ASM also “triggers induced vulnerability” such as ASM-related accidents and negatives health outcomes, which adversely affect livelihood/household income (i.e., diseases, injuries etc.). The research stated that when a miner is injured or perishes due to accidents, their livelihood/household income tends to be directly impacted. However, further comprehensive analysis on what contributed to changes in injured person’s circumstances is required to draw better conclusions.

Smith et al. (2016) investigated health and safety risks facing ASM sector by applying a participatory action framework (PAR), taking into account the responses from three complementary data sources such as the following: surveys administered to ASM practitioners and scholars, data obtained from participants in short courses at the University of Queensland as well as the interaction between Mongolia’s mine inspectors and scholars from UQ. The research mentioned that when a miner is injured, the community shares the burden to care and provide for, whereas a family member (including children) might also step into the role. In agreement with the above findings, Elenge et al. (2013) revealed that injured miners were cared for by their families or colleagues as well as the Red Cross after the investigation of ASM accidents and associated injuries in the Katanga region of D.R.C.  This author did mention a "spill over" consequences but did not give an unambiguous indication on the economic and social consequences of the injured persons.

Against this backdrop, the current research addressed the above-mentioned knowledge gaps by focusing on ASM-related recordable injuries as well as by exploring economic and social ramifications suffered by injured persons and their families' post-injury. This research focused on recordable injury because this has a serious implication on the wellbeing of miners as well as their families.

The next chapter explicitly discusses the specific individual characteristics, behavioural risk factors and job-related risk factors that cause occupational injuries in the mining industry.

# PART TWO - THE CONTIBUTING EFFECTS OF INDIVIDUAL CHARACTERISTICS, BEHAVIOURAL AND JOB-RELATED ON OCURRENCE OF MINING-RELATED INJURIES: A SYSTEMATIC REVIEW

## 2.6 Overview

In Part One of Chapter 2, few peer-reviewed publications, which evinced the present and prevalent of occupational injuries in ASM operation, have appeared in last 6 years; however, the contributing effects of various risk factors beyond mechanism of causations (that is, hazards) have not been sufficiently studied. In table 2.1, only small number of the studies with opposing views have been shown to examine the consequences of factors such as age, gender, education, smoking, alcohol and experience on ASM-related injuries. Therefore, this literature review part 2 systematically reviews and discusses peer-reviewed studies that have researched certain individual characteristics, behavioural risk factors and job-related factors that contributed to occupational injuries in mining industry.

This literature review part 2 has been written inform of the research article in order to comprehensively discussed each step. Thus, establishing the current lacuna.

## 2.7 Abstract


**Background**

The recurrence of injuries in the mining industry, particularly in artisanal and small-scale mining (ASM) sector is area of concerns. However, the body of research currently available demonstrates a disparity in the focus on risk factors that cause injuries. The aim of literature review part 2 was to systematically review published studies that have investigated whether certain individual characteristics, behavioural factors and job-related factors predict occupational injuries in ASM and large-scale mining operation.

**Materials and Methods**

Databases were searched and peer-reviewed publications from 2004 to 2020 were retrieved and

analysed. From 3073 identified articles, only 24 were retained for review and synthesis following careful screening. The majority of identified studies were either cross-sectional or case-control studies, and were rated as moderate to good quality.

**Results**

The review results showed that there is a diverging view in relation to risk factors that causes mining-related injuries. Some publications suggested that old age, male miners, married miners, less educated, less experienced, alcohol and drug usage, poor working conditions, poor management/supervision, job dissatisfaction and job stress predict injury events while other studies found opposite relationships or insignificant statistical associations.

**Conclusions**

Despite studied risk factors having been well established in other industries, there is a significant gap in mining that needs further examination.

## 2.8 Introduction

Mining is one of the oldest and most important socio-economic activities in mineral-rich countries (Banerjee, 2015; Carvalho, 2017; Mason et al., 2014). For some nations, this industry forms the backbone of the economy, and for others, it equally acts as a complementary source of revenue (World Bank and International Finance Corporation [WBIFC], 2002), thus establishing its significance in the economic cycle. Presently, several multinational and local companies have invested billions of dollars for more explorations and developments, as well as for ensuring an increase in the productivity of the existing operations. The mining industry has seen increased research and advancement of OHS standards and management systems. Nevertheless, the sector continues to remain one of the most hazardous occupations.

It has been identified that in addition to chemical, biological and psychosocial health-related problems, the mining industry also exposes the miners to severe physical injuries (Donoghue, 2004). In fact, some miners in the ASM activity have been identified as having experienced injuries ranging from a simple cut to major traumas such as amputation and fractures (Ajith & Ghosh, 2019a; Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015; Nakua et al., 2019b). Similarly, large-scale mining operations have also reported cases, wherein miners sustained fatal and nonfatal injuries (DiChristopher, 2019; Bachelet, 2018; James & Sally, 2012).

Mining injuries can incur serious economic and social implications (Bhattacherjee & Kunar, 2016; Camm & Girard-Dwyer, 2005; Ivaz et al., 2018). A Chilean Miners case study showed that life following a tragedy can result in significant impairment difficulties. The 33 survivors from the mine indicated a significant strain on their financial situation after the incident. They also reported the emergence of adverse health issues that crucially impeded and caused complications in finding employment opportunities (Chambers, 2015). Similarly, a recently conducted study in Kenya revealed significant economic, as well as, social health and lifestyle changes among the seriously injured artisanal and small-scale gold miners (Ajith & Ghosh, 2019b).

Though various physical and ergonomic hazards have been blamed for recurrence of physical and musculoskeletal injuries, there are underlying factors that facilitated injury events (Dembe et al., 2004). Several theories have been developed and tested to explain the reasons behind the frequent occurrence of injuries in ASM and in the large-scale mining sector (Ajith & Ghosh, 2019b; Komljenovic et al., 2017). The researchers have answered these questions by examining various demographical and behavioural factors as well as organizational and job-related factors (Paul et al., 2005). Therefore, the aim of this literature review part 2 was to systematically review peer-reviewed published studies that have investigated the risk factors associated with injuries in ASM and large-scale mining sectors. Specifically, this literature review part 2 reviewed and discussed published papers on miners' age group, gender, marital status, education level, experience, alcohol consumption, drug usage, shift hours, perception about working conditions, management/supervision, job dissatisfaction and job stress. The results of this review will help to identify current lacuna in the literature, as well as advanced management of economic and social consequences in the context of injury prevention and post-injury. In addition, it will ascertain vulnerable groups that require primary interventions and outline areas for further research.

## 2.9 Materials and Methods

### 2.9.1 Search approach

The search for published literatures to be reviewed was guided by the following focus research questions:

1. Does young age, being male, married, less educated and less experienced predict the risk of occupational injuries in ASM operations as well as in the large-scale mining industries?
2. Does consumption of alcohol and usage of drugs as well as smoking of tobacco predict the risk of being injured in ASM operations as well as in the large-scale mining industries?
3. Does working for more than 8 hours, having poor perception about working conditions, poor management/supervision, being dissatisfied and experiencing job stress predict the occurrence of injuries in ASM operations as well as in the large-scale mining industries?

The publications to answer the above research questions were retrieved from electronic databases using the Curtin University Home Library and other sources. The search spanned the following databases: PsycInfo, Science Direct, SciFinder, Scopus, and Springerlink. A further search was conducted in PubMed and Informit. The literature search used the Medical Subject Headings (Mesh) and keywords such as 'occupational injury', 'risk factors', 'antecedents', 'contributing factors', 'work-related injuries', 'injury epidemiology', 'causes of injuries', 'risk factors of injuries', 'injury', 'demographic characteristics', 'individual characteristics', 'personal characteristics', 'mining injuries', 'job-related factors', 'behavioural factors', 'alcohol and drugs', 'substance abuse and injuries'.

### 2.9.2 Inclusion and exclusion criteria

Mining accidents have been heavily studied; however, our inclusion and exclusion of literatures was guided a by number of factors. The emphasis was studies that had investigated the occupational injuries in ASM as well as large-scale mining operation. The population in this study were mineworkers, and only studies conducted between 2004 and the present (2020) were considered. This period of time was chosen because the mining industry has seen improvements in technology and OHS during the past fifteen years, thus questioning the recurrence of mining-related injuries due to the same, or similar causes before this period of time.

Another inclusion criteria was the type of study conducted. We only included peer-reviewed cross-sectional, case-control, longitudinal, cohort and correlation studies. This is because cross-sectional studies provided the timeframe in which the data was collected either using the available records or implemented a survey within the specified period of time. Case-control studies compared and discussed the risk factors between the injured and uninjured group. While the others studies provide strong evident between the risk factors and occurrence of occupational injuries in ASM and large-scale mining. We excluded review articles, reports, and commentaries, unpublished or not peer-reviewed papers.

### 2.9.3 Study selection

The process of selecting articles followed four steps as shown in Figure 2.2. In Step 1 databases were searched using the 'search terms' which resulted in the identification of 3073 potential publications. The majority (2982 articles) of the 3073 articles were found to be irrelevant to the topic. Most of these papers did not specifically examined the risk factors of interest associated with occupational injuries in either ASM or the large-scale mining sector. As a result, they were removed at the title screening phase (initial phase). 91 articles made it to the abstract screening phase. In this stage, articles that were not original studies or duplicates as well as papers with invalid study population, no statistical analysis linking variables to occupational accidents or injuries, and not measuring variables of interest were removed. Thereby, 67 articles were excluded. In the final stage, 24 peer-reviewed published studies that met the selection criteria were included.

### 2.9.4 Data extraction and quality assessment.

The relevant information was extracted from 24 papers using the data extraction Microsoft Excel spreadsheet template developed by the author. This template was developed in accordance with the guidelines for strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (von Elm et al., 2014); for the purpose of consistency and uniformity during the review process (Roche et al., 2015). The STROBE Statement has 22 items designed to extract the data from the observational studies such as case-control, cohort, and cross-sectional studies (von Elm et al., 2014). In the template, the researcher captured from the 24 articles: citations and setting areas, aims/objectives, study population, sampling, variables and statistical analysis as well as providing a place for reviewers' comments.

The quality of the 24 studies included in the reviewed was evaluated according to the Newcastle-Ottawa Scale (NOS). This tool was explicitly designed to evaluate the quality of nonrandomized studies. Newcastle-Ottawa Scale content validity and inter-rater reliability was confirmed (Wells et al., 2000). NOS set out predefined criteria for case-control and cohort studies, but it has been further developed to include cross-sectional and longitudinal studies

(Eijkemans et al., 2012; Herzog et al., 2013). The quality of studies were assessed using the NOS criteria in Table 2.2 and 2.3.

## 2.10 Results

Figure 2.2 presents the results of identification, screening, eligibility and inclusion process. Published articles were identified, however, less than 1% were deemed suitable for full review and synthesis.

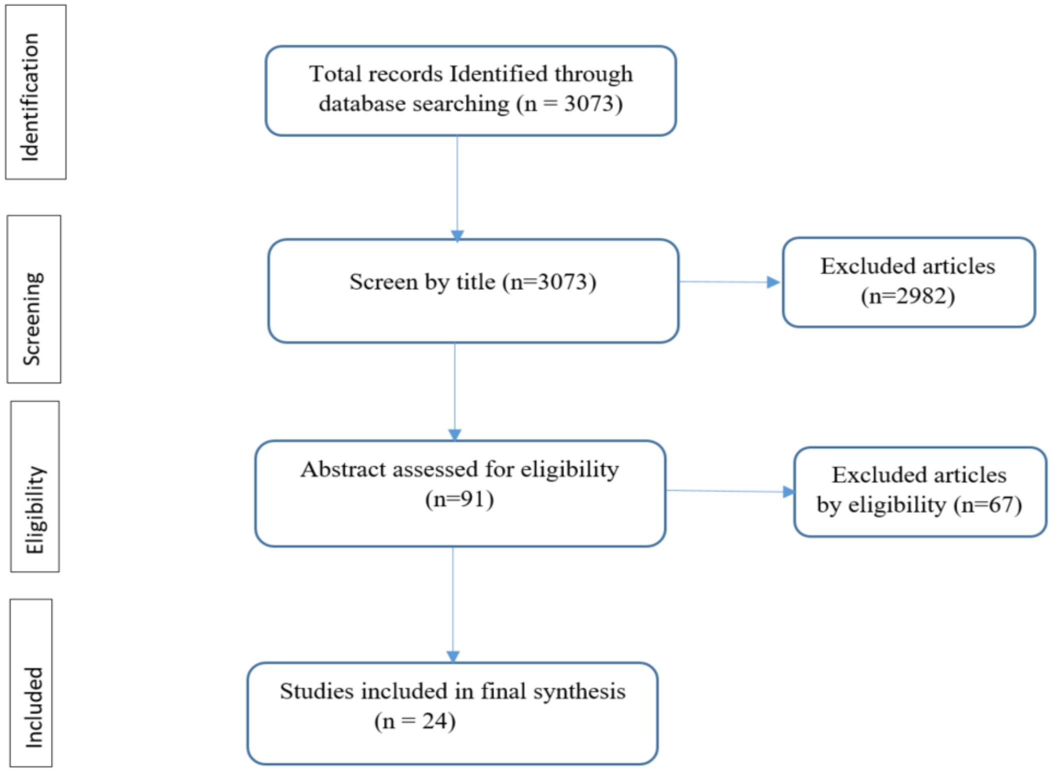


Figure 2. 2 Flow diagram for the selection of literature review articles related to risk factors in the mining industry.

Table 2.2 and 2.3 present the methodological quality assessment of the studies that have attempted to investigate the role of different categories of individual characteristics, behavioural factors and job-related factors against occurrence of occupational injuries in the mining industry. For retained cross-sectional and longitudinal studies, the majority of the studies were moderate to good quality as shown in Table 2.2. The rating was attained after each study was awarded a star for meeting the NOS criteria presented in Table 2.2. Studies were awarded a maximum of 7 stars. A cross-sectional and longitudinal study with a sum of 4 stars or greater was considered to be moderate to good quality while those with less 4 were classified as weak to poor quality.

Table 2. 2 Results of the critical appraisal for cross-sectional studies.

| Authors (Year) | Selection | | | | Comparability | Outcome | | |
|---|---|---|---|---|---|---|---|---|
| | Representativeness of the sample | Sample size | Non-respondents | Ascertainment of exposure | Based on design and analysis | Assessment of outcome | Statistical test | Overall Quality Score |
| 1. Nakua et al. (2019b) | | * | | * | * | * | * | 4/7 |
| 2. Friedman et al. (2019) | | | | * | | * | * | 3/7 |
| 3. Aliabadi et al. (2019) | | | | * | | * | * | 3/7 |
| 4. Calys-Tagoe et al. (2015) | | * | | * | | * | * | 4/7 |
| 5. Long et al. (2015) | | * | | * | * | * | * | 5/7 |
| 6. Cui et al. (2015) | | * | * | * | * | * | * | 6/7 |
| 7. Sanmiquel et al. (2015) | | | | * | * | * | * | 4/7 |
| 8. Kyeremateng-Amoah and Clarke (2015) | | | | | | * | * | 2/7 |
| 9. Bhattacherjee (2014) | * | * | | * | | * | * | 5/7 |
| 10. Boniface et al. (2013) | * | | | * | | * | * | 4/7 |
| 11. Elenge et al. (2013) | * | * | | * | | * | * | 5/7 |
| 12. Onder (2013) | | | | * | | * | * | 3/7 |
| 13. Muzaffar et al. (2013) | | | | * | * | * | * | 4/7 |
| 14. Stojadinović et al. (2012) | | | | * | | * | * | 3/7 |
| 15. Groves et al. (2007) | | | | * | * | * | * | 4/7 |

**Definition of set it criteria** (Wells et al., 2000)**:**

1. **Representative of the sample** (i.e., truly representative of the average in the target population – all subjects or random sampling). **Awarded star**
2. **Sample size** (i.e., justified and satisfactory) – **Awarded star**
3. **Response rate** is assessed and satisfactory (>70%) – **Awarded star**
4. **Ascertainment of exposure (risk factor)** – Validated measurement tool or non-validated measurement tool but the tool is available or described. **Awarded star**
5. **Comparability** – The study controls for potential confounders or subject in different groups are compared based on design or analysis. **Awarded star**
6. **Outcome** - Independent blind assessment, record linkage self-report or no description. **Awarded star**
7. **Statistical analysis** – Statistical test use to analyse the data is correctly described and appropriate, and measure of association is presented, including confidence intervals and p values. **Awarded star**

Similarly, case-control studies were classified to be methodologically moderate to good quality or weak to poor quality. A study was award a maximum of 8 stars. A study with 4 stars or greater was considered to be moderate to good quality and those with less than 4 stars were considered weak to poor quality. All case-control studies reviewed were moderate to good quality as shown in Table 2.3.

Table 2. 3 Results of the critical appraisal of the case-control studies.

| Authors (Year) | Selection | | | | Comparability | Exposure | | | Overall Quality Score |
|---|---|---|---|---|---|---|---|---|---|
| | Case definition adequate ? | Representativeness of the sample | Selection of controls | Definitions of controls | Based on design and analysis | Assessment of exposure | Same of method of ascertainment of case and controls | Non-response rate | |
| 16. Bhattacherjee et al. (2013) | * | * | * | * | * | * | * | * | 8/8 |
| 17. Chimamise et al. (2013) | * | * | * | * | * | * | * | * | 8/8 |
| 18. Paul (2009) | * | | | * | * | * | * | * | 6/8 |
| 19. Paul and Maiti (2008) | * | | * | * | * | * | * | * | 7/8 |
| 20. Kunar, Bhattacherjee and Chau, (2008) | | * | * | * | * | * | * | | |
| 21. Paul and Maiti (2007) | | | * | | * | * | * | * | 5/8 |
| 22. Paul et al. (2005) | * | | * | * | * | * | * | * | 7/8 |
| 23. Ghosh et al. (2004) | * | | * | * | * | * | * | | 6/8 |
| 24. Maiti et al. (2004) | | * | * | | * | * | * | * | 6/8 |

**Definition of set it criteria** (Wells et al., 2000)**:**

1. **Is case definition adequate** – Yes, with independent validation (>1 persons/record/time/process to extraction or reference to primary record source such as x-rays or structured injury data - **Awarded star**
2. **Representative of the sample**. All eligible cases with outcome of interest over a defined period of time or a random sample of those cases. **Awarded star**
3. **Selection of controls –** Controls were selected from the same source population as the case. **Awarded star**
4. **Definition of control** – If the cases are the first occurrence of injury of interest, then it must explicitly state that controls have no history of this outcome. If cases have new occurrence of specific injury, then controls with previous occurrence of outcomes of interest should be excluded. **Awarded star**
5. **Comparability** – Study control for previous injury or study controls for age or confounders. **Awarded star**
6. **Ascertainment of exposure** - structured injury data (e.g., recorded completed by medical staff) or structured interview where blinded to case/control status. **Awarded star**
7. **Same of method Ascertainment for cases and controls –** Yes. **Awarded star**
8. **Non-response rate** – Same for both group. **Awarded star**

The role of various risk factors on mining-related injuries has been extensively studied in India, followed by a few studies in sub-Saharan African countries as shown in below tables. Of 24 studies, 22 publications have tried to investigate the contributing effects of individual characteristics. The association between age of the miners and occurrence of injuries has been examined by 19 studies with conflicting results as shown in Table 2.4. The role of the gender was found to have been examined by 7 articles while marital status was included in only 5 studies. The impact of education level on injury was evaluated by 11 out of 22 studies that included individual characteristics in their analysis. Whereas, the association of experience with occupational injury was considered by 16 published articles.

Table 2.5 showed that only 7 of the 24 studies had attempted to provide evident of the impact of behavioural factors on the occurrence of injuries in mining sector. The results of the data analysis in these studies was either significant or insignificant with injuries occurrence. Six studies showed that alcohol consumption, or working under influence of alcohol, increases the risk of mining related injuries while one found this relationship not significant. The table also shows that drug usage and smoking were least studied as only 4 studies found drugs or smoking a contributing factor to occupational injuries.

The contributing effects of job-related risk factors such as shift hours worked, poor working conditions, poor management and supervision, job dissatisfaction and job stress were found to have been evaluated by 14 out 24 articles as presented in Table 2.6. The role of shift hours worked on injury was examine in 4 publications, 9 articles captured information about poor working conditions, 6 studies were on poor management/supervision while job dissatisfaction and job stress were investigated by 9 and 6 publications.

Table 2. 4 Below showed individual characteristics and risk of mining-related injuries.

| Authors (Year) | Study Design | | Exposures and Findings | | | | |
|---|---|---|---|---|---|---|---|
| | | Effect (e.g. injury) | Age | Gender | Marital status | Education | Experience |
| 1. Paul and Maiti (2007) | • **Setting:** India<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Investigate the risk factors that contributed to accident/injury<br>• **Population:** 1000 underground coal miners<br>• **Sampling:** A total of 300 miners were recruited.<br>• Analysis: Descriptive statistic and t test. | Accident/injury | • The results showed that old age was significantly associated with accident/injury than younger workers ($p<0.05$). | Not evaluated | Not evaluated | Not evaluated | • Less experience was found to be strong indicator of occurrence of injuries. |
| 2. Kunar et al. (2008) | • **Setting:** India<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Investigate the risk factors that contributed to accident/injury<br>• **Population:** 2376 underground coal miners<br>• **Sampling:** 245 male underground coal miners were randomly selected from the population.<br>• **Analysis:** Adjusted and crude odd ratios were computed with Mantel-Haennszel and conditional logistic regression model. | Injury | • The old age was strongly linked with risk of occupational injuries in mining industry than younger age. | Not evaluated | Not evaluated | • Miners with no formal education (those who cannot read or write) had higher of injury compared to others. | • Less mining experience was not found to be associated with risk of injury. |
| 3. Bhattacherjee et al. (2014) | • **Setting:** India<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate the risk factors that contributed to occupational accident among operators.<br>• **Population:** Dumper operators within the span of 2 years | Occupational accidents | Not evaluated | Not evaluated | Not evaluated | • Dumper operators with no formal education had higher incident rates than others operators. | • Dumper operators with less working years had higher incidence rate of accidents than more experience operators. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | • **Sampling:** About 135 dumper operators were randomly from open cast coal mining operation<br>**Analysis:** Univariate and multivariate logistic regression analysis. | | | | | | |
| 4. | Bhattacherjee et al. (2013) | • **Setting:** India and French<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Assessed the role of occupational hazards and individual factors on injuries and 10,046 underground workers as well as 5371 surface workers in French.<br>• **Population:** 2376 miners in India<br>• **Sampling:** In India, about 245 cases and 330 controls were identified from two coal mines. In France, 700 coal miners were contacted and 516 participates.<br>• **Analysis:** Logistic model which generate Odds ratios was used. | Injury | • In both study areas, the study found that older coalminers had high proportion of injuries compared to younger workers. | Not evaluated | Not evaluated | • No formal education was strongly related to occupational injury among the Indian coal miners | Not evaluated |
| 5. | Paul (2009) | • **Setting:** India<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Identify risk factors responsible for work relate injuries in mining.<br>• **Population:** Undefined India<br>• **Sampling:** A total of 375 participants were recruited, of which 175 were cases and 200 were controls.<br>**Analysis:** Multivariate logistic regression | Injury | • Older miners had higher risk of being involving in work-related accident than younger miners. | Not evaluated | Not evaluated | Not evaluated | • More experienced miners have higher risk of being injured compared to less experience miners. |
| 6. | Paul et al. (2005) | • **Setting:** India<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Identify risk factors responsible for injuries in mining.<br>• **Population:** 2,900 miners<br>• **Sampling:** A total of 202 case-control pair randomly selected from 780 cases and 1591 respectively<br>• **Analysis:** Multivariate logistic regression | Injury | • Older miners were found to have high risk of being injured then younger worker.<br>. | Not evaluated | Not evaluated | Not evaluated | Not evaluated |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7. Calys-Tagoe et al. (2015) | • **Setting:** Ghana<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate the injuries and associated risk in ASM industry<br>• **Population:** Undefined<br>• **Sampling:** 404 miners were randomly selected.<br>• **Analysis:** Descriptive statistics and binary logistic regression | Injury | • The age of miners was not associated with the occurrence of injury. | • Women miners had higher injury rate compared to male counterpart. | Not evaluated | Not evaluated | • Less experienced miners were prone to occurrence of injuries in ASM operation. |
| 8. Long et al. (2015) | • **Setting:** Ghana<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Investigate the injuries and associated risk in ASM Industry<br>• **Population:** Undefined<br>• **Sampling:** 173 miners in 2011 and follow-up interview of 22 miners in 2013 which randomly selected.<br>• **Analysis:** Descriptive statistics and binary logistic regression | Injury | • The age of the miners was not associated with the occurrence of injuries. | • Male miners were more prone to work related injuries than their female counterparts. | Not evaluated | • Education level was not predictor of work related injuries in ASM operation | • Mining experience was not associated with mining injuries. |
| 9. Elenge et al. (2013) | • **Setting:** Demographic Republic of Congo (D.R.C).<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate the accident and associated risk factors<br>• **Population:** 394 ASM miners<br>• **Sampling:** 180 were systematically selected from the population.<br>• **Analysis:** Descriptive statistics and binary logistic regression | Accident | • The age of the miners was statistically insignificant with occurrence of accident. | Not evaluated | Not evaluated | • Whether miners have undergo apprenticeship or not, was not associated with the work related accident. | • Seniority (experience) was not associated with miners being involved in accident. |
| 10. Cui et al. (2015) | • **Setting:** China<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate the risk factors associated with occupational injury<br>• **Population:** 200, 000 coal miners<br>• **Sampling:** About 4319 were recruited from 200,000 coal miners in the period | Injury | • Old age was strongly associated with coal mining injuries than young age. | • Female coal miners had higher risk of being injured than male counterpart**.** | • Marital status was not associated with occurrence of occupational injury in coal mining. | • The level of education was not associated with occurrence of mining related injuries. | • Less experienced miners were found to have higher odds risk than more experienced coal miners. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | of July 2013 to December 2013. Of sample population, only 3618 miners responded.<br>• **Analysis:** Univariate and multivariate analysis | | | | | | |
| 11. Chimamise et al. al. (2013) | • **Setting:** Zimbabwe<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate the risk factors associated with occupational injury<br>• **Population:** 200, 000 coal miners<br>• **Sampling:** 180 were systematically selected from the population.<br>• **Analysis:** Descriptive statistics and logistic regression analysis | Injury | Not evaluated | • The risk of severe injuries was high among the male miners than female miners | • The descriptive statistics revealed that married miners were in large proportion than single miners | • Low education was a strong indicator of occupational injury than more educated miners | Not evaluated |
| 12. Boniface et al. (2013) | • **Setting:** Tanzania<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Investigate occupational injuries and fatalities<br>• **Population:** Undefined<br>• **Sampling:** Reviewing of medical records revealed 248 cases.<br>• **Analysis:** Descriptive statistics and logistic regression analysis | Injury | • The age of miners was found to be insignificant with the occurrence of occupational injury | Not evaluated | • The descriptive statistics results showed that most injured miners were married workers. | • Less educated miners were found to high risk of being injured than highly educated miners. | • Less experienced mineworkers were found to be susceptible to the occupational injury in this study. |
| 13. Friedman et al. (2019) | • **Setting:** United State of America (U.S.A)<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Evaluate risk factors associated with long working hours and occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Reviewing of medical records reported in Mine safety and Health Administration (MSHA)<br>**Analysis:** Descriptive statistics and logistic regression analysis | Long working hours as causes of injury | Not evaluated | Not evaluated | Not evaluated | Not evaluated | • Less experienced or new miners were more include injured after long working hours |
| 14. Groves et al. (2007) | • **Setting:** U.S.A<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Evaluate risk factors associated with occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Reviewing of medical records reported in Mine safety and | Injury | • The younger workers were found to have higher risk for non-fatal injuries than aged workers due to inexperience. | Not evaluated | Not evaluated | Not evaluated | • Less experienced workers were found to be prone to injury than more |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Health Administration (MSHA) from 1995 - 2004<br>• **Analysis:** Descriptive statistics and logistic regression analysis | | | | | | experience workers. |
| 15. Onder (2013) | • **Setting:** Turkey<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** Evaluate risk factors associated with occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Analysis of open cast coal mine non-fatal occupational injuries from 1996 to 2009 that were recorded by Western Lignite Corporation (WLC) of Turkish Coal Enterprises (TKI). Overall samples undefined<br>• **Analysis:** Descriptive statistics and logistic regression analysis | Injury | • Old age among the coal miners was found to be strongly associated with occurrence of injury than young age. | Not evaluated | Not evaluated | Not evaluated | Not evaluated |
| 16. Paul et al. (2005) | • **Setting:** India<br>• **Type of study:** Case-control study<br>• **Aims/objectives:** Assess risk factors associated with occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Random sampling of 150 cases and 150 controls<br>• **Analysis:** Logistic regression analysis | Injury | • Older miners have higher risk of being injured than younger workers. | Not evaluated | Not evaluated | Not evaluated | • Experienced workers have higher risk of being injured than less experienced workers. |
| 17. Stojadinovic et al. (2012) | • **Setting:** Serbia<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Investigate the occupational injuries that happened in Serbian Underground coal mines between 2000 to 2009<br>• **Population:** Undefined<br>• **Sampling:** Review of mining logs and reports.<br>• **Analysis:** Descriptive statistics | Injury | • Younger coal miners had higher injury rate compared to the older coal miners.<br>• This age group has less experience, hence making them vulnerable to occupational injuries. | Not evaluated | | • The results of analysis revealed that less educated coal miners had high proportion of occupational injuries compared to highly educated coal miners | Not evaluated |
| 18. Nakua et al. (2019b) | • **Setting:** Ghana<br>• **Type of study:** Cross-sectional study<br>• **Aims/objectives:** This study aimed to determine the potential risk factors for injury, injury rate and miners' safety perception.<br>• **Population:** Undefined | Injury | • The age group of miners did not play critical in predicting the risk of occupational injuries among the gold miners. That there was no statistically significant observed | • The gender of the gold miners was found to be insignificant with the occupational injuries. | • There was no strong statistically association between the marital status of gold miners and occurrence of occupational injuries. | • The level of education of the gold miners was not strongly related to the injuries in gold mining sector. | • More experienced compared to less experienced gold miners were found to be prone to |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | • **Sampling:** About 1,029 participants were selected from purposively identify households in four districts.<br>• **Analysis:** Descriptive statistics and logistic regression. | | between the younger age group and older age group with occurrence of injuries. | | | | occupational injuries. |
| 19. Sanmiquel et al. (2015) | • **Setting:** Spain<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Investigate risk factors that causes Spain mining accidents<br>• **Population:** Undefined.<br>• **Sampling:** About 69,869 instances of mining accidents, recorded by Spanish Ministry of Employment and Social Safety between 2003–2012.<br>• **Analysis:** Descriptive, Bayesian classifiers, decision trees or contingency tables. | Accident | • The age of miners plays critical role in the occurrence of Spain mining accidents. Old miners were found to be prone to mining accidents compared younger miners. The findings are coherent with the fact that the possibility of suffering accidents related with overexertion. This type of type of accident increases with age. | Not evaluated | Not evaluated | Not evaluated | • The results showed that miners' level of experience was the genesis of mining accidents in Spain. High frequency of injuries was noted among those with less than 2.5 years of experience. |
| 20. Aliabadi et al. (2019) | • **Setting:** Iran<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Analysing severe injuries in ten Iran iron ore<br>• **Population:** Undefined<br>• **Sampling:** A total of 425 accident cases that happened between 2008-2017 were reviewed and analysed<br>• **Analysis:** Descriptive statistics and Bayesian network analysis. | Injury | • The age of miners was not directly linked with the occurrence of iron ore accidents in Iran. | Not evaluated | • The marital status of miners was not directly linked with the occurrence of iron ore accidents in Iran. | • Less educated miners were found to be at higher of experience mining accidents compared to those with high education level | • The study results suggested that low-experience miners were prone to accident in Iran. The authors suggested that more experienced should be given higher risk tasks as they are more aware hazards and with ways of dealing with them. In addition, managers must include experienced miners in each working group. |
| 21. Kyeremateng-Amoah and Clarke (2015) | • **Setting:** Ghana<br>• **Type of study:** Longitudinal study | Injuries | • The age of the miners was the factor in the occurrence of ASM injuries. Middle age | • The gender of miners played an important | Not evaluated | Not evaluated | Not evaluated |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | • **Aims/objectives:** Characterised the injuries that happened in ASM operation<br>• **Population:** Undefined<br>• **Sampling:** A review of hospital records resulted in 72 cases from 2006 to 2013 and 2007 to 2012.<br>• **Analysis:** Descriptive statistics | | group suffered more injuries than older and younger miners. | role in the ASM accidents. Major of cases were male miners. | | | |
| 22. Muzaffar et al. (2013) | • **Setting:** United State of America (USA)<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Investigate risk factors associated with fatal injuries among the contractor and operators.<br>• **Population:** Undefined<br>• **Sampling:** Data about 157,410 miners employed by operators or contractors during 1998–2007 were analysed.<br>• **Analysis:** Descriptive statistics and logistic regression | Injury | • The rate of fatal accidents was higher among the older workers compared to younger miners, particularly among the contractors. Older age miners have less reactive time in the emergency. | • Male miners had higher odd risk that significant than female miners | | | • The study showed that miners with fatal events had higher total experience but less experience in the mine where the injury occurred, particularly among the contractors compared to operators. |

Table 2. 5 Below showed behavioural factors and risk of mining-related injuries.

| Authors (Year) | Study Design | Exposures and Findings | | |
|---|---|---|---|---|
| | | Effect (e.g. injury) | Alcohol | Drugs/smoking |
| 1. Kunar et al. (2008) | • **Setting:** India<br>• **Type of study:** case-control<br>• **Aims/objectives:** Investigate the risk factors that contributed to accident/injury<br>• **Population:** 2376 underground coal miners<br>• **Sampling:** 245 male underground coal miners were randomly selected from the population.<br>• **Analysis:** Adjusted and crude odd ratios were computed with Mantel-Haennszel and conditional logistic regression model. | Injury | • The miners who regulated consumed alcohol had higher being injured than the other workers. Alcoholism is a neurophysiological etiology and can lead to impairment of the most human body system. Consumption of alcohol can increase the risk of injury through engaging in risk taking behaviour | • The study did not find a risk of increased injury among the smokers. |

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| | | | or reducing the perception and responses to hazards.<br>• The research recommended that interventions should be carried out to assist workers to reduce alcohol intake by assessing the alcohol concentration via an alcoholmeter at the beginning of the three shifts. | |
| 2. Bhattacherjee et al. (2014) | • **Setting:** India<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the risk factors that contributed to occupational accident among operators.<br>• **Population:** Dumper operators within the span of 2 years<br>• **Sampling:** About 135 dumper operators were randomly from open cast coal mining operation<br>**Analysis:** Univariate and multivariate logistic regression analysis. | Occupational accident | • Dumper operators that regularly consumed alcohol had higher incident rate that was statistically, p =0.03 than other workers. | • Dumper operators that smoke had higher incident rate than other workers. |
| 3. Bhattacherjee et al. (2013) | • **Setting:** India and French<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Assessed the role of occupational hazards and individual factors on injuries.<br>• **Population:** 2376 miners in India and 10,046 underground workers as well as 5371 surface workers in French<br>• **Sampling:** In India, about 245 cases and 330 controls were identified from two coal mines. In France, 700 coal miners were contacted and 516 participates.<br>• **Analysis:** Logistic model which generate Odds ratios was used. | Injury | • Regular alcohol usage was directly associated with occupational injury among the Indian coal miners, p <0.05 | • Psychotropic drug use was contributor of injury among the French coal miners. |
| 4. Elenge et al. (2013) | • **Setting:** Demographic Republic of Congo (D.R.C).<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the accident and associated risk factors<br>• **Population:** 394 ASM miners<br>• **Sampling:** 180 were systematically selected from the population.<br>• **Analysis:** Descriptive statistics and binary logistic regression | Accident | • Working under the influence of alcohol was a contributing effect of accident in this particular operation. | • Working under the influence drugs was statistically significant with occurrence of accident. |
| 5. Cui et al. (2015) | • **Setting:** China<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the risk factors associated with occupational injury<br>• **Population:** 200, 000 coal miners<br>• **Sampling:** 180 were systematically selected from the population. | Injury | • Drinking alcohol was found to be statistically insignificant with occurrence of occupational injuries | • Making was not a strong indicator of injury occurrence |

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| | • **Analysis:** Univariate and multivariate analysis | | | |
| 6. Boniface et al. (2013) | • **Setting:** Tanzania<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate occupational injuries and fatalities<br>• **Population:** Undefined<br>• **Sampling:** Reviewing of medical records revealed 248 cases.<br>• **Analysis:** Descriptive statistics and logistic regression analysis | Injury | • Alcohol consumption was found to be statistically insignificant with the occurrence of occupational injury. The descriptive statistics shows that majority of miners were not alcohol drinkers. | • Smoking cigarette was found to be insignificant with occurrence of occupational injury although majority of miners smoke. |
| 7. Nakua et al. (2019b) | • **Setting:** Ghana<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** This study aimed to determine the potential risk factors for injury, injury rate and miners' safety perception.<br>• **Population:** Undefined<br>• **Sampling:** About 1,029 participants were selected from purposively identify households in four districts.<br>• **Analysis:** Descriptive statistics and logistic regression. | Occupational injury | • Alcohol consumption was found to be predictor of occupational injury among the gold miners. | • Current tobacco smokers and those smoke six hours per shift had higher risk of being injured than those who never or ever smoke. |

Table 2. 6 Below showed job-related factors and risk of mining-related injuries.

| Authors (Year) | Study Design | | Exposures and Findings | | | | |
|---|---|---|---|---|---|---|---|
| | | Effect (e.g. injury) | Working hours | Poor working conditions | Poor management/supervision | Job dissatisfaction | Job stress |
| 1. Maiti et al. (2004) | • **Setting:** India<br>• **Type of study:** Case-control<br>• **Aims/objectives:** To identify risk factors that influence work injury using a causal framework<br>• Population: 592 underground miners<br>• **Sampling:** multi-item survey administered to randomly sampled 200 miners, of which 160 miners consent to participate | Injury | Was not evaluated | • Job hazards has no direct relationship with work injury. This factor had strong link with job boredom, job dissatisfaction, job stress, physical hazards and productions which are symptom of poor good working conditions and not work injury. | • Factor such as social support (supervisor support, co-workers support and management) that measure positive or negative management/supervision was not significant indicators of work injury. | • Job dissatisfaction was associated with job hazards in causal framework, thus was not associated with work injury | • Job stress was related to job hazards in the causal framework, thus, was not a predictor of work injury |

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| | • **Analysis :** Structural Equation Model (Fisher, Mwaipopo, Mutagwaba, Nyange, & Yaron) employed to assess causal relationship | | | | | | |
| 2. Paul et al. (2007) | • **Setting:** India<br>• **Type of study:** case-control<br>• **Aims/objectives:** Investigate the risk factors that contributed to accident/injury<br>• **Population:**<br>• **Sampling:**<br>• **Analysis:** Structural Equation Model (Fisher et al.) | Accident/injury | Was not evaluated | Was not evaluated | Was not evaluated | • Job dissatisfaction was a strong indicator of accident/injury with path coefficient of 0.021. Dissatisfied miners have less job tasks control and as a result, they are unable to cop up with proper safety practices. | Was not evaluated |
| 3. Bhattacherjee et al. (2014) | • **Setting:** India<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the risk factors that contributed to occupational accident among operators.<br>• **Population:** Dumper operators within the span of 2 years<br>• **Sampling:** About 135 dumper operators were randomly from open cast coal mining operation<br>**Analysis:** Univariate and multivariate logistic regression analysis. | Occupational accident | Was not evaluated | • Dumper operators with poor perception about rules and regulations as well as those who worked in poor safety environment have higher incident rates that was significant, $p < 0.05$ than their other colleagues. Mine management should institute safety measures to improve working conditions and dumper operators should also be trained to develop positive psychological traits. | Was not evaluated | • Dumper operators that were dissatisfied with their work had higher incident rate that was significant, $p < 0.05$ than other workers | • Dumper operators that were stressed had a higher incident rate that was significant, [$p < 0.05$] than other workers. |

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| 4. Bhattacherjee et al. (2013) | • **Setting:** India and French<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Assessed the role of occupational hazards and individual factors on injuries and 10,046 underground workers as well as 5371 surface workers in French.<br>• **Population:** 2376 miners in India<br>• **Sampling:** In India, about 245 cases and 330 controls were identified from two coal mines. In France, 700 coal miners were contacted and 516 participates.<br>**Analysis:** Logistic model which generate Odds ratios was used. | Injury | Was not evaluated | • Poor environment/working conditions was found to be associated with injury in India coal mines. | Was not evaluated | Was not evaluated | Was not evaluated |
| 5. Paul et al. (2008) | • **Setting:** India<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Identify risk factors related to work injury<br>• **Population:** Undefined<br>• **Sampling:** In India, about 175 cases and 200 controls were randomly sampled from two mine sites.<br>• **Analysis:** SEM | Injury | Was not evaluated | • Safe work environment was not directly related to injury. Safe work had direct effects on job stress and job dissatisfaction, and indirect effects on safe work behaviour and work injury. | • Proxies for poor management such as social support were not directly linked to injury. The SEM showed that social support has indirect effect on job dissatisfaction, safe work behaviour and work injury.<br>• Social interactions among the workers with supervisors and management make the workers less job-stressed, less dissatisfied with their work. | • Job dissatisfaction was a strong indicator of being injured. | • Job stress was not associated with injury |

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| 6. Paul et al. (2009) | • **Setting:** India<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Identify risk factors responsible for work relate injuries in mining.<br>• **Population:** Undefined India<br>• **Sampling:** A total of 375 participants were recruited, of which 175 were cases and 200 were controls.<br>**Analysis:** Multivariate logistic regression | Injury | Was not evaluated | • Factors that indicated safe work environment such as safety training, safe practises, safe equipment availability and maintenance were statistically insignificant (p>0.05) with risk of injury However, the odd risk was higher among the injured miners<br>• Work hazards such as production pressure and physical hazards were statistically insignificant (p>0.05), but the odd risk was higher among the injured miners.<br>• Since accident-involved workers have poor perception about their working conditions, they should be provided with adequate training and friendly atmosphere | • Social supports factors such as co-workers support, supervision support and management work interaction which indicate level of management/supervision were statistically insignificant (p>0.05), but the odd risk was higher among the injured miners.<br>• Mine should develop a sense of caring and respect for one another<br>• Building helpful and co-operative relationship with co-workers and supervisors/management<br>• Develop a range of social skills and they learn what constitutes acceptable behaviour. | • Job dissatisfaction was statistically insignificant with work-related injury but the odd risk among the injured miners was high. Accident – involved miners are more dissatisfied and thus, less job involved and always bored with their jobs.<br>• Management should discussed the miner's alternative task rotations as well as introduced some motivating initiatives. | • Job stress was not statistically significant with work injury, but the odds risk for injured miners was relatively high. |
| 7. Ghosh et al. (2005) | • **Setting:** India<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Identify risk factors responsible for injuries in mining.<br>• **Population:** 2,900 miners<br>• **Sampling:** A total of 202 case-control pair randomly selected from 780 cases and 1591 respectively<br>• **Analysis:** Multivariate logistic regression | Injury | Was not evaluated | • Injured miners have poor perception about their working conditions than uninjured workers. This indicated that miners who were satisfied with their working conditions have a lower risk. Miners who suffered no injury think positively about their physical environment and take necessary steps to work safely. | • Injured miners had poor perception about management and supervision than non-injured miners | • Injured miners were strongly dissatisfied compared to their counterpart. Job dissatisfaction is an emotional response and represents job related strain which is | • Job stress was strongly associated with injured group. |

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| | | | | | | associated with production, motivation, absenteeism, tardiness, carelessness, fatigue and mental health which in turn cause injuries | |
| 8. Calys-Tagoe et al. (2015) | • **Setting:** Ghana<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the injuries and associated risk in Artisanal and Small-scale Mining (Nakua et al.) Industry<br>• **Population:** Undefined<br>• **Sampling:** 404 miners were randomly selected.<br>**Analysis:** Descriptive statistics and binary logistic regression | Injury | Was not evaluated | • The descriptive statistics showed that majority of miners that have sustained injuries blamed work pressure, lack of personal protective equipment and lack of training which indicated perception about poor working conditions. These miners indicated that safe work environment and reduced work pressure would have prevent injuries. | Was not evaluated | Was not evaluated | Was not evaluated |
| 9. Long et al. (2015) | • **Setting:** Ghana<br>• **Type of study:** Longitudinal study<br>• **Aims/objectives:** Investigate the injuries and associated risk in ASM Industry<br>• **Population:** Undefined<br>• **Sampling:** 173 miners in 2011 and follow-up interview of 22 miners in 2013 which randomly selected.<br>• **Analysis:** Descriptive statistics and binary logistic regression | Injury | • Total working hours per week was not associated with the work injuries. | Was not evaluated | Was not evaluated | Was not evaluated | Was not evaluated |
| 10. Cui et al. (2015) | • **Setting:** China<br>• **Type of study:** Cross-sectional | Injury | Was not evaluated | Was not evaluated | Was not evaluated | • Miners that were moderately satisfied and | Was not evaluated |

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| | • **Aims/objectives:** Investigate the risk factors associated with occupational injury<br>• **Population:** 200, 000 coal miners<br>• **Sampling:** 180 were systematically selected from the population.<br>• **Analysis:** Univariate and multivariate analysis | | | | | those that were dissatisfied compared to those satisfied were insignificantly associated with injury occurrence (p>0.05). | |
| 11. Chimamise et al. (2013) | • **Setting:** Zimbabwe<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Investigate the risk factors associated with occupational injury<br>• **Population:** 200, 000 coal miners<br>• **Sampling:** 180 were systematically selected from the population.<br>• **Analysis:** Descriptive statistics and logistic regression analysis | Injury | • Miners who worked more than 8 hours per shift were found to be more likely to suffer mining injuries.<br>• Working longer hours increased exhaustion, lack of confidence and tardiness. | • The factors that suggested poor working conditions (underground) were found to be associated with occupational injury. | • Poor management/supervision (lack of personal protective equipment and equipment training) was directly related to injury. | • Job dissatisfaction was linked to higher chances of sustaining severe injury. | Was not evaluated |
| 12. Friedman et al. (2019) | • **Setting:** United State of America (U.S.A<br>• **Type of study:** Cross-sectional<br>• **Aims/objectives:** Evaluate risk factors associated with long working hours and occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Reviewing of medical records reported in Mine safety and Health Administration (MSHA)<br>**Analysis:** Descriptive statistics and logistic | Lost workdays injuries | • The study found that long working hours were more likely to result in mining death or accident. | Was not evaluated | Was not evaluated | Was not evaluated | Was not evaluated |

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| | regression analysis | | | | | | |
| 13. Paul et al. (2005) | • **Setting:** India<br>• **Type of study:** Case-control<br>• **Aims/objectives:** Assess risk factors associated with occupational injury<br>• **Population:** Undefined<br>• **Sampling:** Random sampling of 150 cases and 150 controls<br>• **Analysis:** Logistic regression analysis | Injury | Was not evaluated | • Miners with poor perception about working conditions and safe work environment had significantly higher risk of injury. | • Miners with negative attitude toward supervision support, management support and social support had significantly higher risk of occupational injury. | • Dissatisfied miners were more likely to experience mining injuries than satisfied workers. | • Miners who are stressed have higher risk of sustaining mining injuries. |
| 14. Muzaffar et al. (2013) | • **Setting:** United State of America (USA)<br>• **Type of study:** Longitudinal<br>• **Aims/objectives:** Investigate risk factors associated with fatal injuries among the contractor and operators.<br>• **Population:** Undefined<br>• **Sampling:** Data about 157,410 miners employed by operators or contractors during 1998–2007 were analysed.<br>• **Analysis:** Descriptive statistics and logistic regression | Injury | • Miners who worked more than 8 hours per day had greater odd risk of suffering fatal injury. The authors recommended working hours restrictions. | Was not evaluated | Was not evaluated | Was not evaluated | Was not evaluated |

## 2.11 Discussion

This systematic analysis of publications pertaining to risk factors that facilitated injury occurrence in the mining industries led to interesting findings. This literature review part 2 focusses on the three most significant factors identified in this review. These are discussed under the sub-headings 2.11.1, 2.11.2, and 2.11.3. The impacts of these factors have been extensively examined in other industries (i.e., construction, manufacturing, etc.) exclusive of the mining industry, and have presented conflicting conclusions (Berecki-Gisolf et al., 2015; Lin et al., 2008; Tessier-Sherman et al., 2014). Therefore, it was imperative to systematically review the articles and provide comprehensive evidence of mining-related injuries, in addition to examining the personal traits of miners and the occurrence of hazards. Evidence from this analysis should serve as crucial information for the policy makers for making better-informed decisions and to accord researchers' clear areas of focus as the mining industry continues to play significant developmental roles, with the health and safety of the miners at the forefront.

### 2.11.1 Individual characteristics

There are several characteristics such as personal traits of mineworkers that have been investigated and reported in publications, however, our review focussed on five factors as shown in Figure 2.3 that were frequently discussed within and outside of the mining industry.

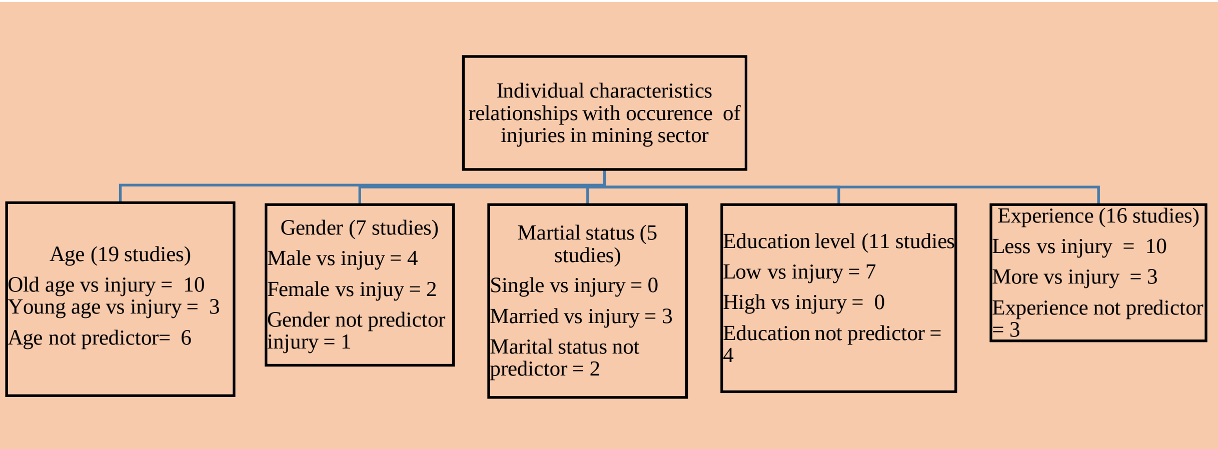


Figure 2. 3 Results of studies that have investigated risk of various individual characteristics on injuries.

Compared to other individual characteristics, the link between age of the miners and risk of being injured has been well studied. However, the results of this review suggested opposing opinions. The large volume of published works showed positive association between the old age and risk of mining-related injuries or accident (Bhattacherjee et al., 2013; Cui et al., 2015; Ghosh et al., 2004; Kunar et al., 2008; Muzaffar et al., 2013; Onder, 2013; Paul & Maiti, 2007; Paul et al., 2005; Paul, 2009; Paul & Maiti, 2008; Sanmiquel et al., 2015). The aged miners have a higher tenure, as a result, are assigned greater responsibilities which place them at greater risk of having an accident/injury. In addition, older mineworkers are inclined to fatigue and to be slower in their actions due to older age, and their reduced reflex actions made them more predisposed to accidents (Paul & Maiti, 2007).

Contrarily, two studies suggested that young and middle aged miners were more at risk of injury than elderly miners (Groves et al., 2007; Kyeremateng-Amoah & Clarke, 2015; Stojadinović et al., 2012). Ghosh and colleagues et al. (2004) explained that younger workers in comparison to older age group have few qualifications/inexperience; and the younger age group also show higher reckless behaviour, which increased their risk of being involved in occupational accidents and the subsequent injuries.

Although six studies have shown that age is not a predictor of mining-related injuries or injuries (Aliabadi et al., 2019; Calys-Tagoe et al., 2015; Elenge et al., 2013; Long et al., 2015; Nakua et al., 2019b), the evidence from ten studies suggested that employers or management should develop and implement earlier intervention strategies as per the specific needs of various age groups. Such interventions must incorporate adequate training or activities oriented towards re-training of the workforce, as well as initiatives involving job re-design (Paul & Maiti, 2007).

The role of gender on occurrence of occupational injuries in mining industry has been limitedly studied as shown in Figure 3.2. Only 7of the 24 articles reviewed have attempted to evaluate the gender differences in relation to mining injuries. Gender refers to a social structure for male and female miners. The results of this review revealed diverging results. Four articles established that male miners were more prone to injuries than female miners (Chimamise et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015; Muzaffar et al., 2013). Such results are supported by recent works which explained that male miners are more inclined to risk-prone behaviours than their female counterpart, and as a result, expose themselves to receiving more occupational injuries (Ajith & Ghosh, 2019a). Conversely, two other studies suggested that female miners were more susceptible to mining-related injuries than their male counterpart (Calys-Tagoe et al., 2015; Cui et al., 2015). Taiwo et al. (2009) conducted a study among manufacturer workers and explained that 'characteristic sex difference in size and physical capacity' influence the high rates of injuries among female workers. Similarly, Calys-

Tagoe et al. (2015) established that the type of activities performance by the women miners had led to direct impacts on the higher rate of injuries after profiling and characterizing the Artisanal and Small-scale Mining related injuries in Tarkwa region of Ghana. The finding of this review illustrated that both male and female miners are to be adequately trained and the workplace and work processes are made as safe as practical. In addition, it is necessary to initiate other health and safety intervention strategies such as job re-designs, job rotations, and task specific roles in the workplace.

Corresponding to gender, the marital status of mineworkers has not been sufficiently investigated. This review identified only five articles, of which three suggested no significant association with occurrence of injuries while others showed married miners had a higher risk of injuries than single or unmarried miners (Cui et al., 2015; Nakua et al., 2019b). The results of two studies (Boniface et al., 2013; Chimamise et al., 2013), are strongly supported by other published research conducted in the construction industry, where it was found that married workers, in addition to workplace responsibilities, have extensive other responsibilities which often affect their performance at the workplace (Hatami et al., 2017). These authors explained that combined financial and multiple jobs stress- responsibilities increases the likelihood of injuries among married workers. Management should ensure that social support and care is accorded to the married miners. In addition, it is equally important that marital status should be investigated in relation to mining-related injuries, which, in turn, would facilitate implementation of policies that target specific groups.

Another variable identified from the review of published literature was education level. Four of the ten published works reviewed that investigated the role of education level showed no significant association (Cui et al., 2015; Elenge et al., 2013; Long et al., 2015; Nakua et al., 2019b), with zero establishing a relationship between being highly educated and occurrence of injuries. Seven of the ten studies identified that low education level has direct implication on the frequency of injuries (Aliabadi et al., 2019; Bhattacherjee, 2014; Bhattacherjee et al., 2013; Boniface et al., 2013; Chimamise et al., 2013; Kunar et al., 2008; Stojadinović et al., 2012). These studies have revealed that miner with less education or no formal education were more likely to experience mining-related injuries.

The highly educated miners were much more aware of the potential hazards and risk control mechanisms, while the uneducated or less educated were more likely to make human errors as they were socially less well prepared to adopt new technologies, undertake job training, and/or follow safe working procedures (Kunar et al., 2010). Furthermore, labourers or those with a lack of formal qualification were more likely to be directly involved in tasks that are considered riskier (Stojadinović et al., 2012). Resultantly, the work practices, procedures, and instructions should be designed and structured in a framework, which also accounts for miners with no formal education, or less educated, for better understandability and interpretability.

Similar to other individual characteristics, the results of studies that have investigate mining-related injuries and link with experience have provided diverging opinion. Experience refers to the amount the time employee has been working in specific task, work or company (Paul, 2009). The first findings revealed by 10 out of 16 articles showed less experienced miners to be riskier group (Aliabadi et al., 2019; Bhattacherjee, 2014; Boniface et al., 2013; Calys-Tagoe et al., 2015; Cui et al., 2015; Friedman et al., 2019; Groves et al., 2007; Muzaffar et al., 2013; Paul & Maiti, 2007; Sanmiquel et al., 2015). Miners that have less work experience are often unaware of hazards and the necessary means to control them (Muzaffar et al., 2013). The second findings suggested that more experienced miners were susceptible to injuries than less experienced (Nakua et al., 2019b; Paul et al., 2005; Paul, 2009). This narrative was established by 3 of 16 studies presented in Figure 2.4. This is because more experience miners are assigned a lot of responsibilities and possibility risker jobs. In addition, with experience, miners tend to be confluence with their safety. In order to prevent injury among both less and more experienced miners, they must be well trained, have document safe work procedures to follow and have appropriate work supervision provided.

### 2.11.2 Behavioural factors

This literature review part 2 aimed to identify if substance usage contributed to the occurrence of injuries in mining industry. As shown in Figure 2.4, alcohol and drug/smoking have been studied.

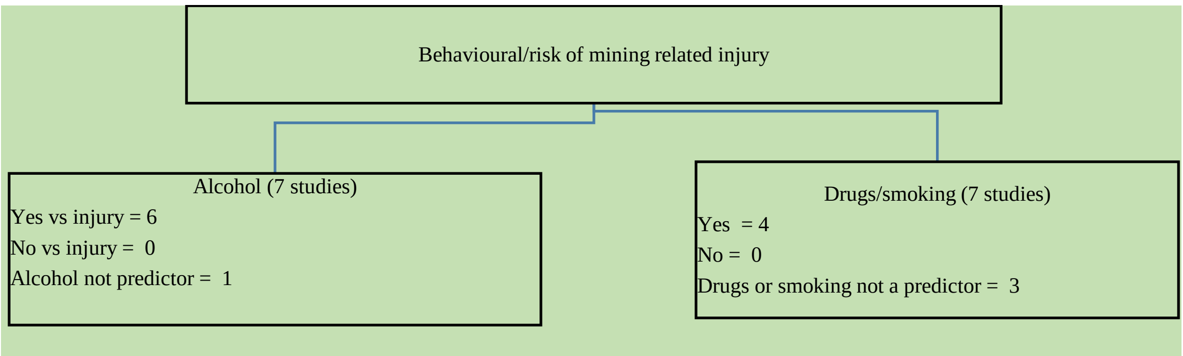

Figure 2. 4 Distribution of studies that have evaluate role of substance usage and risk of mining–related injuries.

Mining, like any other industry, is trying to control the substances usage in workplace. Companies have developed initiatives to detect and prevent alcohol and drug consumption and intoxications during the working hours. However, there are few published studies in the mining industry that have tried to associate the risk of substances use on injury. This review showed that 7 of the 20 published articles from 2004 to present have investigated the role of alcohol and drugs on the occurrence of injuries in mining industry employees. The majority of alcohol-related articles (6 out of 7) and drugs/smoking (4 out of 7) have indicated a positive association with mining-related injuries (Bhattacherjee, 2014; Bhattacherjee et al., 2013; Boniface et al., 2013; Cui et al., 2015; Elenge et al., 2013; Kunar et al., 2008; Nakua et al., 2019b). The results from these publications are not surprising given that substances usage causes cognitive impairment, slow reactive times, and affect decision-making (Iacobelli et al., 2008; Kendrick et al., 2012; Kumar, 2011; Leistikow et al., 1998; Nakata et al., 2006; Ryan et al., 1992; Wen et al., 2005). It is recommended that the mine authorities and management enforce drug and alcohol policies that restrict substance abuse in worksites and the impacts of drug and alcohol as a cause of work related injuries need to be further assessed in the mining environment.

### 2.11.3 Job-related factors

In relation to job-related factors, this research reviewed journal articles concluded that the risk factors shown in Figure 2.5 needed to be explore further within the context of mining-related injuries. This was because evidence from the non-mining industry has demonstrated that there is a direct correlation with occurrence of workplace injuries and job related factors. Therefore, it was imperative to determine whether studies conducted in mining sector had similar results.

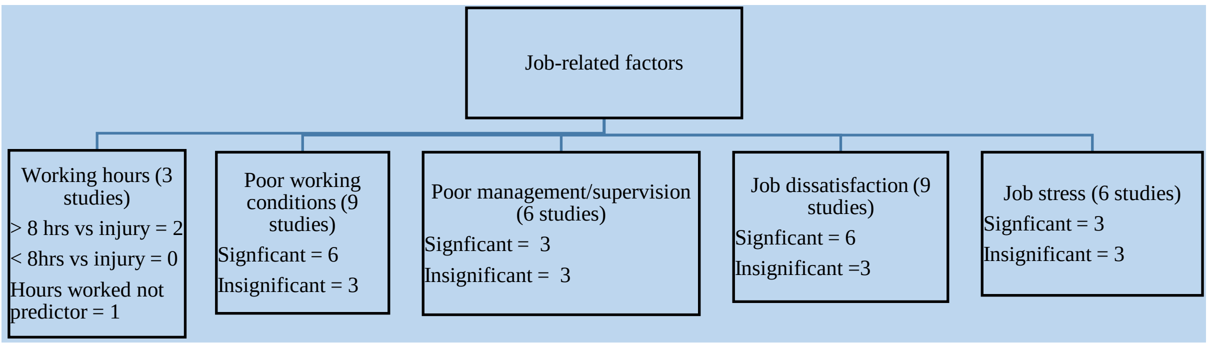


Figure 2. 5 Distribution of job-related factors studies based on the significance with occurrence of mining injuries.

Working for more than 8 hours per day has emerged as a common norm across the mining industry, particularly in large-scale operations. However, there is limited studies in the mining sector that have explained the association of long working hours with risk of injuries. The current review results identified that only 4 out of 24 articles that met inclusion criteria included hours worked as one of their variables. Of the three studies, three established the positive relationship between the occurrence of injuries and longer working hours (> 8hrs) (Chimamise et al., 2013; Friedman et al., 2019; Muzaffar et al., 2013) while one study revealed an inverse relationship (Long et al., 2015). Despite the lack of adequate information on the role of hours worked on the occurrence of mining-related injuries, evidence from other occupations has demonstrated that workers who worked for more than 8 hours suffered from more frequent work related accidents (Dembe et al., 2005; Salminen, 2016). Working for extended hours reduces focus and concentration, and subsequently exposes workers to injuries (Chimamise et al., 2013). Therefore, the length of working hours per shift or week should be reduced to achieve appropriate working hours specific to the work being performed and role in order to mitigate the risk of a mining work related injury.

In addition to the shift hours worked, the systematic analysis of published literature suggested that poor working conditions can increase the risk of being injured. Of the 9 studies that had attempted to understand the role of poor work condition on mining related injuries, 6 publications found strong association (Bhattacherjee, 2014; Bhattacherjee et al., 2013; Calys-Tagoe et al., 2015; Chimamise et al., 2013; Ghosh et al., 2004; Paul et al., 2005). Only two studies revealed a negative relationship (Maiti et al., 2004; Paul, 2009; Paul & Maiti, 2008). Therefore, it can be concluded that injured miners have a poor perception about their working conditions. Workers with no injury were identified as having positive thinking about their working conditions and thus, were more cautious (Ghosh et al., 2004). Several factors contributed to poor working conditions, usually the level of occupational health and safety was a primary indicator of adverse or positive working conditions. The mining industry is one of the most dangerous due to the widespread of presence of hazards and frequent occurrence of injuries (Donoghue, 2004). It has been recommended that the employer should improve workers' perception by increased safety training and positive engagement with mine management/supervisors.

The working conditions are an indicator of the level of management/supervisions (Ghosh et al., 2004). Poor management/supervision breeds negative working conditions. The screening of the published literature resulted in 6 articles that had examined poor working conditions against the occurrence of work related injuries. The majority of the case-control studies had compared the opinion of injured and uninjured miners. Our review identified that 3 of the 6 studies had confirmed that poor management and supervisor contributed to risk of mining-related injuries (Chimamise et al., 2013; Ghosh et al., 2004; Paul et al., 2005), while the rest found this relationship not significant (Maiti et al., 2004; Paul, 2009; Paul & Maiti, 2008). Despite the opposing views, organizational safety performance can be directly linked to mine management's commitment to safety. This is because mine management is responsible for ensuring a safe working environment by providing optimal training, appropriate work tools, work instructions and procedures as well as implementing initiatives for inculcating a positive safety culture and enforcement of company and national policies (Chimamise et al., 2013; Ghosh & Bhattacherjee, 2009; Jacob & Furgerson, 2012; Paul et al., 2005). However, if the leadership fails to safeguard the welfare of the miners, it increases the risk of occupational injuries occurring (Sawacha et al., 1999). Thus, proper training and legislation should address inadequacy in mining management and supervision.

Job dissatisfaction is another factor which was identified as having an impact on occupational accidents and resultant injury occurrence. The majority of the 9 studies that had investigated the consequences of job dissatisfaction showed a positive relationship with the occurrence of mining-related injuries. According to these publications, dissatisfied miners had a higher risk of experiencing mining related injuries than those who were satisfied with their job functionalities (Chimamise et al., 2013; Ghosh & Bhattacherjee, 2009; Jacob & Furgerson, 2012; Paul et al., 2005). Asegid and colleagues et al. (2014) explained that workers who have a sense of accomplishment, resources, personal achievement, good pay, benefits and safe work conditions tend to be satisfied. This assertion is in line with previous work of Ghosh and colleagues et al. (2004) whereby, the authors established that mineworkers become dissatisfied and showed an increased level of carelessness, absenteeism, tardiness, fatigue and mental stress as well as reduced motivation, which in turn can lead to occupational injury. Mine management should improve working conditions of the miners which will subsequently lead to job satisfaction, higher employee productivity and reduced occurrence of mining-related injuries.

Similar to poor management and supervision, our review has identified 6 studies that relate to job stress. Three of the studies established that job stress was not strong indicator of a cause of mining-related injuries (Maiti et al., 2004; Paul, 2009; Paul & Maiti, 2008). However, these studies do not agree with published research findings in non-mining industries (Rommel et al., 2016). The results published in the other 3 articles reviewed showed that job stress does contribute injury events in the mining industry (Bhattacherjee, 2014; Ghosh et al., 2004; Paul et al., 2005). The National Institute for Occupational Safety and Health (NIOSH), defines job stress as, 'the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker' (NIOSH, 1999). Similarly, NIOSH (1999) has identified job stressors as: (i) Job demands like workload, long work hours and shift work, role ambiguity and lack of job control, (ii) Organizational factors such as poor management and supervision, (iii) Interpersonal relation, (iv) Conflicting roles, (v) Job future ambiguity, and (vi) Poor working conditions. These job stressors generate frustration, fatigue and can result in an occupational injury. Therefore, mine management should adopted strategies that eliminated or reduce job stressors.

## 2.12 Summary

The aim of this review was focused on certain individual characteristics, behavioural and job factors that increased the risk of injury occurrence in ASM and large-scale mining operation. As such, published articles on personal traits and work environment factors were excluded. In addition, studies which did not conduct any inferential analysis of the risk of interest were not included in the review.

This review has shown that mining injuries are not simply a result of the existing hazards and personal traits, rather it is a multifaceted intersect. Though the review has identified some relationship between injury occurrence and risk factors, some inconsistencies were identified in both ASM and large-scale mining studies. In ASM-related studies, no single study has agreed with another on the role by played by individual characteristics and behavioural factors. None of the studies have explored the role of job-related factors such as working conditions, poor management and supervision, job dissatisfaction and job stress on ASM-related injuries. While in large-scale mining, a few inconsistencies were identified across all studies. Some studies argued for the positive correlations while others showed no relationship for the factor researched. For positive correlations, workplace intervention strategies are included.

As a result of diverging views and limited studies, some of the following factors: age, gender, marital status, education level, experience, shift hours, alcohol and drugs usage, poor working conditions, poor management and supervision, job dissatisfaction and job stress need to be conducted in both ASM operations and large-scale mining for future research. Specifically, there seem to be an undefined cut-off point for what researchers term as younger miners vs older miners, less experienced vs more experienced. Also, instead of “yes” or “no” responses to substances usage, participants should be categorised into three groups (high-risk users, low-risk users and users) based on frequency of consumption and intoxication. Furthermore, the contributors of job dissatisfaction, poor management/supervisions and stressors need to be examined.

Therefore, Chapter 4 and 5 examined the risk factors associated with likelihood of recordable injuries, likelihood of severe injuries and number sustained injuries in ASM operation. While Chapter 6 evaluate the consequences of severe injuries in this activity.

The next chapter discusses adopted research methodology.

# 3. RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents the research methodology adopted based on the specific objectives to be met and the variables selected for the study. Additionally, it discusses the mixed methods approach and the current research design, before providing a summary, as illustrated in the following flow chart.

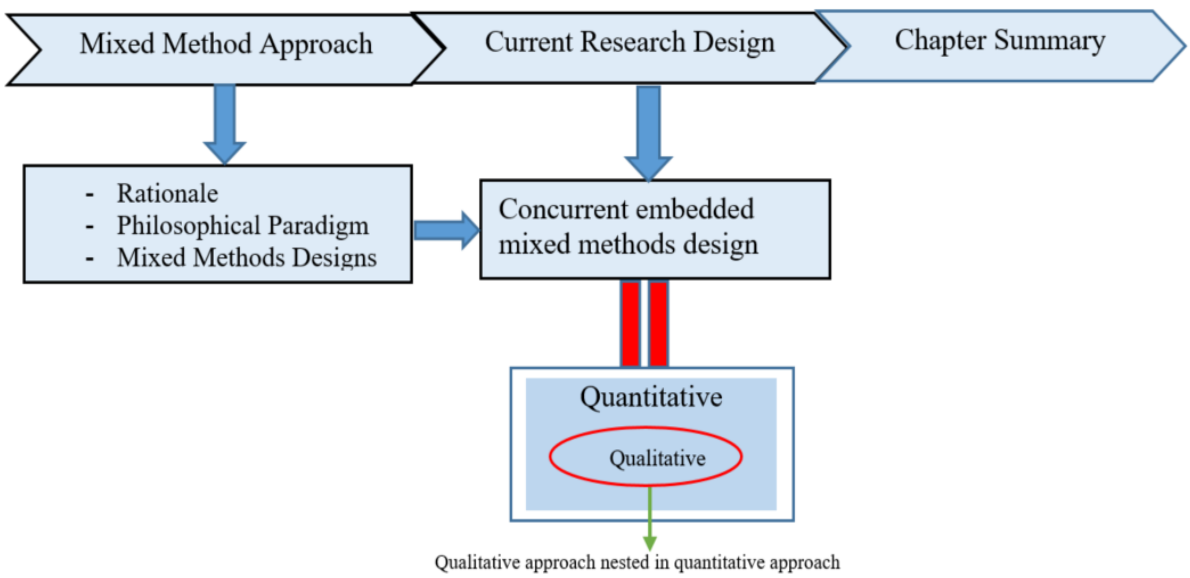


Figure 3. 1 Flow diagram of research methodology.

## 3.2 Mixed Methods Approach

Mixed methods denote an approach wherein the knowledge is based on a pragmatic paradigm and entails the collection of both a quantitative and qualitative dataset sequentially or concurrently. This approach has been specifically adopted to achieve the research Aims (Creswell, 2003). This method of inquiry has been justified on two grounds. First, there are two levels in this research which cannot be addressed using either a standalone or qualitative approach (Creswell, 2009; Johnson & Onwuegbuzie, 2004). Level one involves investigating the recordable injuries and the associated contributing risk factors, for which quantitative survey research is deemed more appropriate. Level two requires qualitative interviews to understand the economic and social challenges confronted by severely injured miners and their dependencies (families). Thus, the combination of quantitative and qualitative approaches helps to nullify the weaknesses of one another, as a result, maximizing the strengths of each (Creswell, 2003).

Broadly speaking, the combination of quantitative and qualitative research has been acknowledged to impart greater benefits (Greene et al., 1989). This includes recognising five rationales why researchers adopt a mixed methods approach, as mentioned below:

- *Triangulation* – The results derived from one method corroborate the findings from the other approach (Greene et al., 1989).
- *Complementary* – The results derived from one method (e.g., quantitative) are used to elaborate and validate the results from the other method (Hanson et al., 2005).
- *Development* – The results derived from one method are used to develop or inform the other phase of the study, particularly in the context of instrument development (e.g., the quantitative dataset being used to design the qualitative inquiry questions) and sampling (e.g., a sample from the quantitative phase being used to facilitate samples for the qualitative phase (Hanson et al., 2005).
- *Initiation* – A particular approach is used to reveal the paradoxes and contradictions from the results of the other method (Hanson et al., 2005).
- *Expansion* – The breadth and depth of the research can be extended using another method for varying components of inquiry (Greene et al., 1989).

### 3.2.1 Research Paradigm

When undertaking mixed methods research, it is equally important for the researcher to declare their philosophical position, considering the fact that it affects not merely the data collection and analysis, but also the interpretation of results (Gray, 2014). The concept of the research philosophy is associated with the development and nature of knowledge (Bahari, 2010). A research paradigm is defined as an ideological stance or an overarching philosophical/shared belief that affects the knowledge being researched and the manner in which collected evidence is deciphered (Broom, 2007).

In quantitative research wherein numerical data is collected to empirically understand the phenomenon of interest, the knowledge claim is based on the paradigm of positivism (Creswell, 2009). Positivists believe that reality is static, and that objective knowledge is obtained through scientific experimentation (Gray, 2014). The outcomes and perceived risk factors are strictly selected and controlled, before determining the relationship between them. Quantitative researchers are always interested in capturing and analysing these variables. They decide on which variables are to be investigated, which form of measurement and analysis will be needed to answer the research questions as well as the hypothesis and provide credible empirical outcomes (Creswell, 2014).

In case of a qualitative approach, non-numerical (i.e., textual) data are collected and the knowledge claim is supported by a constructivist paradigm (Creswell, 2003; Gray, 2014). In this paradigm, “reality is a social construct and so is constantly changing” (Sale et al., 2002). During the data collection and analysis process, the relationship between the researcher and the participants is paramount in achieving optimal outcomes (Onwuegbuzie & Leech, 2005). Furthermore, textual data is collected from those who have experienced the phenomenon and express their willingness to provide deeper insights into it (Yilmaz, 2013). The analysis of the textual data is guided by the participants’ perceptions of reality as well as the interpretive lens of the researcher (Gray, 2014).

Contrastingly, mixed methods research builds on knowledge from a pragmatic viewpoint (Onwuegbuzie & Leech, 2005). Pragmatists evaluate the research problem along with the best means of answering it (Broom, 2007). The researcher chooses the best data collection instruments, variables, and units of analysis in order to answer the research problems of interest in the best possible manner without allegiance to either positivism or constructivism (Tashakkori, 1998). The pragmatic paradigm underpinning the current study allows for the identification and use of both appropriate quantitative and qualitative techniques to investigate likelihood of recordable injuries along with the associated risk factors. Additionally, it explores the economic and social challenges faced by the severely injured miners in ASM operation.

#### 3.2.2 Mixed Methods Design

When a researcher adopts a mixed methods approach, they are required to identify the type of design suitable for their research problem as well as the rationale for their selection. In this regard, Creswell (2003) identified five mixed methods design typologies that researchers need to use when answering research problems necessitating a combination of quantitative and qualitative approaches.

Table 3. 1 Types of mixed methods designs as dictated by the four criteria (Creswell, 2003).

| **Mixed Methods Design** | **Descriptions** |
|---|---|
| Sequential Explanatory Design | The quantitative data collection and analysis happens first, followed by the qualitative data collection and analysis. Priority is given to the quantitative approach, after which the two datasets are integrated at the interpretation stage. |
| Sequential Exploratory Design | The qualitative data is collected and analysed first, followed by the quantitative data collection and analysis. Priority is given to the qualitative approach, after which the two datasets are integrated at the interpretation stage. |
| Sequential Transformative Design | In this design, the two datasets are collected and analysed independent of each other; integration takes place during the interpretation phase. However, either approach can be used first or priority can be given to either the qualitative or quantitative approach. |
| Concurrent Triangulation Design | The quantitative and qualitative dataset are collected and analysed together with equal priority to confirm, corroborate and validate the findings. Integration occurs at the interpretation stage of the study. |

| | |
|---|---|
| Concurrent Nested (Embedded) Design | Under this strategy, both datasets are collected and analysed simultaneously. However, a predominant method guides the entire research. This can mean that one method answers primary questions, while the other method addresses secondary questions. The two datasets can be combined, or the findings can be presented side-by-side, particularly in the case of separate questions. |
| Concurrent Transformative Design | Under this strategy, the quantitative and qualitative datasets are collected simultaneously, and priority of which is more important can be equal or unequal. Integration often occurs at the analysis stage, but sometimes at the interpretation stage. |

## 3.3 Research Design

The present research has been conducted using a concurrent embedded mixed methods design. This mixed methods typology allows nesting of both quantitative and qualitative research as well as simultaneous collection of the datasets as shown in Chapter 1. However, the weighting of the quantitative and qualitative approach in this design is not equal, given that one method plays a predominant role while the other renders support (Creswell, 2009). In this research, the qualitative approach has been embedded in the primary approach (i.e., the quantitative). The main purpose of this design is to apply the quantitative method to investigate recordable injuries along with the concomitant contributing risk factors. The next step would be to identify severely-injured miners and conduct qualitative face-to-face interviews in order to better understand the economic and social challenges faced by not only these miners, but also their families. The rationale for using a concurrent embedded strategy in this study, which was identified by Greene et al. (1989) as a form of 'development', implies that samples from one phase represent the sample frame for another phase of the study. The concurrent embedded design has been undertaken in two phases, which will be discussed in sections 3.3.1 and 3.3.2 below.

# PHASE 1

## 3.3.1 Quantitative Approach

The aim of this section of the research study is to capture recordable injury history and various risk factors in order to answer research question 1-4 stated in section 1.4 of this thesis. It was not possible to answer these research questions using a qualitative approach, as they required inferential statistics.

In this phase of the research, two papers were peer-reviewed and published. The paper presented as Chapter 4 answered research questions 1-3, whereas the paper in Chapter 5 answered research question 4. It is for this reason that quantitative sampling, data collection and analysis procedures are not discussed in this chapter. This section elucidates some key concepts behind the study and analysis.

### *3.3.1.1 Instrument and variables operationalization*

The epidemiology of ASM-related injuries in Kenya was never studied prior to this research. Therefore, the researcher designed an instrument that would measure this concept. To that end, a structured closed-end questionnaire was deemed suitable for the collection of quantitative data to be used in the description, prediction, comparison and explanation of various responses (outcome or dependent) variables from explanatory (independent) variables. A structured closed-ended questionnaire was opted for primarily due to the following reasons: limited bias experienced during a face-to-face interview, reduced pressure on participants and as a sense of anonymity among participants (Hoyle, 2002). One possible challenge associated with this data collection instrument could be a low response rate, which was mitigated through extensive sensitisation of the participants prior to data collection (Gray, 2014). More specifically, several mediums such as flyers, word of mouth and consultations were used to inform the miners and concerned stakeholders of the impending research project.

In accordance with the studies related to ASM and other industries, twelve variables were identified in the quantitative survey phase as a component of a 59-items structured closed-ended questionnaire. This questionnaire was segmented into four sections, with questions ranging from multiple choices, open ended, dichotomous, to 5-Likert scale questions. The classification of the questionnaire and measurement of twelve variables are discussed in the subsequent two chapters.

#### *3.3.1.2 Pilot testing of instrument*

A pilot study was completed prior to the commencement of phase 1 so as to assess the appropriateness of structured closed-end questionnaire and associated challenges that researcher might be confronted with during data collections (van Teijlingen & Hundley, 2001). The nine-page long survey instrument had multiple sections with varying degrees of measurement. Another issue was the different levels of literacy among the gold miners. As a result, it was important for the researcher to perform pilot testing of the questionnaire. The number of participants included in the survey was 20 gold miners, comprising of 10 injured and 10 uninjured gold miners each. These individuals were randomly selected and issued with both English and Kiswahili structured questionnaires twice in a span of 4-8 hours to complete without assistance from the researcher. Hertzog (2008) asserted that a sample size of 10 or fewer participants is appropriate if the goal is to test the adequacy and appropriateness of data collection instrument.  In this research, the aim was to ascertain the participant's understandability, interpretability, consistency as well as the effectiveness of research procedures.

After reviewing the results, it was determined that some of the pilot study samples participants had erroneously answered some of the questions during the first test. Consequently, all participants were educated on how to complete these specific questions and asked to complete the questionnaires again. During the second retest, the participants answered all the questionnaire accordingly. Although pilot study was fundamental for this phase, it was not a hypothesis testing research. Equally, it results were not conclusive enough due to an inherent small number of participants.

#### *3.3.1.3 Reliability and Validity*

Reliability and validity of structured questionnaire were deemed important aspects of this research in order to reduce errors that might compromise the integrity of data. Reliability refers to the ability of questionnaire to produce accurate and consistent results, if administered repeatedly (Bordens, 2011), while validity denotes the level to which specific concepts are accurately measured in the study (Bordens, 2011). Chapter 4 and 5 explicate the manner in which the reliability and validity of this research's quantitative phase were achieved.

#### *3.3.1.4 Study procedures*

This research involved the recruitment of 610 miners, of which 192 had suffered recordable injuries. Representative sample size calculation, inclusion and exclusion criteria, sampling approach, recruitment and data collection procedures has been discussed in detail in Chapter 4 and 5.

#### *3.3.1.5 Quantitative data analysis*

Poorly prepared data can compromise the statistical analysis and eventually, the interpretation of results. Therefore, the outcomes of analysis hinge upon the completeness of survey questionnaires, consistency and appropriate coding. In this regard, the data preparation started while each completed questionnaire was checked in the field for completeness and discrepancy. Questionnaires that were incomplete or wrongly completed were sent back to the participants for corrections, before being returned to the researcher. After the collection and checking of questionnaires, the dataset was manually entered into a Statistical Package for the Social Sciences (SPSS), Version 25 for statistical analysis as discussed in Chapter 4 and 5.

#### *3.3.1.6 Statistical analyses employed*

The quantitative dataset was analysed using both descriptive and inferential statistics.

##### *3.3.1.6.1 Descriptive statistics*

Descriptive statistics were applied in the initial stage of the analysis to obtain the participants' responses to various measures. The frequencies and percentages were then analysed based on the group (injured vs. uninjured) as well as non-grouping.

##### *3.3.1.6.2 Inferential statistics*

Given that the analysis carried out in subsection 3.3.1.6.1 only describes the data without establishing the relationships between response variable (s) and explanatory variable (s), the researcher used logistic regression analysis, which deals with probability outcomes. It examines which explanatory variables and interactions are needed in order to estimate the probability of an event's occurrence in the best possible manner (Hosmer, 2000). This is achieved by evaluating the relationship between one or more explanatory variables on the dichotomous outcome variable. Unlike linear regression analysis, the outcome response variable can be ‘categorical’ or ‘continuous’ (interval scale). In addition, the predicted values of explanatory variables are bounded by 0 and 1, whereas these values can be plus or minus infinity in other regression methods (Hosmer, 2013). These characteristics of logistic regression analysis make statistical analysis less stringent and helps ensure a good fit to the data (Al-Ghamdi, 2002; Anderson et al., 2003).

Logit, the fundamental mathematical concept that underlies the logistic regression model, is a natural logarithm of odds ratios (Peng et al., 2002). The logit transformation helps in linking sets of explanatory variables to the dichotomous outcome variable. Logistic regression analysis is grounded on calculating the odds of the dichotomous outcome variable as the ratio of the probability of having the binary response variable divided by the probability of not having it (Antonogeorgos et al., 2009). The details of modelling concept has been discussed in Chapter 5 Section 5.4.4.

##### *3.3.1.6.3 Odd ratios*

In logistic regression, the relationship between the response and explanatory variable (s) is commonly determined using the Odd ratio (OR) (Sauerbrei & Blettner, 2009; Szumilas, 2010), which is a measure of association and used extensively in epidemiologic studies. Generally, simple 2 x 2 tables can be used for dichotomous explanatory variable to determine the odds of an event’s occurrence and subsequently, ORs. The concept of OR has been discussed in Chapter 5 Section 5.4.4.

##### *3.3.1.6.4 Data analysis procedure*

The SPSS Version 25 statistical software program has built-in functions for performing both descriptive statistic and inferential statistics. Therefore, the researcher firstly subjected the dataset to descriptive statistics, within this environment, whereby the summarised measurements of the data were obtained. Then, binary and multinomial logistic regression was implemented in order to evaluate the effects of various risk factors on a number of outcome variables. Additional explanation of these analyses has been provided in the next two chapters.

# PHASE 2

### 3.3.2 Qualitative Approach

The primary objective of using qualitative interviews has always been to help provide a comprehensive understanding through participants' own experiences of why the phenomenon of interest occurred in the first place (Roberts, 1997). That is, the focus is placed on meanings derived from those at the receiving end of the phenomenon (Al-Busaidi, 2008). To that end, a qualitative interview was pursued in this part of research in order to gain insight into the challenges confronted by severely-injured miners and their families. This was achieved by answering research question 5 and 6 mentioned in Chapter 1.

The research has published one paper from this phase and included as Chapter 6. Some of the procedures have been elaborately explained in this phase of the research design due to the limitation imposed by the journal.

#### *3.3.2.1 Recruitment of participants*

The participants who responded to the quantitative approach were considered as a sample group for the qualitative approach. After completing the quantitative phase, the researcher reviewed the questionnaires that were completed by injured miners. Depending on how they answered questions related to the number of lost workdays, declining body functional limitation and continuing medical care, the researcher could successfully select participants for conducting face-to-face interviews. These individuals were contacted by telephone provided with structured closed-ended questionnaires before being asked whether or not they were interested in being interviewed.

Unlike the case of a quantitative approach, the qualitative sample size was not determined using any formula. The participants were continuously recruited and interviewed until the saturation point was reached. The sampling approach and the manner in which the saturation point was achieved has been described in Chapter 6.

For this research, a participant information sheet was developed by the researcher. The participant information sheet provides detailed information about research, including the risk and benefits, confidentiality and privacy and withdraw voluntarism. Please refer to appendix I for a copy of the participant information sheet. The participant information sheet was either read by the participant or read to them by the researcher, before being asked to sign or place thumb impression, for voluntary participation.

#### *3.3.2.2 Semi-structured interview*

The type of data collection method used in the qualitative interview is predicated on the research purpose, participants' time, available resources and the number of cases being explored. A semi-structured interview, also referred to as guided interview, was deemed suitable among other several domains of data collections in a qualitative interview (Fontana & Frey, 2000). This data collection method was dictated by its great flexibility; ability to explore both sensitive information and new ideas; as well as produce rich information (Jamshed, 2014). Moreover, the pre-determined open-ended questions or checklists that were developed prior to the commencement of data collections guided the research during the interviews process (Al-Busaidi, 2008). Via the semi-structured interview, participants' opinions were systematically and comprehensively explored while maintaining the interview structure (Jamshed, 2014). As a result, economic and social challenges faced by injured persons and their families were examined without exposing participants to psychological and emotional risks. In addition, the topics of discussion were kept focused without overlooking any issues that fell within the framework of the study.

#### *3.3.2.3 Data collection procedure*

The researcher began each interview by introducing himself, after which the participants were debriefed about the study's overarching aim, including confidentiality statement, right to withdraw, the wisdom of not answering any questions, questionnaire format, expected questions, clearly stated objectives, duration of the interview and finally, rules governing the interview. In addition, a consent form was issued for the participants to sign and provide their consent to be interviewed (see appendix J). This process is important because it enables the researcher to develop rapport and establish a trust-based relationship with the participants before starting the interview.

The nine pre-determined questions in the semi-structured questionnaire were divided into three predominant themes. The first theme covered issues relating to mine safety and injuries. The second theme focused on the economic challenges faced by injured persons and their families, whereas the third theme focused on the social impacts of injuries at individual and family level. Before starting the interviews, participants were made aware of these breakdowns, flexibility of questions and the potential to explore new ideas emerging from the interview. The social impacts of injury were inserted later on in the interview because they touch on relationships between miners, family, and community, which meant that they could potentially kindle strong emotions and in effect, distressful situation.

The interviews were conducted in Kiswahili for the sake of consistency and simplicity, as most miners in Migori County can only speak and write in this language. The intention was to ensure that participants comprehend all research documents in their entirety, including reviewing their own responses in researcher's handwritten field notes and providing feedback on whether or not capture information reflects their thoughts and beliefs on the phenomenon.

I began the interview with the social conversation before posting the actual research question. This approach enables the interviewer to develop a good rapport with the participants (Jacob & Furgerson, 2012). I made sure that the neutrality was maintained throughout the process so that the interview could be followed naturally, thus facilitating the attainment of rich information without waiting for the researcher to provide inputs. Participants were allowed to discuss the topics without having the researcher expressing his views and feelings on the topic. The interviews were conducted through note-taking, whereby the researcher recorded participants' responses in order to interview questions verbatim.

Before moving to the next question, the verbatim interview response was read to participants for the sake of validation and accuracy. During the interview, participants were constantly prompted to elicit more detailed answers to key themes being explored. The participants were encouraged to seek clarification. Meanwhile if the question (s) was not clear, the researcher provided clarity on them. Throughout the process, the interview was interactive/flexible, and the researcher was made aware of the participants' cultural beliefs and the sensitivities of language. All study participants were asked the same nine questions in order to ensure that their responses relate to the research objectives.

After the completion of interviews, each participant was given the researcher's handwritten field notes immediately after the information acquired remained fresh to review for further corrections and clarifications of their responses. If the participant was unable to read, the information was read to the participant in order to make sure that their verbal responses to each question had been correctly recorded. The researcher ensured that each interview did not exceeded recommended time of 90 minutes to avoid interrupting other commitments of the participants (Jacob & Furgerson, 2012). Chapter 6 of this thesis briefly describes this data collection procedure.

#### *3.3.2.4 Thematic data analysis*

The qualitative interview results were analysed using the thematic analysis (TA) to determine the objectives of this phase of the research. The approach helps to outline factors that contribute to poor mining safety culture and subsequently injuries, declining economic status as well as negative social health and lifestyle changes. Thematic analysis helps identify and analyse themes across a qualitative dataset (Braun & Clarke, 2006). In comparison to other qualitative approaches, TA is not tied to a specific epistemological standpoint and can be applied to wide range of research questions (Nowell et al., 2017). This flexible qualitative data analysis technique does not require detailed theoretical and technological knowledge of other qualitative analysis techniques, and offers a more accessible form of analysis, particularly for those in the early phases of their research career (Braun & Clarke, 2006). According to these authors, TA should be a foundational qualitative analysis method, as it “provides core skills that will be useful for conducting many other kinds of analysis” (p.78).

The primary purpose of conducting qualitative analysis using the TA approach is to identify important themes and to use them to answer research question(s) under study or phenomenon of interest. Therefore, the theme is a fundamental concept underpinning the TA method, and refers to the patterns of meaning in a qualitative dataset.

During the analysis, Braun and Clarke (2006) classify two levels of identifying themes: In a semantic approach “…the themes are identified within the explicit or surface meanings of the data, and the analyst is not looking for anything beyond what a participant has said or what has been written” (p.84). This research used sematic level because the economic and social impacts of ASM-related injuries have been loosely studied, which is why the researcher relied on the first-hand accounts from participants. The researchers focused on incisive interpretation and explanations, as opposed to simple descriptions of the emerging themes from the dataset.

In contrast, the latent level looks beyond what has been narrated, and “starts to identify or examine the underlying ideas, assumptions, and conceptualisations - and ideologies - that are theorised as shaping or informing the semantic content of the data” (Braun & Clarke, 2006, p.84). Whether the researcher adopts sematic or latent theme or both, specific criteria must be explicitly state to what can and cannot be coded as a theme. Otherwise, this form of analysis runs the risk of being highly subjective. The recurring phrases, sentences and quotes among the interviewed injured miners were considered as themes in this research.

The theme in thematic analysis can be drawn either through the theoretical idea (deductive) or raw data (inductive) (Braun & Clarke, 2006). In the case of deductive analysis, the researcher uses the research guide such as pre-determined questions to develop initial coding. Subsequently, the structure is interactively refined when the interviews are completed (Ranney et al., 2015). This approach was ensued considering the fact that economic and social challenges faced by the injured artisanal and small-scale miners were not well established in literature. Thus, the pre-defined questions developed from literatures relating to other industries were used as baseline for conducting interview and eliciting related information from the participants. Deductive reasoning also allows for the findings to be generalised to a certain extent (Boyatzis, 1998).

In an inductive approach, the generated themes are strongly linked to the qualitative collected dataset (Patton, 1990). The analysis of the collected data started with the precise content and moved into greater generalisation, before finally being developed into theories. This provided the researcher with the flexibility to deal with the collected data throughout the research (Ibrahim, 2012). In an inductive coding process, the researcher does not try 'fit it into a pre-existing coding frame, or the researcher's analytic preconceptions' (Braun & Clarke, 2006, p. 84). This form of coding was not employed because the current research did not endeavour to develop theories. Instead, the researcher was keen to answer the research questions through the narrative determined by participants' responses. Therefore, it was critically important to use pre-defined questionnaires for developing codes and then themes.

Although qualitative researchers have developed and advanced plenty of guidelines for credible and reliable analysis of qualitative data, using this guideline required the researcher's judgement and creativity, because each study is different (Al-Busaidi, 2008). The 6-phase guideline developed by Braun and Clarke (2006) was supplemented by the researcher's own discretion and creativity; this was subsequently followed by thematic analysis. Of the aforementioned guideline clearly demarcated thematic analysis, thus giving the researcher a well-defined explanation on what needed to be done while maintaining the desired flexibility (Fielden et al., 2011). It is also notable that the end goal was to avoid potential pitfalls and harness the latent ability of this approach. The semi-structured data collected through handwritten field notes were analysed using Braun's six steps, as explicated below:

**Step 1: Transcript data familiarisation**

For the Kiswahili interview, handwritten field notes were translated back into English for consistency and simplicity. During translation, the text from each transcript was entered into the word document to form corpses of analysis. I then read them for familiarisation while I was still in the field. If the interview results or the texts were not clear, the researcher recalled back the participants for further clarifications and corrections to ensure that information obtained represent the participants' own understanding of social and economic challenges post-injury. Transcribing the interview documents, especially during translation, increased the researcher's understanding of the text (Braun & Clarke, 2006). After the researcher read all the interview documents and clarified necessary information, a final contact was made with each participant to discuss the translated text and findings as means of protecting accurate picture of information provided by the participants. Additionally, the researcher would not be able to contact the participants once left the station because the telephone number of the participants will be deleted, and pseudonym identity used in the documents. Therefore, it was critical to make these final contacts.

When the researcher came back, further reading of the translated transcript was conducted for more familiarisation. As recommended by Braun and Clarke (2006), I read and re-read the transcripts several times line by line in order to immerse myself in the data and comprehend the depths and breaths of the collected information. Reading through the text several times provides an opportunity to shape patterns or hidden meanings in the content.

The texts were imported into a data management software called NVivo 12, which is a product of QSR International Pty Ltd. Within this environment the process of organising the transcripts, coding and thematic will be carried out. NVivo is a text analysis software with pattern matching, coding and modelling capacities which make it suitable for identifying patterns of responses from interviewed participants. The data management software was used to improve the rigorousness of the analytical steps and allow the researcher to analyse the data at different and more focused levels (Ibrahim, 2012).

**Step 2: Data coding**

Following the transcribing and reading, data immersion, that is, the coding of the dataset was done. The coding process identified features that I considered related to the research question 4 and 5. Coding process was the approach with the research question in mind. All the dataset was given full and equal attention to consider repeat patterns in the dataset. In the coding stage, words, phrases, sentences and specific quotes form a building block for each code. This process of reading and coding of the dataset is called open coding. A 'good code' captures the richness of the qualitative information (Boyatzis, 1998). In NVivo 12 working environment, the identified features are assigned a code called 'nodes.'

**Step 3: Searching for Themes**

When the dataset was coded and collated, a long list of the codes (nodes) emerged, which required the researcher to conduct more focused analysis. In this process, codes are sorted in and merged relevant codes into a single identified theme. Braun and Clarke (2006) suggested that thematic maps must be developed in the form of tables, mind-maps or jotting. The visualisation tools such as words were used to provide brief overview themes. This visual representation provides the researcher with a chance to think about the link and relationship between codes and subsequently themes.

**Step 4: Reviewing themes**

This stage involves reviewing of the themes. The researcher read all the collated extracts for each theme and determined whether the form a coherent pattern. In this process, all the themes coded gives a clear pattern. Then, I read and re-read the dataset again to ascertain whether the themes 'work' in relation to interview results. Any important additional information missed was coded.

**Step 5: Defining and naming themes**

This stage involves defining and names of themes; each individual theme was properly named, followed by a detailed analysis of essence and the aspect of data capture by themes. Both the 'story' provided by each theme and how 'overall story' related to the dataset and subsequently, research question and hypothesis was taken into consideration. During the refinement process, the researcher looks for sub-themes which were identified. Furthermore, it was important to create a concise punchy name that immediately provide the readers with essence of the theme. The theme names were generated from the key words of research questions.

**Step 6: Producing the report**

The final stage of the six steps provided by Braun and Clarke (2006) entails thematic report production. The objective of this phase is to present a coherent and logical story that emerges from the data and the themes. The report must be produced in such a way that it convinces the readers about the merit and ability of analysis (Braun & Clarke, 2006). Transcripts with the elements of the themes will be taken into the account, which will indicate problems with the themes. The tradition form of reporting was adopted, in which the themes and sub-themes supported with quotes were presented.

#### *3.3.2.5 Rigorousness of qualitative research*

The methodology for measuring reliability and validity of quantitative research is different from that of qualitative research. According to Creswell (2003), validity and reliability do not carry the same connotation as it does in quantitative research. Qualitative researchers have established a number of processes to ensure rigorousness in their studies. Mays and Pope (1995) stated that rigorousness is achieved through "systematic and self-conscious research design, data collection, interpretation, and communication" (p.110). The advocates of qualitative research quality have identified four key methods of achieving rigorous and trustworthy research: credibility, transferability, dependability, and confirmability (Guba, 1981; Hadi & José Closs, 2016; Ortlipp, 2008; Shenton, 2004). In this research, a number of techniques was employed to ensure that all qualitative data collected conformed to the true value of rigorousness and trustworthiness as shown in Table 3.2. The trustworthiness of this research was inspired by Guba's (1981) and Shenton's (2004) model of trustworthiness.

Table 3. 2 Rigorousness of qualitative research.

| **Criterion** | **Trustworthiness Criteria** | **How researcher achieve trustworthiness** |
|---|---|---|
| Internal Validity | Credibility | During the data collection process, the research ensured the following steps to increase credibility of this research;<br>• Before data collection, the researcher visited the site to get familiarised with the participants and working conditions and had 'prolong engagement' with some of the miners.<br>• During the data collection, every interview was recorded for appropriateness.<br>• The researcher ensured that participants are given the option to refuse to participate in interviews and to involve only genuinely willing participants.<br>• Constant debriefing between the researcher and supervisors.<br>• Peer review (findings were discussed with the co-workers) |

| | | |
|---|---|---|
| | | • Member check (One of Rieko Kenya who had a background in medical research was recruited to read the transcripts and research emerging themes). |
| External Validity | Transferability | • A thick description of the research processes and data. When the researcher was writing the results of the study, critical attention was paid to specific information about and detailed description of study location, method, subject (s) and my role in the study. This was important because it allows other readers to judge whether or not they can transfer this approach to their own situation. |
| Reliability | Dependability | • The researcher reviewed all planned steps for the research and compared them with the actual steps undertaken. An effective appraisal of the study was done.<br>• Purposive sampling was use to pick information rich cases for interview. |
| Objectivity | Conformability | • Self-reflection to identify the researcher's personal biases.<br>• Consulting participants for clarification during the initial phases of transcripts reviews while remaining on the site. |

Source: Adapted from Shenton (2004) and Guba (1981).

## 3.4 Summary

The concurrent embedded mixed method approach was used in order to better understand recordable injuries and risk factors as well as economic and social problems faced by severely injured miners and their families. The quantitative survey helped to encapsulate the information related to the nature of recordable injuries, bodily part injured, mechanism of causations, and the risk factors for injury, and also to identify the number times a miner got injured, relative level of injury severity, economic situation and social health and lifestyle impacts. The use of a pilot study in the quantitative phase, use of SPSS version 25 and NVivo 12 helped facilitate the attainment of research objectives and ensure rigorousness.

# 4. COMPARISON OF PARAMETERS FOR LIKELIHOOD AND SEVERITY OF INJURIES IN ARTISANAL AND SMALL-SCALE MINING (ASM)

## 4.1 Overview

The discrete published article presented as Chapter 4 was submitted, peer-reviewed and published by the *Journal of Safety Science* in 2019. The whole text of the paper was simply adopted as Chapter 4. Only headings, sub-headings, tables and figures numbering as well as references were modified for thesis flow. This chapter has provided insight into the ASM-related injury history and risk factors that influence likelihood of injuries as well as injury severity.

The permission to reproduce this paper and signed co-authorship form have been appended as appendices D and C respectively. An original published copy can be found from http://doi.org/10.1016/j.ssci.2019.05.058.

## 4.2 Abstract


### Background

Workplace injuries cause lost workdays, performance disability, incessant medical care and fatalities. Therefore, determining their risk factors helps in not only injury prevention but also their consequences. Although most of the researches concentrate on the likelihood of injuries, little research has been done to investigate the causes of severities. This study is an attempt to investigate the factors causing likelihood and severities separately and compare them to interpret their role. The present study used a survey design in order to encapsulate information pertaining to the risk factors and injury history.

### Materials and Methods

The structured survey questionnaire was administered to 162 uninjured and 74 injured miners in the Osiri Gold Mine. In addition, the methodologies of descriptive statistics and logistic regression were used to analyse the data.

**Results**

The results showed that the laceration, contusion and fractures were common injuries, with most of them inflicting the hands and wrists, and were largely caused by dropped objects or equipment. When the risk factors for the likelihood of injuries and severity of injuries were examined, the following contributors were inferred: Male miners, less experienced miners, long shift hours as well as poor management and supervision, job dissatisfaction and job stress. The age group, drug usage, and poor work conditions were associated with likelihood of injuries but not with severity of injuries.

**Conclusions**

The study concludes that some risk factors for likelihood of injuries also influenced the severity of injuries. Therefore, it is advisable that sustained injury prevention mechanism must be instated to safeguard the welfare of miners.

## 4.3 Introduction

The demands for livelihood diversification in the rural areas of mineral-rich developing countries has pushed millions of men, women, and children to engage in Artisanal and Small-scale Mining activities (ASM) (Aizawa, 2016; Arthur et al., 2016; Hilson & Banchirigah, 2009). For some miners, their socio-economic situation has considerably improved, but in the case of others, the activity has confined them to the vicious cycle of poverty (Buxton, 2013). ASM is defined as a type of mining that employs crude, primitive or low-tech equipment for mining metals and minerals through underground and open-cut mining approach, and it can be undertaken by an individual, a family, a community or a small-scale cooperative as means of improving living standard and gaining profit (Hentschel, 2003).

With modern society and advanced technology, ASM unlike large-scale operation is still characterised by rudimentary or semi-mechanised equipment, small capital, small production, environmental problems and poor occupational health and safety standards (OSH) (Hentschel, 2003). In addition, the activity is largely illegal and commonly practised in rural areas with limited or non-existing government surveillance – most countries globally have not formalized or if legalized, the laws are loosely enforced (International Labour Office [ILO] 1999). These complex webs of problems are often dominated by ASM positive socio-economic contributions

(Fisher et al., 2009; Kamlongera, 2011).

The frequent occurrence of occupational injuries is one area of health concern that has captured the attention of policy-makers. In Tanzania, the statistics showed that 11 artisanal and small-scale miners died every year (Kitua, 2006). Recently carried out epidemiologic studies have firmly established that occupational injuries in ASM are prevalent and serious enough to cause significant post-injury consequences (Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015).

Although physical/ergonomic hazards have been blamed for occupational injuries, there are additional underlying factors that influence the occurrence. Artisanal and small-scale miners worked in the environment where safety is completely disregarded (Bansah et al., 2016; Elenge et al., 2011). This is because the sector lack expertise, skills, proper investment and technological know-how to improve both production as well as safety.

According to the ILO, the sector is six to seven times more dangerous than large-scale mining (ILO, 1999). Poor safety culture has been identified to cause catastrophic accidental events in mining industry. The United States Nuclear Regulatory Commission (U.S.NRC) review a case-study carried out to understand the reasons behind mining accident in Upper Big Branch (UBB) mine in southern West Virginia, whereby twenty-nine coal miners were killed (U.S.NRC, 2012). The findings revealed that the company prioritized production over safety, poor environmental conditions, poor ventilation and coal dust which serve as a "catalyst to a resulting series of massive explosions". Correspondingly, some of the epidemiologic studies conducted in sub-Saharan African countries found majority of both injured and uninjured miners with no personal protective equipment and lack health and safety training (Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013). The research also acknowledged high prevalent of hazards without available control mechanisms, poor management and lack of social support. Number of factors indicated positive or negative safety culture at workplace. In ASM operation, the key features of poor safety culture are poor working conditions, poor management and supervision, job stress and substance abuse.

The relationship between the indicators of poor safety culture at work and other risk factors such as individual characteristics with likelihood of occupational injuries has been well researched. However, with the likelihood of severe injury, these risk factors remain under-researched. Depending on the level of severity, occupational injuries are classified into non-recordable and recordable injuries. Non-recordable injuries are workplace injuries that have not resulted in lost workdays or medical attention, whereas recordable injuries are those that have led to a fatality, disability or medical care. The recordable injuries can be further sub-divided into the minor and severe injuries. Minor injuries refer to injuries that have led to only medical care or first aid, while severe injuries are related to recordable injuries that have caused incessant medical attention, disability, and fatality.

This study has focused on the risk factors associated with the likelihood of recordable injuries as well as likelihood of severe injuries in Artisanal and Small-scale Gold Mining (ASGM) operation in Osiri Mines of Migori County. As such, the study specifically has assessed: (i) the relationship between individual characteristics (age, gender, marital status, education level, and mining experience), behavioural-related risk factors (alcohol and drug usage) and job-related risk factors (shift hours, poor working conditions, poor management and supervision, job dissatisfaction and job stress) with likelihood of injuries. (ii) Do the predictors of likelihood of injuries also influence the severity of injuries?

## 4.4 Materials and Methods

### 4.4.1 Study area

This study was carried out in the Osiri Artisanal and Small-scale Gold Mining (ASGM) operations in Migori County. Migori County is situated in western Kenya, bordering Lake Victoria to the west and the Republic of Tanzania to the south. The county is known both in and outside of Kenya as a symbol of the gold mining activities (Ogola et al., 2002).

### 4.4.2 Participants and sampling

The study population was 610 artisanal and small-scale gold miners. The data employed in the study was provided by the mine owners, worker representatives and validated by the research team, wherein, about 192 miners recorded injuries. The sample size for the present study was carried out using the Kathori’s (1990) formula. We first determined the population based on Z values, sample proportion and confidence level.

Sample size $= \frac{Z^2 * (p) * q}{e^2}$ ……………………………………………………………... [1]

- Z = Z value (e.g., 1.96 for 95% confidence level)

- Sample proportion, q = 1-p (p = 0.5 and q = 0.5)
- e = confidence level = (± 5%)

$$\text{Sample size} = \frac{1.96^2 * (0.5) * 0.5}{0.05^2} = \mathbf{384.16}$$

To reduce the sampling error, we corrected the finite population generated in equation 1. Whereby, N = number of current miners (both injured and uninjured) and SS = representative sample size.

$$SS = \frac{Z^2 * p * q * N}{e^2 (N-1) + Z * p * q} = \frac{Z^2 * p * q}{e^2}\left(\frac{N}{N - 1 + \frac{Z^2 * p * q}{e^2}}\right) = SS\left(\frac{1}{1 - \frac{1}{N} + \frac{SS}{N}}\right)$$

$$= \frac{SS}{1 + \frac{SS-1}{N}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .. [2]$$

Using equation 2, the representative sample for 610 miners is shown below.

$$SS = \frac{384.16}{1 + \frac{384.16 - 1}{610}} = \mathbf{236}$$

From the samples generated from equation 2, we adopted stratified random sampling for better sample representation. As a result, the study population was stratified into injured and uninjured stratum with 192 and 418 miners respectively. The samples within each group was calculated as follows:

$$\text{Stratum sample size} = \text{SS} * \frac{(\text{x})}{(\text{N})} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [3]$$

Whereby, SS = sample size determined in equation 2, x = population of injured or uninjured miners and N = overall population of miners. Therefore, the samples to select per stratum based on the proportional ratio is shown below:

$$\textbf{Number of injured miners } (y_1) = 236 * \left(\frac{192}{610}\right) = \mathbf{74}$$

$$\textbf{Number of uninjured miners } (y_2) = 236 * \left(\frac{418}{610}\right) = \mathbf{162}$$

The study only considered the participants who are miners, aged over 18 years and willing to provide free consent. Also, the mine owners, management and local government officials were excluded from the scope of the study.

The sampling approach adopted for conducting this study was stratified and systematic random sampling. The researchers developed the list of eligible miners and provided each of the study participants with pseudonym identifiers in order to safeguard their privacy and confidentiality. During the survey, the participants were segregated in two groups of injured and uninjured, for data collation. The starting random identifier for each group was selected by the research team, followed by the systematic selection of the remaining samples till the researchers reached the calculated target (74 injured and 162 uninjured participants). This approach was adopted for the dual purpose of (i) providing a better representation of the population and (ii) reduced sampling error.

#### 4.4.3 Structure of the survey instrument

In the current paper, survey design has been used in order to achieve the objective of the present study. The survey was employed because of the time, resources and lack of reliable data on ASM recordable injuries.

The study used a structured closed-end questionnaire that was divided into four sections. The section one included questions relevant to the demographic profile of the participants, i.e., age, gender, marital status, education level, mining experiences and hours worked per day. Section two included questions, which sought information as regards the level of alcohol and drug consumption. That is, the participants were asked whether they come to work intoxicated; consumed substance before, during or after; whether they have experienced near misses and/or have been involved in accidents that hurt them or some else. The third section took into account the miners' perception about poor working conditions, poor management and supervision, job dissatisfaction and job stress. The fourth and the last section of questionnaire was restricted specifically to 74 miners with recordable injuries and entailed questions about the number of days spend off work, whether the experience limited their job performance, resulted in continuous body pain and warranted medical attention.

The reliability and validity of the data collection (structured closed questionnaire) were assessed before implementing the study (Heale, 2015). The reliability was achieved by calculating the Cronbach's alpha from pilot testing data. Our calculated Cronbach's alpha was

0.786 which is greater than an absolute minimum of 0.7 (Hinkin, 1998). For validity, we consulted one of public health expert with strong background in public health data collection procedures and instrument design in Migori County. The expert concluded that variables that underpinned the content were considered in the tool and it was valid for current study.

### 4.4.4 Data collection procedure

The participants were contacted and identified through disseminating verbal information through word of mouth and flyers. Prior to initiating the data collection, the primary researcher recruited two research assistants who were conversant with the native language and skilled in public health data collections. The research assistants were subsequently trained on the survey instrument as well as the ethical conduct of the research. Also, this initial spadework included extensive consultation and sensitization with various stakeholders including miners to obtain permissions, inform, validated number of miners and registered the willing participants.

During the survey, each eligible participant was informed of the purpose of present study and provided with an informed consent form to sign or place their thumbprint impression, expressing their voluntary participation. The literate participants were allowed to self-administer the questionnaires, while semi-literate or illiterate participants were assisted by the research team. For these participants, the survey questions and answers were read out, and specific care exercised in order to prevent directing or influencing their responses. The completion of the questionnaire was carried in either English, Kiswahili or Luo language depending on the participants' preferred language. Each questionnaire took about 30-40 minutes to be completed.

### 4.4.5 Data preparation

The collected survey questionnaires were critically reviewed, and those filled in Kiswahili or Luo language were translated back to English for uniformity of response language. The clean dataset was subsequently entered and coded in SPSS software. The study collated and segregated the response under the variables of: (i) likelihood of injuries; and ii) severity of injuries. The likelihood of injuries was further coded into the classifications of (i) No = 0, and (ii) Yes = 1. This classification was based on whether the participants did face injury or not. The severity of injuries was operationalized through number of lost workdays. The participants who reported to have stayed off work less than a week (1-6 days) after getting injured were merged in no injured group and coded as 'No = 0'.  While those that had over a week (7 days) lost workdays were categorised as 'Yes = 1'. Correspondingly, the individual characteristics, behavioural-related risk factors, and job–related risk factors were coded as shown in Table 4.1.

Table 4.1 presents the injury summary statistics of the injured participants in Osiri Gold Mines based on the cross-tabulation of the interested response variables, namely, the likelihood of injuries and severity of injuries.

Table 4. 1 Participants' response to risk factors for both likelihood of injuries and severity injuries (N= 236).

| Risk factors | Likelihood of injuries (%) | | Severity of injuries (%) | |
|---|---|---|---|---|
| | No (N= 162) | Yes (N= 74) | No (N = 176) | Yes (N = 60) |
| *Age groups* | | | | |
| 1= 18-34 | 51.9% | 68.9% | 54.0% | 66.7% |
| 2= 35 and over | 48.1% | 31.1% | 46.0% | 33.3% |
| *Gender* | | | | |
| 1= Male | 51.9% | 67.6% | 52.8% | 68.3% |
| 2= Female | 48.1% | 32.4% | 47.2% | 31.7% |
| *Marital status* | | | | |
| 1 = Single | 42.6% | 51.4% | 43.8% | 50.0% |
| 2 = Married | 57.4% | 48.6% | 56.3% | 50.0% |
| *Level of education* | | | | |
| 1= Low education level (< Year 8) | 60.5% | 75.7% | 60.8% | 78.3% |
| 2= High education level (> Year 8) | 39.5% | 24.3% | 39.2% | 21.7% |
| *Mining experiences* | | | | |
| 1= Less than 3 years | 54.3% | 70.3% | 55.1% | 71.7% |
| 2= More than 3 years | 45.7% | 29.7% | 44.9% | 28.3% |
| *Shift hours* | | | | |
| 1= More than 8hrs/day | 44.4% | 67.6% | 46.0% | 68.3% |
| 2= Less than 8hrs/day | 55.6% | 32.4% | 54.0% | 31.7% |

| | | | | |
|---|---|---|---|---|
| *Alcohol consumption* | | | | |
| 1= High-risk user | 58.0% | 54.1% | 58.0% | 53.3% |
| 2= Low-risk user | 25.3% | 29.7% | 26.7% | 26.7% |
| 3= Not alcohol user | 16.7% | 16.2% | 15.3% | 20.0% |
| *Drug usage* | | | | |
| 1= High-risk user | 24.1% | 45.9% | 26.1% | 45.0% |
| 2= Low-risk user | 40.1% | 23.0% | 38.6% | 23.3% |
| 3= Not drug user | 35.8% | 31.1% | 35.2% | 31.7% |
| *Poor work condition* | | | | |
| 1= Agree | 55.6% | 77.0% | 57.4% | 76.7% |
| 2= Disagree | 44.4% | 23.0% | 42.6% | 23.3% |
| *Poor management and supervision* | | | | |
| 1= Agree | 70.4% | 83.8% | 71.0% | 85.0% |
| 2= Disagree | 29.6% | 16.2% | 29.0% | 15.0% |
| *Job dissatisfaction* | | | | |
| 1= Agree | 61.1% | 78.4% | 62.5% | 78.3% |
| 2= Disagree | 39.9% | 21.6% | 37.5% | 21.7% |
| *Job stress* | | | | |
| 1= Agree | 78.4% | 90.5% | 79.5% | 90.0% |
| 2= Disagree | 21.6% | 9.5% | 20.5% | 10.0% |
| *Table 1 presents the injury summary statistics of the injured participants in Osiri Gold Mines based on the cross-tabulation of the interested response variables, namely, the likelihood of injuries and severity of injuries.* | | | | |

For alcohol and drugs (i.e., marijuana, opium, etc.) usage, the study primarily focused on the risk associated with consumption and intoxication levels. Based on the responses to the questions, the researchers were able to ascertain the risk level, basis which the miners were classified into high-risk users, low-risk users and non-users. Miners who did not consume substances at all were categorised as ‘not a user’, while those who consumed alcohol but did not come to work intoxicated or took substances at work were considered as ‘low-risk users’. Lastly, miners who came to work intoxicated, consumed substances at work, were involved in accident, experienced near misses or got injured because of substances were coded as ‘high-risk users’.

Job-related factors were originally assessed using the 5-Likert scale and subsequently reorganised into two categories – agree and disagree. Each variable Likert item was summed up against the rest and allocated the category depending on the mean. Following which, the ‘strongly agree’ was merged into ‘agree while ‘neutral’, ‘disagree’ and ‘strongly disagree’ into ‘disagree’, as determined by the response sizes. The combination of 5-Likert items into 2-Likert items was necessitated by the sample size and effects on the model. The logistic regression analysis demonstrated that the events per variable (EPV) must be > 20 (Peduzzi et al., 1995). However, Vittinghoff et al. (2007) stated that 5-9 EPV were enough to reduce the instability of the predictive model.

#### 4.4.6 Statistical analysis

The clean and coded data was first analysed using the descriptive statistics, wherein the frequency distributions and percentages of risk factors and injury history were determined. This was followed by the bivariate and multivariate logistic regression analysis to assess risk factors for likelihood of injuries and severity of injuries.

The association analysis test was conducted in two stages: The first involved assessing and establishing the relationship between risk factors and likelihood of injuries. The second stage entailed assessing and establishing the severity of injuries predictors.

In the first stage, the bivariate relationship between the various risk factors and likelihood of injuries was conducted using binary logistic regression. The test was aimed to identify the risk factors through Crude Odds Ratio (COR) at 95% Confidence Interval (CI). The risk factors were then used in the multivariate logistic regression model and backward elimination was performed. In this form of analysis, risk factors that have $p \geq 0.1$ are continuously eliminated until all significant factors were achieved. Participants’ age group and alcohol consumption were eliminated during this analysis. The risk factors with $p<0.05$ were considered as significant for likelihood of injuries.

In the second stage, the experimental work followed the same procedure as in stage one, but herein the focus was more on risk factors associated with the severity of injuries. The bivariate test association was performed between the risk factors and severity of injuries, of which crude odds ratios (CORs) at 95% CI were computed.  Again, the binary logistic regression model was saturated with all the risk factors. We, then manually removed the risk factors that were insignificant in the model until we were left with only significant predictors of severity of injuries, which produced AOR at 95% CI. Marital status, alcohol consumption, age group, drug usage and poor working conditions were removed.

## 4.5 Results

### 4.5.1 Recordable injuries characterization

Artisanal and small-scale gold miners were observed to have suffered a variety of injuries as shown in Figure 4.1 below. Of the 169 injuries self-reported by the participants, 28% of cases were of laceration injuries, followed by contusion injuries with 17% and the least occurring were facial and burn injuries with 1% respectively.

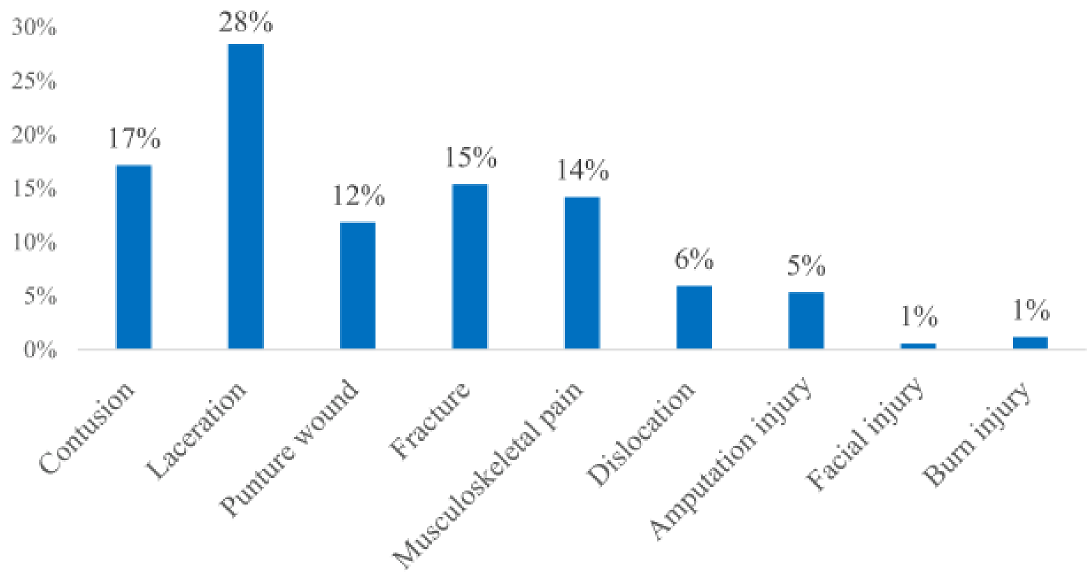


Figure 4. 1 Nature of injuries.

### 4.5.2 Body part injured

Figure 4.2 showed that many of participants sustained injuries on their hands and wrists (17%), with almost equal (12%) proportion having injuries around their shoulder, back, arms and elbows, thumbs and legs. Whereas, neck, faces and hips sustained very few injuries.

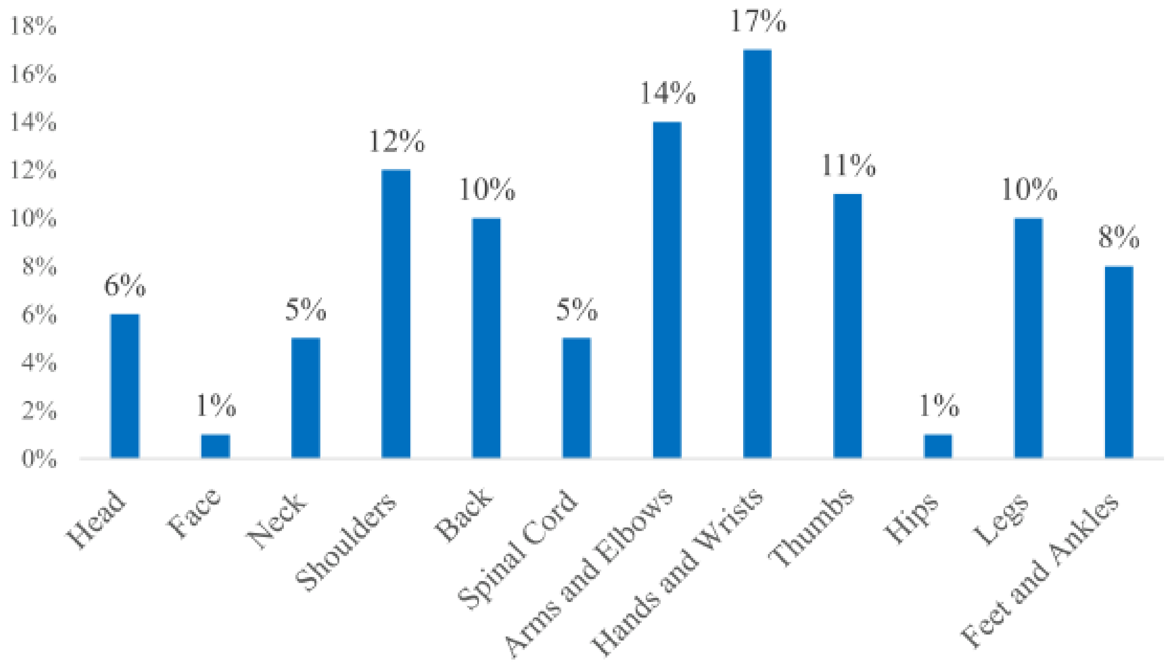


Figure 4. 2 Body parts injured.

### 4.5.3 Mechanism of causation of injuries

Figure 4.3 shows the various causes of injuries sustained by the miners during work. It is observed that the main cause of injury was being struck by an object (38%) and/or work equipment (30%). While the chemicals (1%) and explosions (1%) caused minimal injuries among the miners.

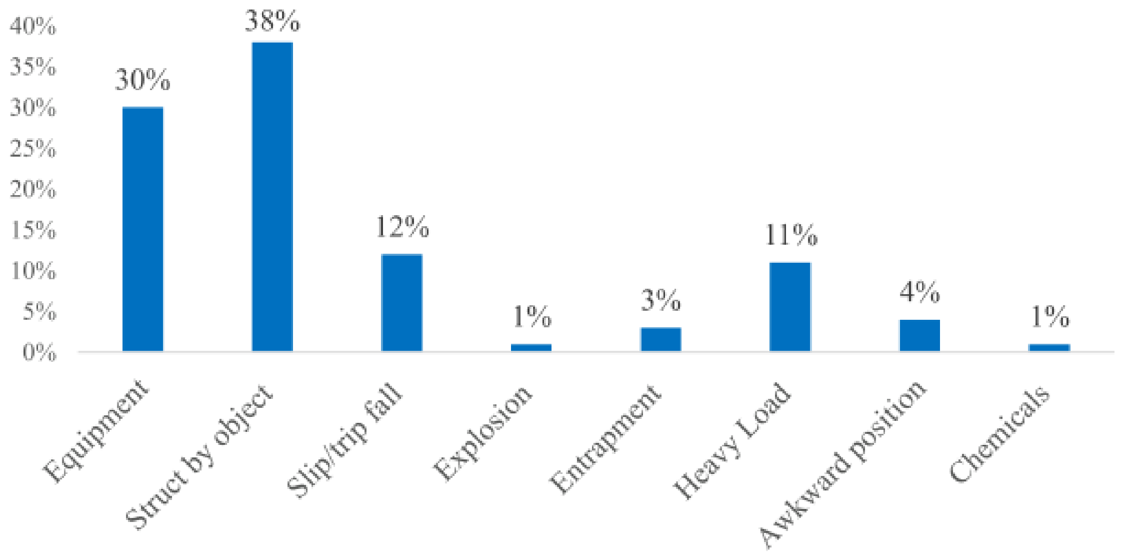


Figure 4. 3 Causes of injuries

### 4.5.4 Determination of severity of injuries

The severity of injuries was assessed through the measurement of the number of lost workdays. Figure 4.4 represents number of participants involved in different lost workdays due to injury. Of the 74 survey injured participants, those that have stayed off work for a duration exceeding 30 days were majority, followed by a range of 14-29 lost work days. The participants who reported the loss of 1-6 workdays were in minority proportion.

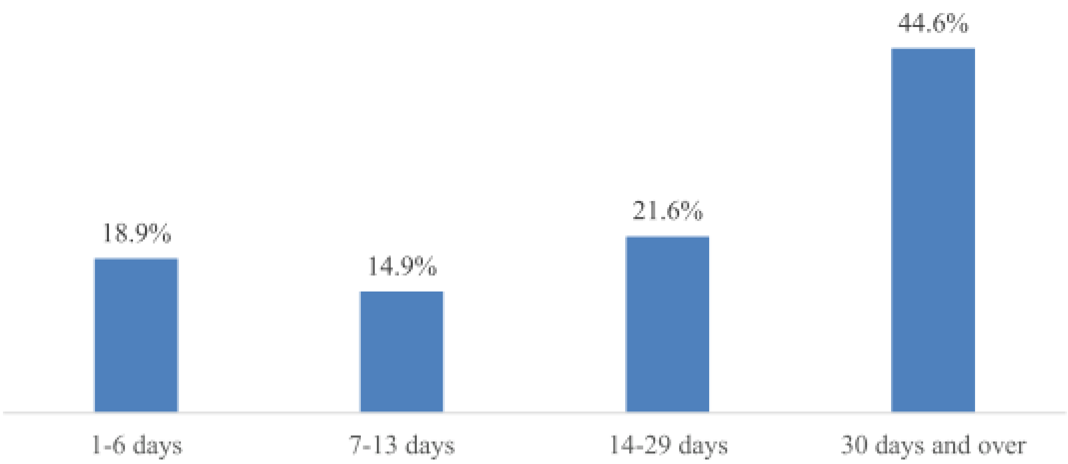


Figure 4. 4 Injuries based on number of lost workdays.

### 4.5.5 Participants' injury condition

Participants were asked about their injury conditions with the purpose to evaluate whether they are continuing to encounter some work-related problems. This objective helped in understanding severity of injuries in ASM operation. Herein, about 43.24% of the respondents (i.e., a majority percentage) reported to have been restricted sometimes by their injuries from performing their daily activities; while 31.08% reported conversely and 25.68% participants reported a continued restriction due to their injuries from performing their daily activities. The questions pertaining to explore whether the respondents had experienced any other distress/pain that affected their body movements apart from visible physical injury, 50% of the respondents (i.e., a majority percentage) had not experienced any other distress/pain that affected their body movements apart from visible physical injury while 50% reported in opposition.

The study also sought to evaluate whether the respondents had seen a doctor or any medical practitioner due to the pain from the injuries endured. As indicated in Table 4.2, 54.05% (i.e., a majority respondent percentage) had not seen a doctor or any medical practitioner due to the pain from the injury while 45.95% reported contrariwise. On the parameter of pain affecting a restricted job performance, 47.30 % of the respondents (i.e., the majority) indicated that their job performance had not been restricted at all by the pains, while 28.38% indicated that their job performance had sometimes been restricted by the pains whereas 24.32% indicated that their job performance had always been restricted by the injury-induced pains.

Table 4. 2 Participants' responses on job performance, bodily pain and medical attention.

| Characteristics | Frequency distribution (n=74) | Percentage |
|---|---|---|
| *Injury restricting daily job performance* | | |
| Not at all | 20 | 27.00 |
| Sometime | 32 | 43.20 |
| Always | 22 | 29.70 |
| *Body pains from Injury* | | |
| Yes | 37 | 50.00 |
| No | 37 | 50.00 |
| *Seen the doctor or any medical practitioner* | | |
| Yes | 33 | 44.60 |
| No | 41 | 55.40 |
| *Pain restricted job performance* | | |
| Not at all | 35 | 47.30 |
| Sometime | 23 | 31.10 |
| Always | 16 | 21.60 |

### 4.5.6 Model Accuracy

In logistic regression, several ways for measuring the observed and the fitted values are common (Hosmer, 2000). However, these models depend on the type of the logistic regression adopted in the study. Hosmer and Lemeshow test is one of the frequently used goodness-for-fit test in binary logistic regression. SPSS has built-in function for determining Hosmer and Lemeshow test. In this test, $p<0.05$ (significant level) indicates that the model does not fit the data while $p>0.05$ (significant level) indicates that the model fit the data adequately. Hosmer and Lemeshow test has similar characteristics as Chi-square accuracy test. The model of likelihood of recordable injury and severity of injury has returned $p >0.05$ as shown in Table 4.3 and 4.4 therefore, the research concluded that the model fitted the data accurately.

Table 4. 3 Hosmer and Lemeshow Test of likelihood of recordable injuries.

| Chi-square | df | Sig. |
|---|---|---|
| 8.758 | 8 | .363 |

Table 4. 4 Hosmer and Lemeshow Test of likelihood of severe injuries.

| Chi-square | df | Sig. |
|---|---|---|
| 6.575 | 8 | .583 |

### 4.5.7 Risk factors for likelihood of injuries

Table 4.5 presents the results of bivariate and multivariate analysis to observe the risk of likelihood of injuries. The results showed that younger age group, male miners, less experienced miners, working for longer hours, high-risk drug users, perceived poor working conditions as well as poor management and supervision, job dissatisfaction and job stress were strongly associated ($p<0.05$) with likelihood of injuries. In the backward elimination, the marital status, alcohol consumption and education were found insignificant, and as a result, they were removed from the model. Therefore, Table 4.5 showed only risk factors that predict likelihood of injuries in ASM operation.

Table 4. 5 Risk factors that predicts likelihood of injuries in ASM operation.

| Risk factors | COR (95% CI) | AOR (95% CI) | Multivariate p-value |
|---|---|---|---|
| *Age groups* | | | |
| 1= 18-34 | 2.06 (1.15 – 3.68) | 2.03 (1.03– 4.03) | 0.042 |
| 2= 35 and over [RC] | | | |
| *Gender* | | | |
| 1= Male | 1.94 (1.09 – 3.44) | 2.61 (1.31– 5.20) | 0.006 |
| 2= Female [RC] | | | |
| *Mining experiences* | | | |
| 1= Less than 3 years | 1.99 (1.11 - 3.57) | 2.19 (1.10 - 4.36) | 0.026 |
| 2= More than 3 years [RC] | | | |
| *Shift hours* | | | |
| 1= More than 8hrs/day | 2.60 (1.46 – 4.64) | 2.34 (1.20 – 4.55) | 0.012 |
| 2= Less than 8hrs/day [RC] | | | |

| | | | |
|---|---|---|---|
| *Drug usage* | | | |
| 1= High-risk user | 2.20 (1.13 – 4.28) | 2.22 (1.02 – 4.85) | 0.045 |
| 2= Low-risk user | 0.66 (0.32 – 1.36) | 0.57 (0.25 – 1.30) | 0.183 |
| 3= Not drug user RC | | | |
| *Poor work condition* | | | |
| 1= Agree | 2.68 (1.44 – 5.00) | 2.34 (1.14 – 4.83) | 0.021 |
| 2= Disagree RC | | | |
| *Poor management and supervision* | | | |
| 1= Agree | 2.18 (1.08 – 4.40) | 2.58 (1.14– 5.85) | 0.024 |
| 2= Disagree RC | | | |
| *Job dissatisfaction* | | | |
| 1= Agree | 2.31 (1.22 - 4.36) | 2.17 (1.04 – 4.51) | 0.038 |
| 2= Disagree RC | | | |
| *Job stress* | | | |
| 1= Agree | 2.64 (1.11- 6.26) | 3.16 (1.18 – 8.51) | 0.023 |
| 2= Disagree RC | | | |
| *$p < 0.05$ represents positive relationship between risk factor, while $p > 0.05$ represents no association. COR represents test association between single risk factor and response variable. While AOR represents contributing effect of multiple risk factors with response variable.* | | | |

### 4.5.8 Risks factors for severity of injuries

In this part of analysis, we have assessed whether the risk factors for likelihood of injuries are also predictors of the severity of injuries. The comparison has revealed that the majority of risk factors for likelihood of injuries except age group, drug usage and poor working conditions also predict severity of injuries. All risk factors except education level, which have been found to predict severity of injuries, are also associated with likelihood of injuries as shown in Table 4.6.

Table 4. 6 Risk factors associated with likelihood of severe injuries.

| Risk factors | COR (95% CI) | AOR (95% CI) | Multivariate p-value |
|---|---|---|---|
| *Gender* | | | |
| 1= Male | 1.93 (1.04 – 3.58) | 2.15 (1.09 – 4.21) | 0.026 |

| | | | |
|---|---|---|---|
| 2= Female [RC] | | | |
| *Level of education* | | | |
| Low education level (< Year 8) | 2.33 (1.18 – 4.62) | 2.51 (1.20 – 5.26) | 0.014 |
| High education level (>Year 8) [RC] | | | |
| *Mining experiences* | | | |
| 1= Less than 3 years | 2.06 (1.09 – 3.89) | 2.20 (1.11 – 4.38) | 0.024 |
| 2= More than 3 years [RC] | | | |
| *Shift hours* | | | |
| 1= More than 8hrs/day | 2.53 (1.36 – 4.70) | 2.32 (1.20 – 4.51) | 0.013 |
| 2= Less than 8hrs/day [RC] | | | |
| *Poor management and supervision* | | | |
| 1= Agree | 2.31 (1.06 – 5.04) | 2.70 (1.17 – 6.21) | 0.020 |
| 2= Disagree [RC] | | | |
| *Job dissatisfaction* | | | |
| 1= Agree | 2.17 (1.09 – 4.31) | 2.17 (1.04 – 4.53) | 0.040 |
| 2= Disagree [RC] | | | |
| *Job stress* | | | |
| 1= Agree | 2.31 (0.92 – 5.80) | 2.68 (1.00 – 7.18) | 0.051 |
| 2= Disagree [RC] | | | |
| *$p < 0.05$ represents positive relationship between risk factor, while $p > 0.05$ represents no association. COR represents test association between single risk factor and response variable. While AOR represents contributing effect of multiple risk factors with response variable.* | | | |

## 4.6 Discussion

The objectives of this research were to identify the risk factors for likelihood of injuries and severe injuries separately and provide explanation for any differences. Prior to the assessment of relationships, we characterized the recordable injuries, lost workdays and injured participants' present health conditions. Our results showed that the most frequent occurring recordable injuries among the gold miners in Osiri were: Laceration injuries, contusion injuries, fracture injuries and musculoskeletal pain. Correspondingly, as per the collated responses of many participants, these injuries mainly were inflicted on their hands and wrists, arms and elbows, shoulders, legs, thumbs, feet and ankles, head and back. The causal mechanisms of these injuries included, being struck by the object, equipment, heavy loads and/or slip/trip fall. Similar findings have been deduced by few limited studies, which were carried out in other sub-Saharan African countries (Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Long et al., 2015), whereby occupational injuries were found to cause severe injuries. The present and past findings can thus be safely inferred to support the hypothesis that indeed ASM operators are susceptible to occupational injuries with varying degrees of severity. The widespread of these injuries among the miners is attributed to the nature of equipment and conditions of the work environment.

The summary analysis of lost workdays revealed that 60 cases fitted the definition of severe injuries while 14 cases were related to minor injuries. These 14 cases were combined with no injury group for the relationship analysis. In spite of studies carried out to understand the widespread presence of workplace injuries in ASM, there is lack of evidence regarding the relationship between the risk factors for likelihood of injuries and likelihood of severe injuries. Severe injuries often resulted in elongated medical attentions, job performance restrictions, disability and fatality. Therefore, it is significant for injury prevention purpose to compare the risk factors for the likelihood of injuries and likelihood of severe of injuries.

We discuss risk factors that influence likelihood of injuries or likelihood of severe injury only in section 4.6.1 and 4.6.2 respectively. In section 4.6.3, we discuss the risk factors that contribute to both likelihood of injuries and likelihood of severe injuries.

#### 4.6.1 Exclusive predictors of likelihood of injuries

Our study revealed that younger age group (18-34) had higher risk (AOR 2.03, $p<0.05$) of occupational injury than older age group (> 35 years). On contrary, when age group was evaluated against the likelihood of severe injury, we found it is insignificant ($p>0.05$) and therefore, was removed from the model to achieve accuracy. These findings are in line with previous studies that associated younger age group with injury occurrence but not likelihood of severe injury (Laflamme et al., 1996; Stojadinovic et al., 2012). This is because younger workers compared to older workers tend to be less experience in hazard identification and management and have recklessness behaviour. However, when it comes to severity of injuries, younger workers have increased body strength and mental ability to recover quicker, thus, suffer less severe injuries (Laflamme & Menckel, 1995).

The research also revealed that the high-level drug users had higher risk (AOR 2.22, $p<0.05$) for the likelihood of injuries than others, but it is not significant ($p>0.05$) for likelihood of severe injuries. This showed that drug usage can reduced concentration, alertness, judgement and impaired performance but not necessarily severe injuries. This study agrees with the research conducted in the United States, wherein, it was found that drugs impacted 25% increase in the occupational accidents among the male workers (Bena et al., 2013). Another study conducted in North Eastern France found drug use as one of the risk factors that accelerate the occupational injuries risk among the employed people (Bhattacherjee et al., 2003).

Our study examined miner's perception about the ASM working conditions. The variable "poor work condition" was measured by whether miners had health and safety training, used personal protective equipment, had injury due to physical and ergonomic hazards. The multivariate regression analysis showed that miners that agreed to these factors had higher risk (AOR 2.34, $p<0.05$) than those disagree. Thus, it is revealed that poor working conditions increases the likelihood of injuries but not necessarily likelihood of severe injury. Corresponding studies in ASM operation have evidence of presence of hazards, lack of personal protective equipment (Bena et al.) and poor management and supervision and increased level of workplace injuries (Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Long et al., 2015).

#### 4.6.2 Exclusive risk factors to likelihood of severe injury

Our study found that only one risk factor (miners' education) is exclusively responsible for likelihood of severe injury but not for likelihood of injuries. Low educated miners (< Year 8) had high risk (AOR 2.51, $p<0.05$) of suffering severe injury than others with higher education (> Year 8). Corresponding studies concluded similar findings despite differences in ORs (Boniface et al., 2013; Stojadinović et al., 2012). The present and past findings can be attributed to the fact that many ASM miners are uneducated or have little education, as a result, commonly work as labourers compared to highly educated miners who work in a less risky environment such as office areas.

#### 4.6.3 Predictors of both likelihood of injuries and severity of injuries

Our results showed that the following risk factors associated with likelihood of injuries also influenced the likelihood of severe injuries: (i) Gender, (ii) experience, (iii) shift hours, (iv), poor management and supervision, (v) job dissatisfaction, and (vi) job stress.

The multivariate analysis showed that male gender had higher (AOR 2.61, $p<0.05$) risk of occupational injury than female gender, but when tested with likelihood of severe injury, the risk was less (AOR 2.15, $p<0.05$). In a study conducted in Zimbabwe, it was found that male miners were 15.3 times more likely to suffer severe injuries compared to female miners (Chimamise et al., 2013). Another study conducted in the Amhara region state of Ethiopia also demonstrated that males were 2.54 times more likely to experience severe injuries (Aderaw et al., 2011). According to these researchers, male workers are more 'inclined to risk taking behaviour', resultantly, exposing themselves to varying degrees of occupational injuries. This reason holds good for this study as well, as male miners were observed to engage in riskier duties such as using rudimentary equipment to dig in the unventilated and unlit working areas while women worked in open space with less labour-intensive duties.

Regarding mining experience, the multivariate results suggested that less experienced miners (< 3 years) had higher risks (AOR 2.19, $p<0.05$) of occupational injury than more experienced miners (> 3 years). The analysis with the likelihood of severe injury showed less risk (AOR 2.20, $p<0.05$)-between the groups. Previous studies have used different cut-off points in regard to the criteria for classifying miners as less experienced; however, a consistency is apparent across the board that the less experienced workers suffer from frequent injuries with varying degree of severities (Aderaw et al., 2011; Boniface et al., 2013; Calys-Tagoe et al., 2015). This can be attributed to the fact that inexperienced miners are less aware of the new working environment, its associated hazards and necessary safety measures.

In terms of shift hours, the findings delineate that miners who worked more than 8 hrs/day were inclined to experience injuries which are mostly severe. The study found miners that worked longer hours had higher risk (AOR 2.34, $p<0.05$) for likelihood of injury than others. However, the risk dropped (AOR 2.32, $p<0.05$) when assessed with the likelihood of severe injury. In this regard, Chimamise et al. (2013) found that working more than 8 hrs per day causes severe injuries because working long hours reduced the focus and concentration of the workers. Several studies conducted previously have concluded the same findings (Dembe et al., 2005; Salminen, 2010). This is attributed to the fact that extended working hours resulted in fatigue, reduced concentration and consequentially severe injuries.

In the analysis of job-related risk factors, the results showed that perception of poor management and supervision was significant association with likelihood of injuries as well as likelihood of severe injury. The variable “management and supervision” were assessed by relationship between the workers and leadership, social support, recognition and work schedule. Participants that negatively agreed to these indicators had higher risk (AOR 2.58, $p<0.05$) for likelihood of injuries than others. However, with the likelihood of severe injury, the risk increased (AOR 2.70, $p<0.05$). According to several studies, poor perception of management and supervision are manifested through the lack of safety training, poor equipment, lack of policies and social hazards, presence of hazards without proper control mechanisms (Calys-Tagoe et al., 2015; Chimamise et al., 2013). When leadership fails, the risk of occupational accidents and outcomes become frequent and severe (Sawacha et al., 1999). During a casual discussion with mine operators, they revealed that the inadequate health and safety measures in their working area were due to poor leadership. According to them, safety is the last thing in their supervisors’ mind, and they are pushed to increase production. As a result, many of them have suffered minor and major injuries.

Our study also found that job dissatisfaction was associated likelihood of injuries and severity of injuries. Job dissatisfaction is a miners’ negative feeling toward their work conditions. Participants that have bad relationship with their superior, had negative feeling about work conditions, do not receive recognitions, have no social supports, are not satisfied with earnings and believe that present job is bad for their health had higher risk (AOR 2.17, $p<0.05$) for likelihood of injuries as well as likelihood of severe injury. The same risk indices were surprising, given the variance revealed by other study variables. A study carried out among underground coal miners in India also revealed higher risk indices among the highly job dissatisfied workers compared to less job-dissatisfied workers (Paul et al., 2005). Similar conclusion was drawn by McCaughey et al. (2014), whereby those who experienced job-related injuries were less satisfied.

Job stress was another risk factor that was of interest in this study. Our findings revealed that miners who agree to experiencing job stress in ASM operation had higher risk (AOR 3.14, $p<0.05$) for likelihood of injuries. When this risk factor is tested against the likelihood of severe injury, we found that the risk dropped (AOR 2.68, $p<0.05$). Other studies have evidenced that excessive workload, extended working hours, poor working environment, poor management and supervision, and job dissatisfaction produced stress and subsequently occupational injuries

(Ghosh et al., 2004; Amponsah-Tawiah et al., 2013; Nakata et al., 2006). This study upholds this inference, as manifested by the study findings of a strong association between the shift hours and poor management and supervision with likelihood of injuries.

## 4.7 Discussion on Limitations and Future Research Directions

Although ASM operation continues to operate with rudimentary or semi-mechanised equipment and predominately is located in rural areas of developing countries, our study recommends for future studies to look into how modern society and technological-economic complex system affect health and safety of miners and nearby communities. In addition, the impact of external factors like the complexity on the performance and risks of various socio-technological-economic systems are not considered. We also recommend further studies to investigate the organizational and human performance as well as motivational and cognitive biases and their significant impact on the ASM safety.

If possible, the future research should be supplemented with participants' medical records. This will help to validate the number and severity of injuries, period of treatment rather than relying solely on the self-report. Moreover, interviews with local health officers, worker representatives, mine owners and government officials are recommended to ascertain the risk level.

## 4.8 Conclusions

The present study has shown that the recordable injuries in ASM operation ranged from minor injuries to severe injuries. Previously, greater attention was paid to the risk factors associated with likelihood of injuries, with limited focus on likelihood of severe injury. The analysis of risk factors for likelihood of injuries and severity of injuries independently and comparing them provide insight into why there are more severe injuries in ASM operation or other workplaces. This information is critical for injury prevention and post-injury socio-economic and psycho-social consequences management. Our study has demonstrated that majority of risk factors for the likelihood of injuries also predict severity of injuries.

# 5. RISK FACTORS FOR THE NUMBER OF SUSTAINED INJURIES IN ARTISANAL AND SMALL-SCALE MINING OPERATION

## 5.1 Overview

Although Chapter 4 has presented the results, discussed and compared risk factors for likelihood of recordable injuries and likelihood of severe injuries, the contributing effects of such factors was not explored against the number of times miners have experienced recordable injuries. Therefore, presented as Chapter 5 is the paper that was peer-reviewed and published by *Journal of Safety and Health at Work*. This publication filled current knowledge gap identified in Chapter 5 by categorizing the number of times miners have been injured and associated each group with risk factors.

The published paper was simply adopted as Chapter 5, with only tables' numbers and references modified. The permission to reproduce this paper and signed co-authorship form have been appended as appendices E and C respectively. The original article can be found from https://doi.org/10.1016/j.shaw.2020.01.001.

## 5.2 Abstract


### Background

The relationship between risk factors and likelihood of occupational injury has been studied. However, what has been published has only provided a limited explanation of why some of the employees working in the same environment as other employees suffered a single-injury event, while other employees experienced multiple-injury events. This article reports on an investigation of whether artisanal and small-scale miners in Migori County of Kenya are susceptible to a single-injury or multiple-injury incidences, and if so, what underpinning parameters explain the differences between the single incident injured and the multiple incident injured group. Mine management commitment to safety in artisanal and small-scale mining (ASM) operations is also considered.

**Materials and methods**

The research objectives were achieved by surveying 162 uninjured and 74 injured miners. A structured, closed-end questionnaire was administered to participants after the stratification of the study population and systematic selection of the representative samples.

**Results**

The results showed that most injured miners suffer a single-injury incident rather than experiencing multiple-injury events, and laceration (28.40%) was the common injury suffered by the miners. The analysis showed that the risk factors for the single incident injured group were not similar to those in the multiple incident injured group. The research also found mine workers have low opinion about mine management/owners commitment to safety.

**Conclusion**

The study concluded that mine management and miners need to be educated and sensitized on the dangers of this operation. Provision of safety gears and positive safety culture must be a top priority for management.

**Keywords:** Incidence; logistic model; miners; occupational injuries; risk factors.

## 5.3 Introduction

Occupational health and safety in the mining industry has significantly improved in recent years; however, still more needs to be achieved to ensure work can be accomplished without health-related problems (International Council on Mining and Metals [ICMM], 2019). The mining methodology practised particularly in large-scale mining (LSM) operations continues to change with improved safety focus [MPI], 2017). Technological improvement, automation and tightened regulations, and increased companies' commitment to safety have positively impacted operational philosophy (Intergovernmental Forum on Mining, Metals and Sustainable Development [IGFMMSD], 2018). Previously, companies consider production more important than safety. However, this operational emphasis has shifted to what many companies in developed nations called "safe tonnages". Mine safety has become an integrated part of sustainable production (IGFMMSD, 2018).

Although artisanal and small-scale mining (ASM) activity is an important source of livelihood among the impoverished people in developing nations, the sector has not achieved health and safety improvements similar to LSM (Smith et al., 2016). The risk of accident in ASM is believed to be 6-7 times higher than that in LSM, and women and children are 90 times at risk of fatality (International Labour Office [ILO, 1999). The published work of Elenge et al. (2011) and Bansah et al. (2016) carried out in the Democratic Republic of Congo and Ghana, respectively, established that people working in ASM operations are exposed to various hazards with notable serious health implications. The authors attributed current state of ASM conditions to illegal operations, unsafe acts, and poor safety culture, as well as lack of mine owners' or companies' commitment to health and safety. Smith et al. (2016) also highlighted similar problems and emphasized knowledge building and sensitization of mine workers and other stakeholders on health and safety risks.

ASM operation is predominately located in mineral-rich rural areas of developing nations (Hentschel, 2003). In many of these countries, about 70-80 % of mine workers operate illegally (IGFMMSD, 2018). Bansah et al. (2016) found that government agencies do not monitor and enforce rules and regulation in small-scale underground mines of Ghana. Resultantly, miners were found to operate without licenses. Similarly, Smith et al. (2016) call for proper regulation for ASM operation after implementing participatory action research. In alignment, a plethora of published literature has evidenced ASM miners as disapproving government initiatives to formalize the sector (Hilson et al., 2017; Huggins, 2016; Salo et al., 2016). However, without formalization, the sector continues to contribute to damaging socioeconomic situation, environmental degradation, and health and safety problems (IGFMMSD, 2018).

Despite the complex web of problems linked to the ASM sector, the available published literatures on health and safety are dominated by occupational illnesses and their contributors, with limited publications on injuries and underlying causes. The studies that have specifically investigated the injuries that happened in ASM operation cited this problem to be a common phenomenon (Ajith & Ghosh, 2019a; Ajith & Ghosh, 2019b; Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015). These publications have revealed that ASM-related injuries vary in severities (simple injuries to major physical traumas), with some evidencing frequency of occurrence (single-injury or multiple-injury events). Although the present findings have provided valuable insight into the nature, bodily distribution, and causation mechanisms of ASM-related injuries, these studies have failed to explain *why some of the employees working in the same environment as other* *employees suffered a single injury event while other employees experience multiple injury events?*

So far, in accordance with the available research, the factors for mining-related injuries fall under two categories: (i) individual factors and (ii) work environment and work practices factors (Paul et al., 2005). The individual factors are the demographical and behavioral characteristics, while work environment and work practices factors are incidents related to job hazards and organization factors (Ghosh et al., 2004). The commonly cited demographical and behavioral characteristics are age group, gender, marital status, education level, experience, alcohol, and drugs. The association of these risk factors with occupational injury continues to generate debate. Some studies argued that these demographical and behavioral factors influence the risk of injuries while others demonstrated opposing opinions. Similarly, work environment and work practices factors such shift hours, poor work conditions and environment, poor management and supervision, job dissatisfaction, and job stress have been mentioned to be significant or insignificant with the risk of occupational injuries.

The occurrence of injuries in the workplace is not a simple linear association, but rather it is a complex event. The concept of Human and Organization Performance (HOP) stated that to be human is to make errors, and the role of the organization is critical for preventing or reducing such errors (Conklin, 2012). That is, everyone is willing to perform adequately to meet expectations; however, mistakes cannot be avoided sometimes (Komljenovic et al., 2017). Human error is a complex construct which is responsible for a high proportion of mishaps and accidents in complex and dynamic systems (Reyes et al., 2015). It is defined as “a generic term that encompasses all those occasions in which a sequence of physical or mental activities fail to achieve the desired result and when these failures cannot be attributed to the intervention of some chance” (Reason, 1990).

The human errors are fundamentally foreseeable and manageable in many ways (Komljenovic et al., 2017). The rate of injuries in ASM operations can be reduced by ascertaining influencing factors that are favorable to error occurrence and by developing means of controls. Komljenovic et al. (2017) in his article explained that human error is a symptom of organization failure. As a result, analysis should focus on “why the event happened?” and “why it was not stopped?” From this viewpoint, the role of organization factors such as management/ supervision and commitment to safety is critical for preventing error occurrence. ASM operations are run by individuals, families, communities, and occasionally small cooperatives (Hentschel, 2003).

However, little information exists on how such a management creates conditions for accidents and consequential injuries.

Management commitment to safety refers to “workers’ perceptions of the degree to which their managers value and support safe working and are dedicated to workers’ safety” (McGonagle et al., 2016). The workers’ safety behavior and risk of accidents and associated illnesses and injuries is a leading indicator of the level of management commitment to safety (Oah et al., 2018). Workers who have positive attitude toward their organization tend to be in compliance to their company’s safety policies are more inclined to have safe work performance (Hofmann & Morgeson, 1999; Michael et al., 2005). Social support and being valued generate a sense of accomplishment, which then resulted in progressive outcomes (Fariba & Mohammad, 2014). Contrastingly, workers that are dissatisfied with their organization developed a negative attitude toward safety which resultantly increased the likelihood of being exposed to hazards and developing injuries (Hofmann & Morgeson, 1999, Michael et al., 2005). Steenkamp and Van Schoor (2004) stated that occupational health and safety is a complex problem for management, and as a result, it must be prioritized.

This study aimed to investigate the risk factors for single and multiple recordable injury events among the mineworkers. Recordable injuries are occupational injuries that have resulted in lost workdays. The research study also evaluates miners’ perceptions with regard to their mine management commitment to safety. The findings will help the government and nongovernmental organization to develop targeted policies that will reduce, or prevent, recurrence of injuries in ASM operations. Furthermore, it will enhance understanding that poor health and safety in ASM operation is attributed not only to personal characteristics but also to organization commitment to safety.

The first aim was informed by a recent comprehensive analysis of risk factors for recordable injuries in artisanal and small-scale gold mining operation by Ajith and Ghosh (2019a). The authors found that likelihood of recordable injury was predicted by: Age, gender, mining experience, long shift hours, drug usage, as well as poor working conditions, poor management and supervision, job dissatisfaction and between job stress. However, these authors failed to explain whether these risk factors made miners susceptible to a single injury event or to multiple injuries incidents. Therefore, these risk factors and other factors such as marital status, education level and alcohol consumption were evaluated to determine whether they were responsible for single or multiple injuries. Single injury referred to an incident where the miner

(s) had experienced a one-time injury which resulted in lost workdays while multiple injuries implied that the miner had suffered more than one-injury event during his working time in this mining industry. Mineworkers are often transient workers so this definition provides an industry injury frequency experience record.

The second aim was informed by the HOP concept developed by Komljenovic et al. (2017). In his article, the author established HOP as a complex system because a linear approach cannot deliver a full picture of accident or injuries' underlying causes. According to this concept, workplace accidents causes can be divided into direct ("why the event occurred?") and fundamental causes ("why the event was not prevented?").

## 5.4 Materials and Methods

### 5.4.1 Study area

This study was implemented in Osiri artisanal and small-scale gold mining operation in Migori County, situated in western Kenya, neighboring Lake Victoria to the west and the Republic of Tanzania to the south (Ajith and Ghosh, 2019a). Traditionally, the mine was referred to as Malcader. However, in recent times, it has been popularly known as Osiri or Karibu.

### 5.4.2 Sample procedure

The study population encompassed 610 miners, of which about 192 mine workers were injured. Using Kothari's (1990) formula for sample size calculation, a representative sample of 236 participants was calculated as shown in step 1-3. Thereafter, this population was further partitioned into 162 uninjured and 74 injured participants as presented in step 3 for better representation (Ajith & Ghosh 2019a). In the recent work of Ajith and Ghosh (2019a), sample determination steps were followed as shown in the following:

Firstly, we calculated the population based on Z values, sample proportion, and confidence level.

Sample size $= \frac{Z^2 * \ (p) * q}{e^2}$ ……………………………………………………………….. [1]

- Z = Z value (e.g., 1.96 for 95% confidence level)
- Sample proportion, q = 1-p (p = 0.5 and q = 0.5)
- e = confidence level = (± 5%)

$$\text{Sample size} = \frac{1.96^2 * (0.5) * 0.5}{0.05^2} = \mathbf{384.16}$$

To decrease the sampling error, we corrected the finite population produced in Eq. 1, where N = number of mine workers (both injured and uninjured) and SS = representative sample size.

$$SS = \frac{Z^2 * p * q * N}{e^2 (N-1) + Z * p * q} = \frac{Z^2 * p * q}{e^2}\left(\frac{N}{N - 1 + \frac{Z^2 * p * q}{e^2}}\right) = SS \left(\frac{1}{1 - \frac{1}{N} + \frac{SS}{N}}\right)$$

$$= \frac{SS}{1 + \frac{SS - 1}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Applying Eq. 2, the representative sample for 610 miners is shown as follows:

$$SS = \frac{384.16}{1 + \frac{384.16 - 1}{610}} = \mathbf{236}$$

From the samples generated from Eq. 2, we adopted stratified random sampling for better sample representation. So, the study population was partitioned into injured and uninjured stratum with 192 and 418 miners, respectively. The samples within each stratum were calculated as follows:

$$\text{Stratum sample size} = \text{SS} * \frac{(\text{x})}{(\text{N})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

Where, SS = sample size determined in Eq. 2, x = population of injured or uninjured miners, and N = overall population of miners. Therefore, the samples to select per stratum based on the proportional ratio are shown as follows:

$$\textbf{Injured mineworkers } (y_1) = 236 * \left(\frac{192}{610}\right) = \mathbf{74}$$

$$\textbf{Uninjured mineworkers } (y_2) = 236 * \left(\frac{418}{610}\right) = \mathbf{162}$$

The inclusion criteria included mine workers that were older than 18 years who provided freely given consent for participation. Exclusion criteria included were as follows: supervisors and management and local government officials.

During the consultation meetings, the research team registered all the willing mine workers with pseudonym names and asked each miner to remember their identifier. In the registering process, the participants were asked to identify whether they have experienced lost time injuries or not. This information was attached to the participant identifier. The research team then reorganized the pseudonym identifiers and formed a separate list for the injured group and uninjured group. During the survey, each representative sample size was systematically selected from the list of pseudonyms for each group. To do this, the researcher initially identified a random pseudonym from each group to begin with, who was then issued with the necessary research documents. Subsequently, the next identifiers to be surveyed were chosen systematically until the target sample of 162 uninjured and 74 injured participants were achieved in each group.

### 5.4.3 Instrument and procedures

A multi-item structured closed-ended questionnaire was developed from relevant published literature. The questionnaire was divided into four sections. In the first section, participants were asked about their age group, gender, marital status, education level, years of experience, and hours worked per week. The second portion of questionnaire asked participants about substance usage (that is, alcohol and drugs); specifically, we asked whether they have ever tried substances, about their frequency of coming to work just after consumption, about their frequency of coming to work with hangover, about their frequency of consumption while working, about near misses due to substances, about accident due to substances, and about getting injured or injuring someone because of substance use. The substance usage questions were adopted from Alcohol Use Disorders Identification Test and Alcohol, Smoking, and Substance Involvement Screening Test which were developed by the World Health Organization and some from the study of Pidd et al. (2011).

In the third section, we questioned participants about the working conditions, management and supervision, job dissatisfaction, and job stress, which included five constructs of assessing occupational safety developed by Hayes et al. (1998). This construct assessed management safety practices, supervisor safety, co-worker safety, and job safety and satisfaction with the safety program This research study was complemented by a number of other publications (Amponsah-Tawiah et al., 2013; Calys-Tagoe et al., 2015; Ghosh et al., 2004; Macdonald & Macintyre, 1997; Parker & Decotiis, 1983). A section of the questionnaire asked injured miners about their nature of injuries, lost workdays, and number of times they have being injured.

The reliability and validity of the instrument was measured before implementation of the research (Heale & Twycross, 2015). Cronbach's alpha calculated from pilot testing data was 0.786 which is higher than an absolute minimum of 0.7 (Hinkin, 1998), indicating that the instrument developed was reliable. To ensure validity, a public health expert was consulted to review the questionnaire and provide feedback. The expert concluded that the research included the necessary information for this specific study.

Before data collection, the participants were contacted through word of mouth from their workers' representatives and mine owners. Flyers were also emailed out to these individuals so that they could distribute and post the rest to other mines in close proximity to their mine site. Upon the arrival of the researcher in Migori County, two research aides, who were familiar with the native language and skilled in public health data collection, were recruited. The researcher then trained these individuals on the use of the research instrument and the ethical conduct of this research. Subsequently, consultation and sensitization meetings were carried out by the research team with the relevant authorities and miners. During the session with miners, the research team provided detailed information about the research instruments and informed consent forms, in addition to registering all willing participants.

During the data collection process, the participants were asked to sit in a group of uninjured and injured miners, following which a random pseudonym was selected to start with in each group, who were then issued a survey to complete. The subsequent names were systematically selected to fill in the questionnaire, during which the literate respondents were allowed to self-administer the survey, while semiliterate or illiterate participants were administered the questionnaire by a research team member in their preferred languages (i.e., English, Kiswahili, and Luo). The completed questionnaires were then collected personally by the researcher. This provided the opportunity to review while maintaining privacy and confidentiality. Each questionnaire took less than 1 hour to complete.

#### 5.4.4 Data analysis

The questionnaires completed in Kiswahili or Luo language were translated back to English for consistency of the response language. The cleaning and analysis of the survey results were conducted in SPSS software, version 25. The individual characteristics such as age, gender, marital status, and level of education and mining experiences were coded as shown in Table 5.2. Then, behavioral factors and job-related factors were coded.

Although alcohol and drug (i.e., marijuana, opium and so on.) were assessed with several questions, the objective was to find high-risk users, low-risk users, and not users. Those who did not take substances at all were grouped as "not a user", while those who consumed but did not come to work intoxicated or did not take substances at work were categorized as "low-risk users" and lastly, individuals who came to work intoxicated, consumed substances at work, were involved in an accident, near misses or got injured because of substances were coded as "high-risk users".

For the job-related risk factors which were assessed using a 5 point Likert scale, coding was carried twice depending on the aim of interest. For the evaluation of mine workers' perception of mine management safety, each item under individual risk factors was coded as strongly agree, agree, neutral, disagree, and strongly disagree.

However, for the purpose of the logistic regression analysis, responses to statements under variables were added and assigned an overall category depending on the mean. During the review and coding process, it was found that responses to strongly agree, neutral, and strongly disagree were significantly lower. As a result, strongly agree responses were merged into agree, while neutral and strongly disagree were collapsed into disagree. This combination was dictated by the number of events per variable. That is, in logistic regression analysis, the events per variable must be > 20 to avoid model instability (Concato et al., 1995; Vittinghoff & McCulloch, 2007). However, the widely recognized rule of the thumb is 10 per variable.

After coding, the survey data were subjected to descriptive statistics, whereby a Chi-square ($\chi^2$) test was performed to determine the factors association with the number of sustained recordable injuries as shown in Table 5.2. This response variable was coded into three levels: (i) single injury, (ii) multiple injuries, and (iii) no injury. The risk factors from $\chi^2$ analysis that had $p < 0.05$ were considered to influence the number of sustained injuries. To evaluate which categories of risk factors were significant, further analysis was conducted using multinomial logistic regression analysis. The multinomial logistic regression model is an extension of the binary logistic regression model and is used essentially when the response variable demonstrates more than two discrete and unordered categories with nominal properties and multinomial distribution (Arı, 2016). The bivariate and multivariate (binary) logistic regression model with the considered variables has been explained in the following sections with respect to amount of time spent on the job (experience).

In our study, we have captured and analyzed the mining experience against the number of injuries sustained. Participants were asked to cite how many years they have worked in ASM. The continuous variable experience is then converted to categorical variable. For analysis, the participants' responses were categorized into less than 3 years and more than 3 years mining experiences and then subjected to multivariate (binary) logistic regression. Experience was coded in this way because few miners cited 1 year experience and more with 2 years' experience. Similarly, most miners cited 4 years but not 5 years and over 5 years mining experience. Therefore, it was necessary to find the mean of years worked, which was 3 years of mining experience. Thus, we coded the experience as mentioned. How the amount of time one spends on the job (experience) has been adjusted in the crude odds ratio (COR) and adjusted odds ratio (AOR) is mentioned in following sections.

*Crude Odds Ratio (COR)*

In bivariate analysis, COR is calculated by normalizing the injuries with respect to experience (number of years worked in the mine).

| | Injury | No Injury | Total Exposure |
|---|---|---|---|
| Less Experienced | a | b | a+b |
| More Experienced | c | d | c+d |

Odds (for Less Experienced) = a/ (a+b) ≈ a/b [‘a’ being very small compared to ‘b’, a+b ≈ b]

Odds (for More Experienced) = c/(c+d) ≈ c/d [‘c’ being very small compared to ‘d’, c+d ≈ d]

In bi-variate analysis

$$Crude\ Odds\ Ratio\ (COR) = \frac{a/_b}{c/_d} = \frac{ad}{bc}$$

COR may give the misleading result, as the influence of other variables is not adjusted. In multivariate (binary) logistic regression analysis, the influence of all variables is adjusted and it gives the AOR.

Multivariate (binary) logistic regression analysis is an extension of bivariate (i.e., simple) regression in which two or more independent variables ($x_i$) are taken into consideration simultaneously to predict a value of a dependent variable (Y) for each subject and gives AOR.

If $x_{gend}$, $x_{mari}$, $x_{exp}$, $x_{drug}$, $x_{shift}$, $x_{pwc}$, $x_{pms}$, $x_{jds}$, and $x_{js}$ represent the risk factors gender, marital status, experience, drug usage, shift, poor working condition, poor management and supervision, job dissatisfaction, and job stress (independent variables), respectively, and y is a binomial outcome variable with p = probability of injury, then the multivariate (binary) logistic regression model is given as follows:

$$\text{logit}(p) = \ln\left[\frac{p}{1-p}\right]$$

$$= \beta_0 + \beta_{gend}\, x_{gend} + \beta_{mari}\, x_{mari}. + \beta_{exp}\, x_{exp}. + \ldots + \beta_{rt}\, x_{rt} + \ldots\ldots\ldots\ldots + \beta_{sp}\, x_{sp}$$

$\ln\left[\frac{p}{1-p}\right]$ is called the logistic transformation and it is used as the dependent variable.

The term $\left[\frac{p}{1-p}\right]$ is known as the odds of risk.

2.5.2. Adjusted odds ratio

Let us consider two individuals with different values for emotional stability (coded as '1' which represents less experienced and '0' which represents more experienced) and the same values for all other variables in a multivariate (binary) logistic regression model which are shown in the following table.

| | Risk Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Individual | gend | mari | exp | … | pms | … | … | jst |
| A | $x_{gend}$ | $x_{mari}$ | 1 | … | $x_{mari}$ | … | … | $x_{jst}$ |
| B | $x_{gend}$ | $x_{mari}$ | 0 | … | $x_{mari}$ | … | … | $x_{jst}$ |

In this case, the multivariate (binary) logistic regression equations will be as follows: For individual A:

$$\ln\left[\frac{p_A}{1-p_A}\right] = \beta_0 + \beta_{gend}\,x_{gend} + \beta_{mari}\,x_{mari}. + \beta_{exp}\,(1). + \ldots + \beta_{rt}\,x_{rt} + \ldots\ldots\ldots + \beta_{sp}\,x_{sp}$$

For individual B

$$\ln\left[\frac{p_B}{1-p_B}\right] = \beta_0 + \beta_{gend}\,x_{gend} + \beta_{mari}\,x_{mari}. + \beta_{exp}\,(0). + \ldots + \beta_{rt}\,x_{rt} + \ldots\ldots\ldots + \beta_{sp}\,x_{sp}$$

Subtracting 2$^{nd}$ equation from 1st, we obtain

$$\ln\left[\frac{p_A}{1-p_A}\right] - \ln\left[\frac{p_B}{1-p_B}\right] = \beta_{exp}$$

$$\ln\left[\frac{p_A/(1-p_A)}{p_B/(1-p_B)}\right] = \beta_{exp}$$

$$\left[\frac{p_A/(1-p_A)}{p_B/(1-p_B)}\right] = e^{\beta exp} \qquad \text{i.e. } \frac{Odds_A}{Odds_B} = e^{\beta exp} \qquad \textit{Adjusted Odds Ratio (AOR)} = e^{\beta exp}$$

During the analysis, all the risk factors with $p < 0.05$ were examined first. Next included were other factors with $p < 0.1$ to explore their effects. Some of risk factors were manually removed until the model achieved ideal "goodness of fit" shown in Table 5.1. The risk factors that returned $p < 0.05$ were considered as a predictor of either single injury or multiple injuries, and their CORs and AORs at 95% confidence interval were noted. The CORs were generated by testing one risk factor against the number of injuries sustained and AOR by inputting several risk factors in the model.

To understand the miners' perception about the management commitment to safety and subsequently organizational safety performance of ASM operation, the participants' responses to items measuring poor working conditions and poor management/supervision were subjected to descriptive statistics. The means and standard deviations as shown in Tables 5.6 and 5.7 were generated to measure the safety performance and the level of safety culture.

## 5.5 Results

### 5.5.1 Model goodness-of-fit test

The MRL goodness-of-fit test was evaluated using the Person's Chi-square ($\chi^2$) test. This test is determined by the model significance level. If the p-value (significance level) is more than 0.05, the study can conclude that the model adequately fits the data; however, if the p-value is less than 0.05, then the model does not fit the data. In this article, the Person's Chi-square p-value was >0.05 as shown in Table 5.1; therefore, showing that our model sufficiently fitted the data.

Table 5. 1 Goodness-of-Fit.

| Chi-square statistics | Chi-Square | df | Sig. |
|---|---|---|---|
| Pearson | 333.439 | 338 | 0.560 |
| Deviance | 239.04 | 338 | 1.000 |

Pearson p > 0.05 indicates that the model fitted the data adequately.
df, degree of freedom; sig., significance level.

### 5.5.2 Risk factors and Chi- square test

Table 5.2 presents the $\chi^2$ test of risk factors which was an initial test to assess which risk factors predict the number of sustained injuries. The results showed in the following order of significance that poor work conditions (p = 0.001), drug usage (p = 0.001), shift hours (p = 0.002), poor management and supervision (p = 0.019), job dissatisfaction (p = 0.027), and age group (p = 0.037) all had a value of p < 0.05 and therefore influenced the risk of either a single injury event or multiple-injury events.

Table 5. 2 Participants response to number of injuries sustained (N= 236).

| Risk factors | Multiple injuries | Single injury | No injury | Chi-square (p) |
|---|---|---|---|---|
| ***Age groups*** | | | | **0.037** |
| 1=18-34 | 18 (13.3%) | 33 (24.4%) | 84 (62.2%) | |
| 2=>35 | 6 (5.9%) | 17 (16.8%) | 78 (77.2%) | |
| ***Gender*** | | | | **0.064** |

| | | | | |
|---|---|---|---|---|
| 1=Male | 15 (11.2%) | 35 (26.1%) | 84 (62.7%) | |
| 2=Female | 9 (8.8%) | 15 (14.7%) | 78 (76.5%) | |
| ***Marital status*** | | | | **0.085** |
| 1=Single | 16 (15.0%) | 22 (20.6%) | 69 (64.5%) | |
| 2=Married | 8 (6.2%) | 28 (21.7%) | 93 (72.1%) | |
| ***Level of education*** | | | | **0.069** |
| 1=Low (< year 8) | 19 (12.3%) | 37 (24.0%) | 98 (63.6%) | |
| 2=High (> year 8) | 5 (6.1%) | 13 (15.9%) | 64 (78.0%) | |
| ***Mining experiences*** | | | | **0.069** |
| 1= Less than 3 years | 17 (12.1%) | 35 (25.0%) | 88 (62.9%) | |
| 2 = more than 3 years | 7 (7.3%) | 15 (15.6%) | 74 (77.1%) | |
| ***Shift hours*** | | | | **0.002** |
| 1= More than 8hrs/day | 14 (11.5%) | 36 (29.5%) | 72 (59.0%) | |
| 2= less than 8hrs/day | 10 (8.8%) | 14 (12.3%) | 90 (78.9%) | |
| ***Alcohol consumption*** | | | | **0.710** |
| 1=High-risk user | 14 (10.4%) | 26 (19.4%) | 94 (70.1%) | |
| 2=Low-risk user | 8 (12.7%) | 14 (22.2%) | 41 (65.1%) | |
| 3=Not alcohol user | 2 (5.1%) | 10 (25.6%) | 27 (69.2%) | |
| ***Drug usage*** | | | | **0.001** |
| 1=High-risk user | 9 (12.3%) | 25 (34.2%) | 39 (53.4%) | |
| 2=Low-risk user | 3 (3.7%) | 14 (17.1%) | 65 (79.3%) | |
| 3=Not drug user | 12 (14.8%) | 11 (13.6%) | 58 (71.6%) | |
| ***Poor work condition*** | | | | **0.001** |
| 1=Agree | 15 (10.2%) | 42 (28.6%) | 90 (61.9%) | |
| 2=Disagree | 9 (10.1%) | 8 (9.0%) | 72 (80.9%) | |

| | | | | |
|---|---|---|---|---|
| ***Poor management and supervision*** | | | | **0.019** |
| 1=Agree | 17 (9.7%) | 45 (25.6%) | 114 (64.8%) | |
| 2=Disagree | 7 (11.7%) | 5 (8.3%) | 48 (80.0% | |
| ***Job dissatisfaction*** | | | | **0.027** |
| 1=Agree | 20 (12.7%) | 38 (24.2%) | 99 (63.1%) | |
| 2=Disagree | 4 (5.1%) | 12 (15.2%) | 63 (79.7%) | |
| ***Job stress*** | | | | **0.069** |
| 1=Agree | 21 (10.8%) | 46 (23.7%) | 127 (65.5%) | |
| 1=Disagree | 3 (7.1%) | 4 (9.5%) | 35 (83.3%) | |
| *P < 0.05 represents positive relationship between risk factor and single injury, as well as multiple injuries, while p value > 0.05 represents negative association.* | | | | |

### 5.5.3 Frequency of injuries and lost workdays

Table 5.3 shows that most injured miners had suffered one injury incidence, which resulted in a significant number of lost workdays compared with those who had experienced two, three, and four incidences.

Table 5. 3 Cross tabulation of number of times miners have been injured and lost workdays (n=236 participants).

| Number of injury incidences | Lost workdays (Indicated severity) | | | | | |
|---|---|---|---|---|---|---|
| | No injury | 1-6 days | 7-13 days | 14-29 days | 30 days and over | Total |
| No injury | 162 | 0 | 0 | 0 | 0 | 162 |
| One time | 0 | 10 | 5 | 9 | 26 | 50 |
| Two times | 0 | 2 | 4 | 2 | 5 | 13 |
| Three times | 0 | 1 | 2 | 4 | 1 | 8 |
| Four times | 0 | 1 | 0 | 1 | 1 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total | 162 | 14 | 11 | 16 | 33 | 236 |

### 5.5.4 Multinomial logistic regression results

Table 5.4 presents the results of multinomial logistic regression analysis to observe the risk of single injury and multiple injuries with no injury as the reference category. The risk factors identified in Table 5.3 with $p < 0.1$ were included in the model. The results showed that no single factor was statistically associated with multiple injuries. However, compared with single injury, the research found that all risk factors except age group and job dissatisfaction were contributors ($p < 0.05$).

Table 5. 4 Association of risk factors with single injury and multiple injuries keeping no injury as reference category.

| Risk factors | Single injury vs no injury | | | Multiple injuries vs no injury | | |
|---|---|---|---|---|---|---|
| | COR (95% CI) | AOR (95% CI) | p | COR (95% CI) | AOR (95% CI) | p |
| *Gender* | | | | | | |
| Male | 2.17 (1.1 – 4.27) | 2.55 (1.16 – 5.58) | 0.020 | 1.54 (0.64 – 3.74) | 1.70 (0.65 – 4.42) | 0.280 |
| Female RC | | | | | | |
| Marital status | | | | | | |
| Single | 1.06 (0.56 – 2.00) | 0.80 (0.37 – 1.72) | 0.560 | 2.70 (1.09 – 6.66) | 2.65 (1.02 – 6.91) | 0.047 |
| Married RC | | | | | | |
| *Experience* | | | | | | |
| Less than 3 years | 1.96 (1.00 – 3.87) | 2.43 (1.09 – 5.44) | 0.031 | 2.04 (0.80 – 5.19) | 2.42 (0.90 – 6.50) | 0.080 |
| More than 3 years RC | | | | | | |
| *Drug usage* | | | | | | |
| High-risk users | 3.38 (1.45 – 7.65) | 4.39 (1.71– 11.27) | 0.002 | 1.11 (0.43 – 2.90) | 1.23 (0.44 – 3.44) | 0.698 |
| Low-risk users | 1.14 (0.48 – 2.70) | 0.94 (0.35 – 2.51) | 0.901 | 0.22 (0.06 – 0.83) | 0.36 (0.10 – 1.25) | 0.038 |
| No users RC | | | | | | |
| *Shift hours* | | | | | | |
| More than 8hrs/day | 3.21 (1.61 – 6.41) | 3.33 (1.50 – 7.25) | 0.003 | 1.75 (0.73 – 4.17) | 1.80 (0.71 – 5.54) | 0.216 |
| Less than 8hrs/day RC | | | | | | |
| *Poor working conditions* | | | | | | |
| Agree | 4.20 (1.86 – 9.51) | 3.71 (1.49 – 9.29) | 0.005 | 1.33 (0.55 – 3.22) | 1.30 (0.50 – 3.37) | 0.594 |
| Disagree RC | | | | | | |
| *Poor management and supervision* | | | | | | |
| Agree | 3.79 (1.41 –10.13) | 4.63 (1.56 – 13.73) | 0.006 | 1.02 (0.40 – 2.63) | 0.91 (0.32 – 2.61) | 0.863 |
| Disagree RC | | | | | | |
| *Job dissatisfaction* | | | | | | |
| Agree | 2.02 (0.98 – 4.15) | 2.05 (0.89 – 4.69) | 0.090 | 3.18 (1.04 – 9.74) | 3.64 (1.12 – 11.88) | 0.032 |
| Disagree RC | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Job stress* | | | | | | |
| Agree | 3.17 (1.07 – 9.41) | 3.70 (1.07 – 12.83) | 0.039 | 1.93 (0.54 – 6.84) | 1.72 (0.45 – 6.64) | 0.429 |
| Disagree RC | | | | | | |

RC *represent reference category*
COR: Crude Odds Ratio
AOR: Adjusted Odds Ratio
*P < 0.05 represents positive relationship between risk factor and single injury, as well as multiple injuries, while p-value > 0.05 represents negative association. COR represents test association between single risk factor and response variable, whereas AOR represents contributing effect of multiple risk factors with response variable.*

### 5.5.5 Type of injuries

Table 5.5 shows that majority of miners suffered from laceration injuries and contusion injuries, with facial and burn injuries being the least occurring.

Table 5. 5 Type of injuries sustained by miners.

| Type of injuries | Percentage (%) |
|---|---|
| Contusion | 17.16 |
| Laceration | 28.40 |
| Wound | 11.83 |
| Fracture | 15.38 |
| Musculoskeletal pain | 14.20 |
| Dislocation | 5.92 |
| Amputation | 5.33 |
| Burn | 1.18 |
| Facial | 0.59 |

### 5.5.6 Mine management commitment to safety

#### *5.5.6.1 Miners' perception of work conditions*

The study aimed to analyze the respondents' working conditions at the mines. As evidenced in Table 5.6, respondents concurred that their poor working conditions were to a reasonable extent, as revealed by an average score of 3.40; meanwhile, they agreed that lack of personal protective equipment (PPE) was to a moderate extent, which is demonstrated by a mean score of 3.50. Respondents also agreed that they often faced risk of injury on account of performing physical demanding tasks at the mine to a moderate degree, as revealed by a mean score of 3.41.

Respondents also agreed that lack of health and safety training put them at high risk of injuries, as revealed by a mean score of 3.54 in both the injured and uninjured category.

Respondents agreed that they often faced risk of injuries because they always worked in awkward positions, as evidenced by a mean score of 3.47; they agreed that lack of identification mechanisms and risk control measures for hazards in this mine site exposed them to injuries, as revealed by a mean score of 3.42. Meanwhile respondents concurred that constant bending/twisting exposed them to injuries, as evidenced by a mean score of 3.23. Finally, they agreed that they often faced risks of injury because their tasks were always repetitive, as indicated by a mean score of 3.21.

Table 5. 6 Miners' perception with regard to work conditions.

| Miners' perception with regard to work conditions | **Mean** | **Standard deviation** |
|---|---|---|
| I often faced risk of injury because of doing physical demanding tasks at the mine. | 3.41 | 1.23 |
| I often faced risk of injury because I am always working in an awkward position at the mine | 3.47 | 1.27 |
| I often faced risk of injury because my tasks are always repetitive. | 3.21 | 1.26 |
| Constant bending/twisting exposed me to injuries. | 3.23 | 1.34 |
| Lack of hazards identifications mechanism and control measures in this mine site exposed me to injuries | 3.42 | 1.31 |
| Lack of personal protective equipment (PPE) | 3.50 | 1.37 |
| Lack of health and safety training put me at high risk of injuries. | 3.54 | 1.35 |
| **Total** | **23.78** | **9.13** |
| **Average** | **3.40** | **1.30** |

### *5.5.6.2 Miners' perception about management and supervision*

Table 5.7 illustrates the findings on management and supervision of respondents. According to the findings, respondents agreed to management and supervision in the mines, which was demonstrated by an average score of 3.53. Respondents agreed that workers interest was to a reasonable extent, as revealed by a mean score of 3.56. They agreed that good job performance was to a reasonable degree, as indicated by a mean score of 3.52. Respondents also agreed that honesty and dignity was occurring to a reasonable degree, as shown by a mean score of 3.51. Respondents agreed that workers' suggestions were acted upon to a reasonable degree, as shown by a mean score of 3.53. They also agreed that employers demonstrated care to a reasonable degree, as evidenced by a mean score of 3.56. Finally, respondents agreed that flexibility at workplace was to a reasonable degree, as shown by a mean score of 3.47.

Table 5. 7 Miners' perception about management and supervision.

| Miners' perception about management and supervision | **Mean** | **Standard deviation** |
|---|---|---|
| I am not treated with honesty and dignity in this workplace | 3.51 | 1.13 |
| The management does not consider suggestions from me or other workers | 3.53 | 1.11 |
| The interest of the workers is not protected at this place | 3.56 | 1.18 |
| There is no recognition of good performance at this place | 3.52 | 1.15 |
| My superiors only care about the interest, not for their workers. | 3.56 | 1.20 |
| There is no flexibility of break here at this place | 3.47 | 1.16 |
| **Total** | **21.16** | **6.92** |
| **Average** | **3.53** | **1.15** |

## 5.6 Discussion

This study was aimed at investigating why some of the employees working in the same environment as other employees suffered a single-injury event while other employees experience multiple-injury events. The study also evaluated the commitment of mine management to safety in Migori County of Kenya. In the first analysis of risk factors for the number of injuries sustained using multinomial logistic regression, we found that most participating mine workers had suffered a single-injury incident. This finding is similar to the research results of Calys-Tagoe et al. (2015) where they found that 75 of 95 of severely injured miners experienced only a single injury in the past 10 years. The results of this study can be explained by general awareness and cautiousness of the miners after being injured. In addition, some of personal characteristics, behavioral factors, and job-related factors influenced the number of times participating mine workers got injured as discussed in Section 5.6.1 and 5.6.2.

### 5.6.1 Predictors for occurrence of multiple injuries

Our results of multinomial logistic regression suggested that marital status, drug usage, and job dissatisfaction were responsible for some miners being injured multiple times. We found that single miners (unmarried) compared with married mine workers have a higher risk (AOR = 2.65, $p < 0.05$) of being prone to multiple injuries. Most of the single miners were young people with a limited education background, were less experienced, and had risk-taking behavior. In addition, single miners had less household responsibilities and as a result, tended to work longer hours to continue socializing with friends consequently resulting in fatigue and injuries because of working longer hours. Contrastingly, a study carried out in a construction company has found married workers to have high rates of injuries because of the household and financial stress (Rahmani et al., 2013).

Surprisingly, this study found that miners that were classified to be low-risk drug users frequently got injured. This is contrasted to previous findings which suggested direct correlation between the high-risk users or those who came to work intoxicated or consumed alcohol at work suffering more injuries (Ajith & Ghosh, 2019a). The substance abuse in the ASM operation is a recurrent phenomenon, but the rate of consumption varies amongst miners. The individuals within the low-risk drug usage category consume drugs but not at work. Nevertheless, they might come to work intoxicated which subsequently impairs their work performance resulting in a recurrence of being injured.

The results of the data analysis identified that dissatisfied miners had a higher risk (AOR = 3.64, $p < 0.05$) of experiencing multiple injury causing events than single-injury incident miners. ASM operators engage in mining work as a "necessity" to provide an income and as a result many do not have sense of job fulfilment or enjoy doing mining work. This finding is supported by evidence that lack of accomplishment, lack of resources, lack of personal achievement, lack of good pay, lack of benefits, and unsatisfactory work conditions can increase the level of employee carelessness, absenteeism, tardiness, fatigue, and mental stress, as well as reduce the miner's motivation, which in return can produce an occupational injury (Ajith & Ghosh, 2019a).

### 5.6.2 Predictors for occurrence of a single-injury event

In addition to the reasons mentioned in section 5.6.1, most mine workers suffer a single accident incidence because of gender, experience, hours worked, perception about work conditions, perception about management/supervision, and job stress. We found that male gender had a higher risk (AOR = 2.55, $p < 0.05$) of a single-injury incident occurring than the female counterpart. Previous studies have also shown that male miners were more inclined to be injured than female miners (Chimamise et al., 2013; Kyeremateng-Amoah & Clarke, 2015). The results of this study are explained by the fact that male mine workers worked in underground mines where hazards are prevalent, while females worked in the surface mines with limited risks (Ajith & Ghosh, 2019a). Male miners tend to be aware of hazards and become cautious after being injured. As a result, the number of multiple injuries is reduced. Although incidences of multiple injuries are limited in this category, underground working conditions need to be improved by frequent monitoring and safety awareness.

We also found that mine workers with less than 3 years work experience had a higher risk of suffering a single-injury event (AOR = 2.43, $p < 0.05$) than those with more than 3 years mining experiences. Although previous studies have not specifically divided occupational injuries into single and multiple injuries, they revealed that less experienced workers are prone to job-related injuries (Aderaw et al,. 2011; Bena et al., 2013; Calys-Tagoe et al., 2015). The results of this study can be explained by the fact that less experienced miners tend to be not aware of hazards which often lead to a major single incident, but after the single exposure to injury, miners tend to be more aware, focused, and even find means to self-protect.

Further analysis suggested that miners who worked for more than 8 hours per day had a higher risk of experiencing a single-injury incident (AOR = 3.33, $p < 0.05$) compared with those who worked for less than 8 hours per day. Previous studies have demonstrated that working for more than 8 hours increased the risk of fatigue and subsequent loss of concentration among the miners which latter resulted in a single-injury event (Chimamise et al., 2013; Dembe et al., 2005). Most miners were found to work more than 8 hours per day in Migori. Therefore, the present study recommends that miners and mine owners should reduce the number of hours worked per day to 8 hours and that fatigue management plans needed to be instituted by the mine owners and used by miners.

Contrasting to the finding in multiple-injury incidences, we found that the miners classified as high-risk drug users had a higher risk (AOR = 4.39, $p < 0.05$) of experiencing a single-injury incident than "low-risk users" and "non-users". This finding is not surprising given that drug usage reduces judgment, concentration, and alertness, as well as impairs performance (Bena et al., 2013; Ramchand, 2009) and if the use was excessive, the risk of getting injured increased significantly.

Similarly, research participants that had a poor perception of working condition had a higher risk (AOR = 3.71, $p < 0.05$) of a single-injury incident occurrence than those who disagreed and recorded that their working conditions were not poor. This result corresponds to work conducted by Ghosh et al. (2004), where poor working conditions were found to predict the occurrence of occupational injuries. This research result is explained by there being a high prevalence of hazards with nonexisting control mechanisms when the working conditions are poor. Miners learned through their exposure to incidents which might cause a single-injury incident, but this learning was not necessarily undertaken by miners who experienced multiple-injury incidents. A recommendation based on the finding of this research is that miners need to be educated on work related-hazards, hazard identification, risk assessment, and risk control measures to prevent the likelihood of experiencing an injury.

The study results also suggested that workers who perceived poor management and supervision had a higher risk of a single injury (AOR = 4.63, $p < 0.05$) compared with those who perceived that they experienced good supervision and management at work. Studies have shown that poor leadership produced a bad safety culture with serious health problems (Cui et al., 2015; Paul, 2009). To resolve health and safety issues in ASM operation, it is important to have competent and effective front-line management who are trained on health and safety and other leadership skills.

In addition to the other factors this research identified, participants who agreed to having job stress had a higher risk (AOR = 3.70, $p < 0.05$) of experiencing a single-injury incident than those who disagreed and reported not being stressed by their job. Job stress can be caused by a number of problems in ASM operations that include having poor equipment, poor safety, and labor intensiveness work and by having a number of psychosocial problems that lead to stress and subsequent injury. In other industries with improved safety, stress also continued to cause occupational injuries (Li et al., 2001; Nakata et al., 2006). Therefore, several stress management plans have been developed in most countries with well-established work environment safety programs that can be replicated in the ASM operation to protect the miners.

### 5.6.3 Mine management safety commitment perspectives

The determination of risk factors for injuries using multinomial logistic regression provided an understanding of what influences single-injury and multiple-injury incidences. However, whether miners suffer single or multiple injuries, it is equally important to evaluate the direct and fundamental causes of injuries beyond linearity test. Our analysis in section 5.2 has shown that poor work condition and poor management influences occurrence of injuries. This part of the discussion focuses on why injuries happened and why they were not prevented. As a HOP model dictated that to be human is to err, and therefore, management and the employer should have ensured that preventative risk control strategies were implemented.

According to the descriptive statistics results, miners agreed with the assertion that physical and ergonomic hazards influenced their risk of injuries. The miners' opinions about the labor intensiveness of ASM activities, dangers of working in awkward positions, repetitive tasks, and bending as well as twisting were found positive. These findings are in consistent with the results of the recently published works, wherein the authors revealed physical and ergonomic hazards as a cause of injuries (Ajith & Ghosh, 2019a; Ajith & Ghosh, 2019b). The present results are explained by the lack of safety measures, including proper risk assessment and means of controls. As compared with large-scale mining operations, such hazards are mitigated by conducting job hazard identification assessments and training. Therefore, it is imperative that tools need to be developed and tailored for risk management in accordance with ASM conditions.

Further analysis of the indicators for poor working conditions revealed that all miners agreed to a lack of hazard identification mechanisms, risk control measures of hazards and PPE, as well as the lack of health and safety training being provided. A corresponding study recently conducted in Ghana revealed that the miners perceived their working conditions to be dangerous, and injuries were attributed to the absence of hazard awareness, training, and PPE absence (Calys-Tagoe et al., 2015; Long et al., 2015). In the present study, these results can be explained by three key themes that were identified from the interview results, whereby all of the participants reported a lack of health and safety, in addition to no equipment training and a lack of PPE. Mining is routinely undertaken with crude equipment such as hand-held shovels, wheelbarrows, and semi-mechanical drills. To access the ore, the miners reported entering the underground through a wooden supported shaft, without proper ventilation and lightning. Furthermore, the interviewed miners cited that mine owners or management have never issued them PPE and that their salaries are not sufficient enough to cover the costs of purchasing PPE. As a result, they ignored any safety challenges so that they that could sustain their livelihood, thus exposing themselves to accidents and injuries.

The casual undertaking of ASM operation and resultant consequences are frequently blamed upon miners. However, as evidenced from the large-scale operation, the top and front-line management, in conjunction with government agencies, has a significant influence on the safety of mining operations. If the management does not provide proper frameworks, tools, and adequate leadership, the consequences are almost always catastrophic. For example, in the Upper Big Branch mine in southern West Virginia, a coal mining accident claimed the lives of twenty-nine miners. The United States Nuclear Regulatory Commission (2012) reviewed the reasons behind this tragic development and discovered that the mine management had brazenly prioritized production over safety. In addition, the workplace had numerous hazards (poor environmental conditions, poor ventilation, and coal dust), which acted as “catalyst to a resulting series of massive explosions”.

The analysis of miners’ perceptions toward their mine management and assistances illuminates’ concerns related to matters of safety. The mean data analysis results of miners’ view on whether the management treats them with honesty/dignity, considers suggestions, recognizes good performance, and cares and provides break flexibility were found to be low. Miners perceive management to be ignorant of their well-being and interest, thereby undermining their safety. A recent study conducted by Ajith and Ghosh (2019b) revealed that safety is “safety not priority” among the mine owners of ASM operations.

All the participants reported that the mine owner or management prioritized production over safety and never discussed any safety issues at the start of a shift. This was because government rules and regulation enshrined in relevant laws are not enforced. Safety issues that occurred in ASM operation are not adequately addressed by the government (Smith et al., 2016). In addition, ASM operations are run by an individual, families, communities, as well as cooperatives with limited resources and knowledge to be able to advance the welfare of miners (Hentschel, 2003). In large-scale mining operations, the management ensured that everyone, including themselves, complied with health and safety standards (Smith et al., 2016). Therefore, reducing negative feelings from the miners and providing a sense of fulfilment subsequently translated into a safe and productive day.

## 5.7 Conclusions, Limitations, and Future Research Direction

The determination of the risk factors associated with single-injury and multiple-injury events, as well as understanding the organizational safety performance (i.e., role of mine owners or management), will help government and nongovernment organizations to develop targeted policies that will reduce, or prevent, reoccurrence of injuries in ASM.

In the first part of analysis, we have shown that most ASM miners in Migori County only became injured once. The research also established that the predictors for a single-injury event were similar to those of multiple-injury events. Only single (unmarried miners), lower-risk drug users, and dissatisfied workers were found to relate to multiple injuries, while single injuries were associated with male gender, less experienced worker, long work hours, high-risk drug users, perception about poor working conditions, perception about poor management/supervision, and job stress. Further analysis using the concept of HOP has shown that mine management is not committed to the well-being and health of miners. Generally, mine workers have a low opinion about the contribution of mine owners toward safety. Therefore, the results of this study have indicated that miners and mine management are required to be trained on safe mining practices. In addition, monitoring and recording of the incidences by the mine owners and government need to be encouraged. Furthermore, means of improving safety culture in the workplace should be put at the forefront of any discussion regarding ASM operations.

This research has a number of limitations. Firstly, the data set used for analysis was collected through self-reporting. Therefore, future research should consider comparing self-reporting results with hospital records. Secondly, our study has only focused on the recordable injuries. As a result, some of the frequent occurring minor injuries were missed. The third noted in this research is the adopted sampling approach, whereby participants were systematically selected after stratification. In this form of sampling, particularly in the injured stratum, each participant was given the number, and during the survey, the first random number (first selected participant) was identified followed by systematic choosing of successive participants. Therefore, biasing the number of miners who have suffered single-injury incidences compared with those who suffered multiple-injury events. Finally, working hours record is not available in the mine being an unorganized sector. As no work no pay system is followed, workers do not miss the job except injury-like emergencies. All workers considered here have faced injuries. So their off days are nullified to some extent. As a result, injury exposure level was not calculated.

The present research recommended future research to consider the mentioned limitation for the evaluation of the mine safety issues in ASM operations. In addition, future research should include an in depth of analysis of motivation biases and cognition biases, as well as debiasing mechanisms. Lastly, the impacts of regulatory/ legislative bodies need to be evaluated in context of mine safety and illegality.

# 6. ECONOMIC AND SOCIAL CHALLENGES FACED BY INJURED ARTISANAL AND SMALL-SCALE GOLD MINERS

## 6.1 Overview

Presented in Chapter 6 is a paper submitted, peer-reviewed and published in the *Journal of Safety Science* in 2019. Chapter 4 and 5 have provided answers to nature of injuries, areas of bodies affected, mechanism of causation as well as influencing risk factors for injury occurrence in ASM operation. In addition, the linearly explained the contributing factors for severe injuries, single-injury event and multiple-injury incidences. However, the post-injury impacts were not analysed and discussed. This chapter connects dots to discover post-injury impacts by identifying and qualitatively interviewing severely injured miners from the injured research participants described in Chapter 4 and 5. In this chapter, severely injured reflects and narrates the mine safety issues, economic and socials negative magnitudes post-injury within the paradigm of complex system.

The content of this chapter were simply adopted from the published paper without major alteration. The researcher only modified headings, sub-headings tables and figures numbering as well as references. The permission to reproduce this paper and signed co-authorship form have been appended as appendices D and C respectively. An original copy of published article can be found from https://doi.org/10.1016/j.ssci.2019.05.058.


## 6.2 Abstract

### Background

Miners in Artisanal and Small-scale Mining (ASM) operations have been evidenced to sustain injuries frequently. However, literature review reveals a lack of research in this domain especially in understanding the challenges faced by injured miners and their families. Consequently, in order to address this lacuna, the current study aims to provide a comprehensive insight into the post-injury economic and social issues.

**Materials and Methods**

A semi-structured qualitative interview was administered to severely injured miners. The survey comprised questions pertaining to the study participants' economic, social and lifestyle challenges post sustaining the injury. Severely injured miners were identified, purposively selected and interviewed until the sample achieved ideal saturation. This point was reached after the interview of thirty-three seriously injured miners.

**Results**

The thematic analysis results revealed a reduction in economic sufficiency, negative social health and alterations in lifestyle. The study concluded an impending need of educating the miners on the ASM-related hazards and associated health problems.

**Conclusions**

The study encourages the mine owners and relevant government institutions to develop policies that protect injured miners and their families. Overall, this study has enhanced the understanding of the issues faced by workers in the informal or formal small-scale industries.

**Keywords:** Artisanal and small-scale mining; serious injuries; economic and social impacts.

## 6.3 Introduction

Artisanal and Small-scale Mining (ASM) is an important factor for poverty alleviation especially in mineral-rich rural areas of developing countries. Millions of men, women and children engaged in this activity as a 'necessity' (International Labor Office [ILO], 1999). Despite its great role in improving livelihood and increasing rural development, the sector is still lacking universally accepted definition (Hentschel, 2003). The difference is demonstrated worldwide with each individual country considering varied parameters such as: the number of workers, production rate, capital investment, level of mechanisation, size and nature of the operation (ILO 1999). In this paper, ASM is defined as a type of mining method that employs crude or low-tech equipment to exploit mineral or metal deposits, and it can be undertaken either by an individual, a family, community and/or small-scale cooperatives (Hentschel, 2003).

Despite the lack of common definition, universally, ASM activities are widely characterized by inadequate occupational health and safety (OSH) standards (Hentschel, 2003). This is mainly attributed to the poor safety culture. ASM operators and sites owners rarely take safety seriously as they always focussed more on production (ILO, 1999). An organization with good safety culture encourages: hazards identifications and controls training, issuing of personal protective equipment (PPE), safe operation of machines, daily safety briefing and good working conditions. However, if the organization does not uphold safe operations, the consequences are always detrimental to human wellbeing. The United States Nuclear Regulatory Commission (U.S.N.R.C) investigate the coal mining accident that happened in southern West Virginia, whereby twenty-nine coal miners were killed (U.S.N.R.C, 2012). The findings indicated that the company paid more attentions to production than safety. Also, the review revealed that a poor working environment significantly contributed to this catastrophic accident.

ASM operation is considered one of the most dangerous activity across the globe. In fact, the risk of accidents in this activity is believed to be six to seven times higher compared to large-scale mining operation especially in developing countries (ILO, 1999). The activity is characterized by adverse working conditions as exemplified in Figure 6.1. As a result, accidental injuries are frequent phenomenon. A discussion with the worker representatives and public health officials in Migori County, Kenya revealed that artisanal and small-scale gold miners in the area regularly experienced accidents with disastrous outcomes. A case in point was the recent mine collapse in Osiri, which resulted in six fatalities (Otieno, 2018). Some of the current published epidemiologic studies outside Kenya have collaborated this revelation (Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015). Figure 6.1 shows different ASM working sites in Osiri Gold Mine.

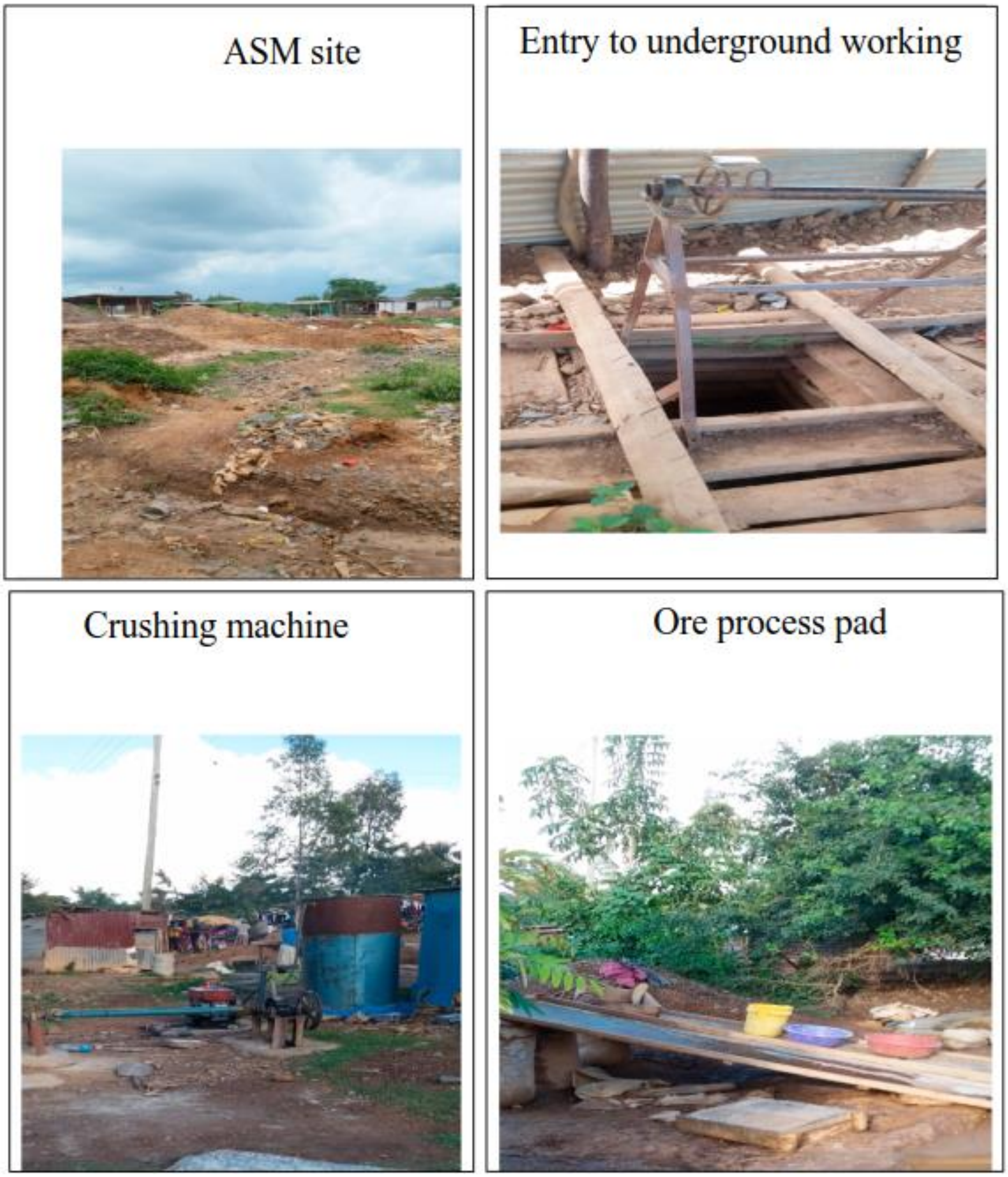


Figure 6. 1 ASM working areas in Osiri Gold Mine.

**The complexity of mining accident**

Depending on the research designs, the investigators of ASM-related injuries have only identified the physical hazards and certain personal characteristics as the risk factors. In spite of this information, accidents in ASM operations continue to occur with serious consequences. This is because the studies adopted the reductionist view. According to this viewpoint, the injury or other phenomena is reduced into basic components and described by rational of deduction (Dekker et al., 2011). The risk factors for the injuries were determined by logistic regression. This view of the event possessing linearity is often insufficient to completely and usefully understand the issues related to mine safety (Komljenovic et al., 2017).

Considering the complexity associated with the occurrence of injuries and associated negative impacts, it is important to apply complex system approach to determine the underlying causes of injuries as well as challenges faced by seriously injured miners and their families. A complex system is literally one in which there are multiple interactions between many different components (Rind, 1999). Mining accident as a complex system is composed of a human component, organizational component and technical component (Maria et al., 2017).

From the definition, it can be inferred that several factors act together to contribute to mining accident within the complex systems (Komljenovic et al., 2017). Human error is one of the factors identified to influence accident; however, it is not the root cause (Department of Energy [DoE], 2009). Statistics showed that about 80% of the accidents are attributed to human error. But, when this percentage is broken down, it reveals that indeed human error interacts with other factors to facilitate the event occurrence (DoE, 2009).

In addition to operators' error, managerial ignorance is one of the key factors that has impact on mine safety. Failure by the leadership to learn from the past experiences produced recurring event of mining accidents (Komljenovic et al., 2017). In fact, this study stated that the individual human behaviour is always influenced by the environment in which it takes place. In ASM operation, mine owners and even miners believed that production superseded safety. Therefore, miner's behaviour is to ignore hazards to achieve production target. In addition, if the accident occurs, leadership or miners are not held accountable. Moreover, accidents, injuries and post-injury impacts are rarely documented except in the catastrophic events that have been reported by media.

The lack of proper organizational structure in ASM is another source of a problem for increased accidents. As stated in the definition, most ASM sites are operated by the individuals, families, communities and occasionally small cooperatives (ILO, 1999). This leadership structure coupled with lack of government supports and effective management often leads to non-compliance with local or international safe mining practices (Hentschel, 2003). A well-established industry has organization components such as safety culture, decision-making process and several other attributes (Komljenovic et al., 2017). However, in the case of ASM operations, there are no clear operating policies and procedures, work instructions, documentation, training etc. (Smith et al., 2016). As a result, limited shields exist that prevent the occurrence of accidents and subsequently injuries.

Technologically, ASM still relies on rudimentary tools and techniques whether in mining or processing stage (ILO, 1999). Nevertheless, it has been established that technological evolution and modern organization create an important source of complexity in relation to mine safety (Komljenovic et al., 2017). Both ‘‘structural” and ‘‘dynamic” complexities are introduced to increase integration among various systems (Dekker et al., 2011). Consequently, modern organizations such as mining industries become complex socio-technological-economic entities involving many interacting and interdependent elements with barely foreseeable long-term behaviour (Komljenovic et al., 2017). For ASM operation, such technological complexities are limited due to the backwardness of the sector (ILO, 1999). The technological deficient of the sector has been blamed for low production and poor OSH (Intergovernmental Forum [IGF], 2018).

To better understand the effects of human and organization consequences on workplace accident within the complex systems, number of models have been developed. However, the model created by DoE entitled “Anatomy of an Event” gives clear picture of the role played by both human and organizational factors (DoE, 2009). This model as shown in Figure 6.2 was recently modified by Komljenovic et al. (2017). The advantage of the new model showed events as complex interactions with number of potential influences and accident scenarios (Komljenovic et al., 2017).

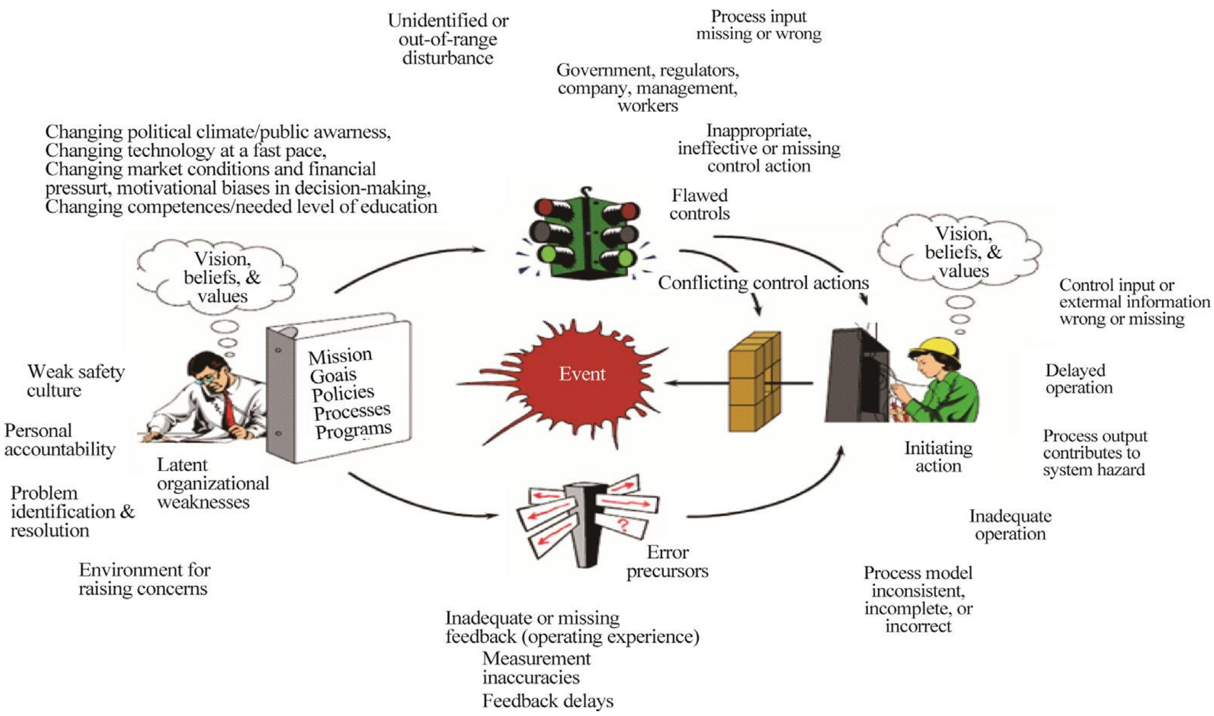


Figure 6. 2 Anatomy of an event as modified by Komljenovic et al. (2017).

An event is “an unwanted, undesirable change in the state of facility structures, systems, or components or human/organizational conditions (health, behaviour, administrative controls, environment, etc.) that exceeds established significance criteria” (DoE, 2009). Komljenovic et al. (2017) stated that human performance is an occurrence of event error. That means, the human error is a symptom within the event for which the cause must be found (direct causes). Therefore, investigators should determine why event occurred and why it was not stopped (fundamental causes). This fundamental causes should target organization while the direct causes are associated with preventive barriers, mitigating barriers and error precursors (Komljenovic et al., 2017).

The preventive barriers include the training, qualification, procedures and work practices. These barriers stopped making of the errors within the complex systems. While mitigating barriers limit the consequences that may follow an inadequate action. For example, steel cap boot is a mitigating barrier to limit any consequential mishaps. Precursors include the elements in working environment, or invisible constraints within the task. Job stress, job dissatisfaction and poor management and supervision influence on the cognitive processes required for safety and proper operation of the task (Komljenovic et al., 2017).

Human and organization performance cannot assume that decision-making is often rational.

Therefore, in decision-making process, cognitive and motivational biases are likely to occur, which always impact on mine safety (Komljenovic et al., 2017). The cognitive bias is defined as "a systematic discrepancy between the "correct" answer in a judgmental task, given by a formal normative rule, and the expert's actual answer to such a task" (Montibeller & Winterfeldt, 2015). While motivational biases, on the other hand, is refer to distortion of the judgement (decision-making) due to desirability or undesirability of events, consequences, outcomes, or choices (Montibeller & Winterfeldt, 2015). The main cognitive biases for occurrence of mining accident are: overconfidence, omission of important variables, myopic problem representation. The motivational biases are: desirability of options/choice, groupthink, confirmation biases, desirability of options/choice, and undesirability of a negative event or consequence (Komljenovic et al., 2017).

**Beyond injury occurrence**

It is not only the occurrence of injury that is complex, but also post-injury consequences. Occupational injuries are known to have direct negative impacts on injured persons as well as "spill over" effect on family members, friends, communities, employers, and insurance companies. The European Commission (EU) (2011) conducted a survey where it was observed from an employee's perspective, injury results in not only pain but other adverse fallouts such as suffering, undesirable impacts on his/her family, a possible decrease in physical ability, and salary loss. In addition to the employee, the report highlighted extra accident cost burden for the employer, i.e., production losses and increased insurance premiums.

According to Brown and Harris (1989), the term "life events" represents situations that yield an emotional disorder and often involve danger, thereby, leading to significant changes in health, lifestyles, and success or failure of the victims. Artisanal and small-scale miners have been evidenced to operate in volatile social environments that subject them to the inevitable encounter with circumstances of varying kinds that are mostly impulsive. In this case, when miners are exposed to life events such as severe occupational injuries, they are inevitably exposed to emotional fluctuation and psychological heaviness.

When experiencing a life event, the human body responds by conducting cognitive evaluations based on nature, severity and its ability to handle the events in accordance with the psychological traits and tendencies, social support system, and existing knowledge (Zhang, 2014). Following which, the individual is able to choose the right strategy in order to cope with the situation based on these evaluations (Zhang, 2014). Consequently, artisanal and small-scale miners who demonstrate an inability to mobilize their social and internal resources towards rebalancing their minds tend to suffer from overpressure and the loss of action.

According to the S-O-R theory of human errors, as propounded by Thurley, the contrivance of human behaviour is viewed as the procedure, wherein, an organism responds when stimulated, thereby, causing the blend of judgment, insight, and action (Li et al., 2006). In this case, it is imperative to properly address the incidents involving miner' accidents in order to ensure that they do not attribute towards psychological overpressure, thereby leading to a decline in their psychological and physiological functions (Zhang, 2014).

The injuries can be prevented through the utilization of modern mining equipment as well as tightening of the policies and regulations governing the sectors. In absence of sufficient financial and social support from the mine management and other relevant governing bodies, the injured workers and their families are subjected to deteriorating economic situation and declining social health as well as lifestyle (Camm & Girard-Dwyer, 2005; Dembe, 2001; Kim, 2013; Lax & Klein, 2008). In addition, this situation subsequently causes psychological issues in both the injured workers and their families.

The objective of this study is to explore qualitatively the economic and social challenges faced by injured persons and their families. The findings of this research will not only provide a clear understanding of safety in ASM operation but also revealed economic and social consequences of mining-related injuries. This information is critical for injury prevention and post-injury consequences management. Figure 6.3 showed a complex model for causes and consequences of injuries.

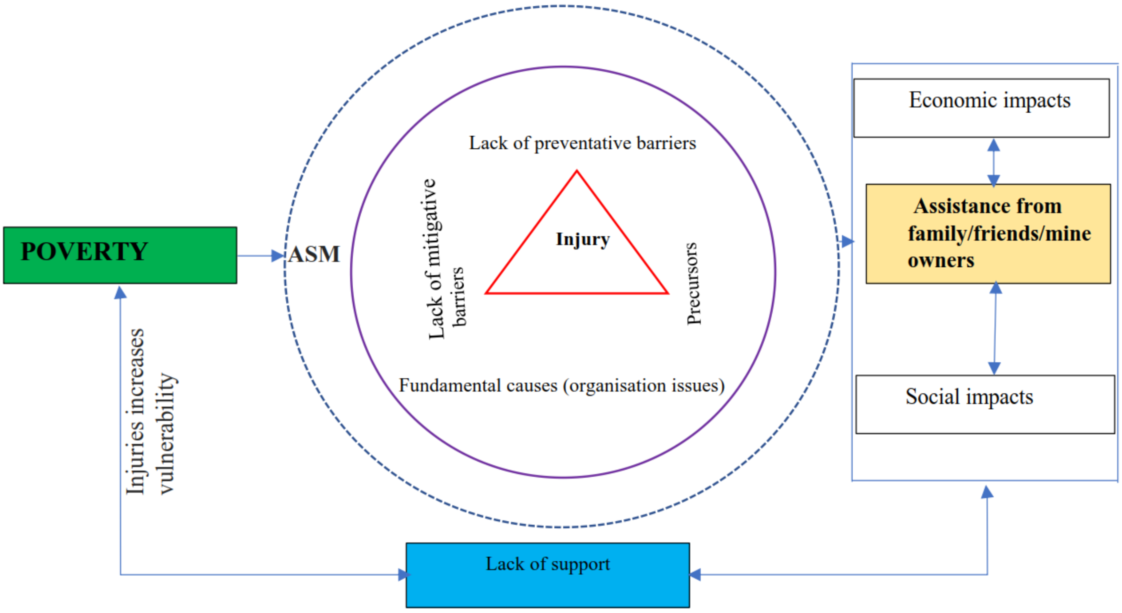


Figure 6. 3 Complex model for causes and consequences of injuries.

## 6.4 Materials and Methods

To achieve the research objective, semi-structured interviews were conducted with severely injured artisanal and small-scale gold miners. The study samples were seriously injured miners who could provide the necessary insight into complex issues of post-injury economic and social consequences.

### 6.4.1 Study Area

The study was implemented in Osiri Artisanal and Small-scale Gold Mining (ASGM) in Migori County. Migori County is situated in Western Kenya, with neighbouring Lake Victoria in the west and Republic of Tanzania in the south. Previously, the mine was called Malcader, however, lately, it is known as Osiri or Karibu mine. The site has several small pits or underground workings which are run independently by different owners, but all the business operates under the common aegis of cooperative leadership.

### 6.4.2 Sampling and participants

The qualitative approach does not mandate a specific rule for determining the sample size which usually is based on the saturation point (Mark, 2010). In such cases, the interviewing process continues until additional participants fail to provide new information pertinent to the research objectives (Fusch & Ness, 2015). In this study, the sample size was determined by the richness of information obtained with every interview. The ideal saturation was achieved when no new themes or ideas were emerging from the recruiting of more participants. That is, newly interviewed participants did not provide new themes or ideas that is different from the previous interviewees. In addition, Mason (2010) reviewed five hundred and sixty PhD studies to determine the sample sizes that have been used by authors and found that 85% of total proportion of qualitative studies reached saturation after interviewing 25 participants. This research had slightly higher number of participants, as the saturation was reached with 33 participants. The methodology of purposive sampling which is widely used in qualitative research was considered appropriate for identifying these cases. This strategy was adopted in alignment with the objectives to interview individuals with firsthand experience of post-injury economic and social problems.

The inclusion criteria for the interview included: (i) sustaining minimal one injury during ASGM operations, (ii) over 18 years of age and (iii) freely providing consent for the interview. While the exclusion criteria included: (i) employed as mine leaders, (ii) government officials, (iii) not seriously injured and (iv) under 18 years old.

### 6.4.3 Instrument

The information on economic and social challenges faced by the severely injured ASM workers (i.e., study participants) was captured using semi-structured interview instrument comprising of nine open-ended questions. The questionnaire was constructed based on the findings reported in the pertinent literature. Essentially, all the study participants were asked the same nine questions in order to ensure that their responses relate to the research objectives. During the semi-structured interviews, the researcher asked for further clarification when needed (i.e., on need basis), and accordingly explored new ideas emerging from the participants' responses.

### 6.4.4 Procedures

Prior to the commencement of the interviews, the primary authors conducted extensive sensitizations and consultations with the key stakeholders. This conglomerate included mine workers, and the cohort was identified in alignment with the purpose to explain study purpose and protocols, as well as discuss research documents and interview process. The authors focused on engaging and developing an in-depth understanding of the seriously injured miners without the involvement of local officials and mine owners. In fact, miners who voluntarily consented to take part in the study provided their telephone numbers and were subsequently contacted to arrange the time and place for the interviews.

All the interviewees were extended the opportunity to bring along their closest relatives for emotional support if they so desired. Each interview commenced with the researcher's introduction, followed by an explanation of the research purpose, the data collection instruments, and sharing the examples of possible questions for the interview. Participants were given sufficient time to understand the deliverables expected from the respondents and give their final consent/approval for the interview. The informed consent form and semi-structured interview instrument were signed necessarily by all the study participants before commencing with answering the questions.

The interviews were documented through note-taking, whereby the researcher also recorded participants' verbatim responses. Before moving on to the next question, the verbatim response was read out to the respondent for validation and accuracy. Despite the time-consuming feature of note-taking, the process also presents several inherent advantages compared to audio recordings (Ranney et al., 2015). Particularly, in addition to safeguarding against equipment failure, the note-taking process also allows for immediate validation of the captured data. Each interview lasted 60 minutes on average and was predominantly held in the Kiswahili dialect. Upon completion of each interview, the researcher transferred the field notes into a Word document, which was subsequently translated into English to produce the final 33 transcripts that constituted the corpus of analysis.

The demographic characteristics of the interviewed miners are shown in Table 6.1. Of the interviewed participant cohort, the age group 18-34 were over 50% of the total sampled population. Also, the majority of the participants were male and married.

Table 6. 1 Demographic characteristics of the interviewed participants (n = 33).

| Characteristics | Frequency | Percent |
|---|---|---|
| *Age group* | | |
| 18-34 | 19 | 57.60 |
| Over 35 years | 14 | 42.40 |
| *Gender* | | |
| Male | 31 | 93.90 |
| Female | 2 | 6.10 |

| | | |
|---|---|---|
| *Marital status* | | |
| Married | 31 | 93.90 |
| Single | 2 | 6.10 |

### 6.4.5 Data Analysis

Thematic analysis of the interview data was conducted using the NVivo 12 software. Correspondingly, the deductive approach of analysis was used to develop major themes and sub-themes. The research questions and principle of complex systems in Figure 6.2 and 6.3 were used to guide thematic analysis, in alignment with Braun and Clarke's (2006) iterative step-by-step procedure described below:

In the first step, the transcripts were read and reread, line by line several times, thereby allowing the researcher to fully immerse himself in the data and gain an in-depth understanding of the same. Following which, in the second step, the words, phrases, sentences, and specific quotes were coded in order to facilitate the emergence of themes. This step is referred to as open coding, wherein, the aim is to capture the richness of the qualitative information (Boyatzis, 1998). In the third step, a thematic map was developed, as suggested by Braun and Clarke (2006), in order to devise a way to visualize the codes. This visual representation accorded the researcher with optimal opportunity to contemplate and identify the intersecting links and relationships between codes. In the fourth step, all phrases and paragraphs that corresponded to the themes were extracted and classified as quotes. This was followed by a comprehensive analysis of essence and aspect of data captured by themes, which was intended at evaluating the sufficiency of the theme towards explaining the 'overall story' related to the dataset and subsequently the research objective (Braun &Clarke, 2006). The quotations were synthesised systematically to showcase the foremost ideas. In the last stage, the researcher provided a detailed description of the findings, wherein, the number of quotes accompanied the description results to safeguard the study robustness.

## 6.5 Results

The thematic analysis of qualitative interview data revealed six main themes, which are presented in this section. The verbatim quotes were taken directly from the participants' transcripts in order to substantiate the emergent key themes or sub-themes, denoted with the code P and followed by the transcript number.

### 6.5.1 Mine safety and cause of injuries

This theme assessed the type and causes of injuries. The human and organization model in Figure 6.2 was used to determine the state of preventative, mitigating and precursor barriers as well as fundamental causes (organisational factors).

#### *6.5.1.1 Injury occurrence*

Before we asked participants about the causes of injuries, we tried to identify the nature of injuries they have suffered. Most of the injured participants reported ruptured spinal cords, back pain, fractured legs, and joints as well as the shoulders.

> *"When we were digging and loading out the rock, the wall opened and one of the rock landed on my back and leg. The major injury was in my back." (P012).*

> *"My leg and arm were trapped under a rock and when the rock was removed, several bones in my leg were fractured." (P006).*

> *"While I was digging, the wall cracked, and the rock hit me in the back, breaking my spinal cord." (P010).*

In addition to the physical trauma and musculoskeletal pain resulting from these accidents, some participants cited unfortunate incidences of injury fatalities either immediately or while undergoing treatment.

> *"I and my three workmates entered the shaft and start digging. But at around 10 am the roof caved on us. In this sudden caving, two of my colleagues were killed, and I was seriously injured." (P008).*

The participants were asked about any preventive barriers or issues that might have led to injury occurrence. All the participants interviewed reported complete lack of OSH training as well as knowledge on hazard identification and controls. They only see wall or roof collapses as the harmful hazards. In addition, none of them had any formal training on the use of semi-mechanised equipment.

> *…… I have never been trained on how to operate hand held drill or other equipment… as*

*you can see my hands and elbows were injured several times, but my only concern is roof failure (P001).*

In addition to stories provided by participants, no single work instruction or procedure document was provided by the miners or mine owners during the fieldwork. Also, the research observed that miners starts all the tasks without looking around for potential harms.

Because of high number of hazards and lack of preventative barriers, participants were asked about available basic mitigating barriers. All participants reported lack of basic PPE such as safety glove, helmet, steel cap boots, ear mask etc. Some of participants further explained that they have never worn or seen any PPE among their workmates.

*"……… occupational health and safety of oneself and colleague is not always a top priority. I have never used any personal protective equipment or had health and safety training while working in this operation." (P001).*

The identification of issues related to precursor barriers showed that most participants working area had widespread presence of occupational hazards, which contribute to the accidental injuries. Moreover, these incidents, in fact, assume substantial adverse proportions inside the underground workings. Correspondingly, the majority of the seriously injured miners reported that they were injured while operating in the underground.

*"I was injured while working in the underground. When we were digging and loading out the rocks, the wall collapsed and one of the rocks landed on my back and leg. The major injury was in my back." (P012).*

The researchers observed causal undertaking of tasks with complete disregard for safety. The underground working environment had no proper ventilation and lighting. In addition, miners entered underground through the shaft using the wooden ladders. Moreover, underground workings are not well scaled; walls and roofs were not protected for any potential collapses and generators used to pump waters produced carbon monoxide.

The informal discussion with mine owners, worker representatives and public health officers revealed that number of fundamental or organization causes are responsible. Firstly, sites are operated with no formal government surveillance and recording of any incidents. Therefore, mine owners are not held accountable. Secondly, within the mine sites, there are number of shafts run and operated by families and individuals without proper management structure.

Thirdly, working is on causal basis. That is, some miners tend up to work when they are looking for easy money. Fourthly, mine owners and local governments have no programs in place to improve safety culture.

### 6.5.2 Consequences of injuries

Following understanding of the safety culture and nature of injuries, we have investigated how individuals including their families have survived with such severe injuries and whether their social life has changed. These results are discussed in theme 6.5.1 – 6.5.5

#### *6.5.2.1 Functional limitation*

Depending on the nature and relative degree of injury severity, the participants reported functional limitation (physical inability) to perform the tasks or functions they would be able to undertake prior to being injured. And, resultantly, some of the participants were forced to change their jobs to physically less restrictive and less labour-intensive roles.

> *"I stayed-off work for a duration of 2 years when I got injured, but now the mine owner has allowed me back on work, however, in the processing plant because it is less physically demanding and does not require me to stand up or work in awkward positions. I crush rocks, and wash and sieve them while sitting." (P001).*

> *"It has been 3 months since I got injured and I continuously feel severe pain every time I bend to pick or lift something. I have come back to work but now am engaged in light duties such as guarding the entrance of the shaft and communicating, in case of any problem to the mine owner." (P002).*

While others reported that they have not Returned-To-Work (RTW) at all due to the severity of injuries. Some reported a permanent disability or presently undergoing treatment. Thus, pushing them into a difficult and demanding financial position.

> *"The incident happened in February and I still feel the pain. The injury has not fully recovered, and I haven't gone back to work since." (P008).*

Only a few participants reported having changed their jobs from mining to jobs outside of the ASM operations.

> *"The injury has forced out of mining activities and now I sometime ride boda boda (motor*

*cycle) to support my family." (P010).*

In addition to on-job restrictions, some of the injured participants mentioned experiencing functional limitations in performing their household roles. They also reported that their physical inability had forced some of the family members to shoulder more responsibility. For example, women and children were cited by the participants to assist in or assume the injured persons' previous household roles.

*"The role of the household management has shifted from me to my mother and somehow my wife. I cannot even clear bushes due to the pain in my shoulder and my head when I bend." (P008).*

*"The injury has forced me to cut down on the number of hours I initially used to spend working on the farm and other income-generating activities. My wife has to shoulder some of the household responsibilities until I will fully recover." (P013).*

#### *6.5.2.2 Economic impact*

The economic impacts of severe injuries on miners and their dependents were assessed through computation of the associated medical costs, assistance provided by the mine owner or management and lifestyle changes.

##### *6.5.2.2.1 Medical costs*

Almost all the participants reported to have shouldered their own medical expenses in addition to the financial support garnered from the family post-injury. Commonly, the participants cited depletion of individual savings, which subsequently led to the selling of assets, fundraising and borrowings to cover the costs of the medical costs.

*"My medical expense was 35,000Ksh (Kenya shillings) excluding the first-aid fees. I managed to pay half from savings and selling the cattle, and my mother paid half. My mother was forced to borrow from friends in order to cover this percentage, as the little she had was not enough." (P007).*

*"This situation forced me to borrow some money from my friends, after spending all of my savings and selling some of the assets. Also, my family managed to raise some funds but still the money was not enough to pay for the medical bills" (P012).*

Very few participants mentioned having been extended any support or help by the mining management in order to cover their medical bills. Also, in the cases, where the management did offer help, notably, only a minimal part of the bill was paid by the management, thereby, leaving the bigger part of the bill to the injured miner.

*"…. I did not receive enough assistance from the mine management. The only assistance provided by the mine owner was the transportation from the place of accident to the hospital and clearing of the initial first aid charges. The mine owner made it clear that subsequent to the initial aid, I have to bear the rest of the medical bills." (P002).*

*"The mine owner paid for the quarter of medical bills as well as first aid and transportation fees which was a big help." (P009).*

*"I was rescued and transported to the hospital by pit owner who later cleared the first aid money. But afterward, I was left without assistance for the major part of medication. I had to eventually cut short the medical care because the family could not bear the expenses." (P009).*

Few participants mentioned having been insured, and hence insurance catered to partial expense. However, as the amount was insufficient to cover the entire medical expense, the participants were forced to seek help from family and friends. Conversely, the participants without insurance undertook the burden of entire medical expense.

*"To make matters worse, I was not insured and therefore I had to clear the bills without much assistance from any other quarter." (P001).*

Some of the participants who could not afford to pay the medical expenses reported to have opted for a traditional healer for treatment since they are cheaper.

*"Now I visit a traditional healer who massages my feet and ankles since I cannot afford to go to the hospital." (P013).*

*"……. I have started to consult traditional doctors, and sometimes when I collect enough money for transport, I travel to a nearby health centre that is run by a non-governmental organization." (P013).*

#### *6.5.2.2.2 Assistance rendered by mine management*

All the participants typically reported that the mine management failed to extend any help to the injured in the clearing of hospital bills. In addition, a major percentage of respondents did report that the management helped them by providing transport to the hospital and clearing the initial first-aid bills. However, following the initial payment, the participants had to assume the responsibility for the subsequent treatment bills, which were too high.

> *"No, I did not receive enough assistance from the mine management. The only assistance provided by the mine owner was transport from the place of accident to the hospital and clearing of the initial first aid charges." (P002).*

Some of the participants reported to have approached the mine management in order to garner assistance in clearing their hospital bills but the attempts were futile as the management declined their requests.

> *"The mine management or the pit owner did not provide any assistance. I requested them for help, but they declined, and I cannot force them." (P033).*

The participants noted that as per their employment contract, the mining management was not bound by any by-laws to extend any financial support to address occupational hazard related accidental injuries. Hence, the participants were forced to find alternative ways of clearing their medical bills, and whatever help the management offered was on humanitarian grounds and not due to any mandatory clauses.

> *"Because these activities are not legalized when injured, you are responsible for all medical expenses." (P025).*

However, according to the responses of some participants, they did receive partial assistance from the mine management. This may be attributed to their interaction levels with the top management as quoted below:

> *"The mine owner provided me with necessary assistance, although there is no legal requirement to pay for the medical expenses. This may be partly due to the fact that we are very close." (P017).*

As such, the study made an observation that the mining management was beyond any legal obligation to cater for the medical bills resulting from mine injuries; and hence, the participants were forced to cater to their own medical bills. It was also established that the mine management presented an absolute lack of compensation policies/programs to address such scenarios.

> *"Every injured miner individually shoulder the medical and other expenses when involved in accidents. As regards compensation program, here at the mine, no compensation programs exist." (P019).*

*6.5.2.2.3 Lifestyle impact*

It was observed that multiple factors including, the lengthy RTW duration, job changes, hefty medical bills, lack of enough assistance from mine management, as well as not being insured, contributed cumulatively towards the reduction of injured persons and their families' lifestyles. This alteration is evident from drawing comparisons between their earnings from mine job and lighter duties like washing and cleaning. The majority of injured miners mentioned a reduction in their income to less than half of previous earnings from mine job. Apparently, the job of a digger provides relatively higher returns despite being one of the most dangerous jobs. Prior to being injured, the individuals earned about an average of 1500Ksh a day as compared to the light jobs, which could only pay an average of 250Ksh a day. This reduction in earnings caused a strain on their economic situations and affected their family.

> *"The changing of roles has affected my economic situation a lot. My income has reduced from 2500Ksh to 500Ksh." (P003).*

> *"This leg injury has significantly changed my life. My income ceased immediately after I got injured, and as a result, I have been struggling to sustain my family. When I was not injured, my daily income was 2500Ksh a day but now I am lucky to even get 200Ksh a day. Also, the injury has impacted my ability to perform other supplementary jobs such as cattle rearing and ploughing. The little I get from mining is the only source of income now." (P005).*

As such, the responses evidence that the injury adversely impacted the quality of life and living standards of the family, with most participants reporting challenges in sustaining their normal life due to affordability issues. This was attributed to the exorbitant medical bills which exhausted the family savings, compounded with the inability of the breadwinner to work and source any income. It was also reported that in certain cases, the affected family could not afford meals, which forced them to only have one meal a day and even go without meals on several occasions.

*"We are currently surviving on hand to mouth equation. Sometimes my family has to go without food." (P005).*

*"I cannot engage in the difficult tasks such as slashing and digging. Therefore, personally, my economic situation has worsened, and I depend on the handouts from my family. I used to earn to around 4000Ksh day but now I am getting nothing." (P008).*

Moreover, attributed to the financial strain in the family, the wife of the injured household head was forced to start fending for the family and assume the breadwinner's responsibility. Some of the wives went to work on light jobs at the mines, while others started small businesses to help meet the family needs.

*"I used to be the breadwinner but my mother who is 60 years old and my wife have taken over until I am fully recovered. My mother ploughs the land and sells vegetables. While my wife is engaged in small businesses around the community and at the mine site." (P008).*

*"……Because I was the breadwinner and could not walk properly again, my wife took up the responsibility for catering for the family. Whatever little I get from riding boda boda is spent on the food. My wife gets very little, she is early childhood development education (ECDE) teacher but not yet officially absorbed into the system. Also, my parents are adversely affected because I used to plough their farm and assist them financially." (P010).*

Participants also reported that their children's schooling had been greatly affected. While some children were forced to drop from school because of lack of school fees, the children enrolled in private schools were transferred to public schools due to affordability issues. This decline was predominant in households, where the injured was the household head and as such the main breadwinner.

*"My family has been affected by my economic situation. I used to be the only person who worked and provided for the family but now my income cannot feed the family as well as educate my children. This difficult financial situation forced my wife to seek an alternative job to supplement my income. Also, the children have been taken from private school to public school." (P012).*

*"Due to the situation my elder son who is in secondary school had to drop out this year and now he is working at someone else's land." (P014).*

#### *6.5.2.3 Mental and emotional trauma*

It was observed that the injury and dire economic situation resulted in mental and emotional trauma amongst the injured participants. Because of decreasing physiological function, some of the injured participants also reported transitioning to diverse job roles, i.e., functions which they considered less manly in their culture. As a result, they experienced a dip in their self-esteem with their counterparts (i.e., fellow men) who were, in fact, employed in higher paying and physically demanding jobs like digging in the shaft. This greatly affected their interactions with their friends and colleagues employed at the mines who could not understand their situations.

*"I would feel worthless amongst my peers if I worked in the sieving and cleaning and they worked in the shaft." (P025).*

In addition to self-esteem, most of the participants reported being stressed and depressed due to their conditions. The use of family savings and selling family assets in order to clear their treatment bills made them feel bad and regretful about the injury. The participants reported experiencing feelings of being a burden to their family and/or being helpless when the family was struggling financially. Some of them have even reported of contemplating suicide at some point.

*"This one time I considered committing suicide because I felt useless to my family especially kids and wife. I consider myself as a burden to them." (P010).*

*"Personally, I feel worthless as I cannot walk nor am able to work to cater for my family. I feel like there is no point of survival if you cannot do simple things such as going to the men's room by yourself. I have thought of suicide, but I feel bad for my kids and wife." (P030).*

*"I often feel like my medication costs exceed even the funeral cost and therefore I should have died." (P010).*

#### 6.5.2.4 Substance use

Some of the participants reported that they decided to drink more alcohol in order to forget their adversities. Apart from alcohol, some reported having increasingly engaged in drug abuse by smoking marijuana and bhang because of the mental and emotional trauma they were experiencing.

> *"Sometimes, I go to the bar with friends to drink alcohol and forget about the problems. I know it is not a solution but at least it clears my mind." (P003).*

> *"My level of alcohol consumption has tremendously increased and that has somehow affected my relationship with my wife." (P006).*

> *"I am excessively involved in taking drugs and alcohol, and this has caused tension within the household." (P006).*

#### *6.5.2.5 Social support*

Some of the participants shared that their children, wives, friends, and relatives were supportive towards them, in order to help them cope with the adverse circumstances, by extending financial, physiological as well as mental support. However, some wives had to necessarily assume the role of the men as breadwinner, and this, in fact, made the participants feel bad.

> *"I am excessively involved in taking drugs and alcohol, and that has caused tension within the household." (P006).*

> *"I received great support from my family, relatives, and friends, who supported me emotionally and financially." (P021).*

In contrast, some of the injured participants were unable to receive sufficient social support from their respective families and friends, as they considered participants an economic and social burden. This resulted in the injured worker's isolation and affected his mental and emotional state.

> *"My relationship with my wife and children has significantly declined over time due to the financial stress and the fact that I do not provide enough support in the household." (P001).*

> *"Honestly, my relationship with the family has been somehow strained due to the large*

*medical bills. My immediate family constantly blames me for exposing them to difficult financial situations." (P011).*

*"The injury has really affected my relationship with my wife and friends. I used to be a loving and caring husband to my wife but all I hear now is that I am useless and a drunkard. Nothing I do is appreciated in the house. My wife still blames the accident on me despite advice from the family that she should not stress me. One day my wife moved out of our home and went to stay with her parents, but she was convinced later by her parents to come back. (P012).*

As a result of the thematic analysis, our study identifies some of the cognitive and motivational biases that have contributed to poor safety culture which led to injuries and associated impacts as shown in Table 6.2 (Montibeller & Winterfeldt, 2015).

Table 6. 2 The cognitive and motivation bias drive from the thematic analysis of qualitative data (adapted from Komljenovic et al., (2017).

| Safety culture | Example of poor safety culture | Cognitive bias/descriptions | motivational bias/descriptions |
|---|---|---|---|
| Occupational health and safety (OSH) training which help miners to make an informed decision about the tasks at hand and work environment | ….. Since I started working in this type of mining activity for the last 2 years, I have never been trained on issues to do with safety. I learned how to operate safely as years goes by (P003) | • Myopic problem representation *(an important variable is overlooked)* (Komljenovic et al., 2017).<br>• Omission of important variables (*oversimplified problem representation is adopted based on incomplete mental model)* (Komljenovic et al., 2017). | • Desirability of options/choice *(This bias leads to over- or underestimating probabilities, consequences, values, or weights in a direction that favours a desired alternative)* (Montibeller, 2015).<br>• Groupthink *(Voicing untrue opinions or keeping silent due to social pressure)* (Komljenovic et al., 2017).<br>• Undesirability of a negative event or consequence *(This bias occurs when there is a desire to be cautious, prudent, or conservative in estimates that may be related to harmful consequences)* (Montibeller, 2015). |
| Proper hazards identification and control mechanism to help miners to identify, control and report hazards. This will reduce injuries and improved safety culture. | …… I am not aware of other hazards apart from the rock fall which caused my injured, and carbon monoxide that killed two people last year (P017). | • Overconfidence *(the Decision makers provide estimates for a given parameter that are above the actual performance)* (Montibeller, 2015). | |

| | | | |
|---|---|---|---|
| Working processes in which daily tasks are outline and instructions provided. | ……. I have worked here for a long time and no single day that the mine owner explained to us how to safely perform any tasks. The instructions we often get relate to production and benefits (P024). | • Myopic problem representation *(Idem)*<br>• Omission of important variables *(Idem)* | • Undesirability of a negative event or consequence *(Idem)* |
| Incident reporting and recording mechanisms, whereby injuries are documented by the mine owners and reported to the local government to improve safety. | …… as a leading hand, I do not record and report on the injuries that happened in my work area. If there is a record, then it is possible with the nearby health facility. I only knew of severe injuries (P031). | • Overconfidence *(Idem)*<br>• Omission of important variables *(Idem)* | • Confirmation biases *(The bias occurs when there is a desire to confirm one's belief, leading to unconscious selectivity in the acquisition and use of evidence)* (Montibeller, 2015).<br>• Undesirability of a negative event or consequence *(Idem).* |
| Mine owners should be safety conscious. Production should not replace safety. | ……we are encouraged to achieve good tonnages with no focus on the hazards and controls (P019). | • Myopic problem representation *(Idem)*<br>• Omission of important variables *(Idem)* | • Desirability of options/choice *(Idem).*<br>• Undesirability of a negative event *(Idem).* |

| | | | |
|---|---|---|---|
| Individual miners' accountability, whereby individual take care of their own safety and that of their workmates. | … this activity is my sole source of livelihood… returning home safely is always on my mind, but because of the working conditions, I always hope for the best every day (P011). | • Myopic problem representation *(Idem)*<br>• Omission of important variables *(Idem)* | • Desirability of options/choice *(Idem).*<br>• Undesirability of a negative event or consequence *(Idem).* |
| Effective safety communication, where miners raise any safety concerns with mine owners and the necessary action taken. | …… we rarely raised safety issues with the mine owners. Some of us did raise the safety issues when a government official visits a few months ago but nothing has changed (P023). | • Myopic problem representation *(Idem)*<br>• Omission of important variables *(Idem)* | • Desirability of options/choice *(Idem).*<br>• Undesirability of a negative event or consequence *(Idem).* |
| Institute insurance policies or compensation programs to help miners and their families financially and emotionally. Thus, allowing them to return to work after full recovery and limited recurrence of injuries. | ………. although I got injured at the mine, the medical costs were shoulder by me and family. I used my saving, and my family sold some belongings to offset the cost of injuries. The impacts of medical costs were also felt by an uncle who provide a loan to cover other extra costs that we could not afford (P002). | • Overconfidence *(Idem)*<br>• Omission of important variables *(Idem)* | • Confirmation biases *(Idem).*<br>• Undesirability of a negative event or consequence *(Idem).*<br>• Group thinking *(Idem).* |

## 6.6 Discussion

This study was aimed to develop an understanding of the economic and social challenges faced by miners who have experienced severe injuries. To the best of primary authors' knowledge, this study presents the first comprehensive analysis of severely injured miners' firsthand account of their challenges post-injury. The study serves as a platform for the miners to narrate how their quality of life as well as social lifestyle and health has been impacted by injury. The study employs the use of thematic analysis to firmly establish the hypothesis that the injured miners struggled with resultant functional limitations, medical bills, reduced lifestyle and psychological issues as well as substance abuse despite the financial and social support of family members and friends. Though the study additionally identified a few positive aspects in the well-being of injured miners, the analysis deliberately adopts a subjective approach to focus more on negative economic and social impacts on miners and their dependencies (families).

### 6.6.1 Nature and causes of injuries suffered by severely injured miners

The injured miners' description of events leading to injury revealed that most accidents and injuries happened during underground working. This can be attributed to the poor safety culture evident through minimal regards for OSH standards. For example, one of the participants conceded that production superseded their own health and safety. This viewpoint was firmly confirmed by the fact that some of the miners had no prior health and safety training and never used PPE as they operated with 'hope and faith of coming out fine'. The study findings complement a survey conducted by Lecomte et al. (2012), whereby the study findings indicated a high incidence of employee noncompliance with the set federal and corporate regulations to wear the appropriate PPE. The researcher concluded that this was mainly influenced by the ignorance of the employees. Moreover, the responses and the accident incidents established that the increased noncompliance with protocols resulted in an alarming threat to the safety and health of workers.

The study results also revealed that majority of severely injured miners had sustained back injury, spinal cord injuries and fracture in the leg as well as joints, arms, and shoulders. The participants also reported cases of permanent disability and amputations. In addition, the respondents also shared unfortunate incidences where some of their colleagues died instantly at the accident site while others died during treatment. These findings are in line with several studies conducted in sub-Saharan African countries, where injuries were found to be distributed in different body parts with varying degree of severity and causation mechanisms (Boniface et al., 2013; Calys-Tagoe et al., 2015; Elenge et al., 2013; Kyeremateng-Amoah & Clarke, 2015; Long et al., 2015).

Correspondingly, Rop (2017) conducted a study focused on assessing and evaluating the circumstances during the occurrence of injury and nature of the injury. The study significantly contributed towards the available literature, whereby miners were found to lack mitigation barriers such as safety boots, gloves, helmets, goggles, and ear muffs. The lack of safety equipment is attributed to the absence of funds, negligence, and ignorance of the miners, poor law enforcement from the concerned authorities, and the dearth of skills and adequate training specific to OHS.

### 6.6.2 Livelihood and lifestyle of severely injured miners' post-injury

On post-injury consequences, the study found that some participants experienced functional limitations (i.e., on-job and off-job performance restrictions) which forced them to change jobs. Consequently, causing a reduction in the injured miner's income and self-worth. In a study conducted by Floyd and Gallagher (1997), it was found that the majority of injured workers reported back to work soon after the accident due to financial constraints. The study also showed that they continued working in the mines regardless of the experience. Moreover, the injured workers were found to be incapacitated in diverse attributes towards undertaking or resuming their previous duties as before the injury. Thus, they were forced to opt for simpler tasks or even in some cases change to other individual workstations.

In addition to job change at the mine, some of the injured participants had to remove themselves from the activity temporarily during the nursing period or permanently due to disability. The findings correspond with the work of Boniface et al. (2013), which shows that some proportion of the miners went back to work and in fact, continued working in the mines regardless of their experience. However, some of the injured workers were forced to stop working due to the severity of injuries.

Besides the on-job restriction, the participants revealed that their injuries also resulted in limiting their ADLs (activities of daily living) and daily household roles. As a result, the women and children were exposed to performing tasks such as digging, ploughing and catering for livestock which are culturally considered for male and older people. These findings from the current study correspond to a survey conducted by Hensler et al. (1991), which detailed some of the family impacts from workplace injuries. The results of the study indicated to a great extent that injured individual's involvement in household activities was adversely affected post-injury. The increased demand for care from their family or caregiver was found to be time-consuming, thus reducing their participation level in household activities.

The study also established that occupational injuries significantly impacted the economics of injured persons and their families. The study established that hefty medical bills, lack of support from mine management as well as lack of insurance cover or compensation resulted in distressful financial position. Furthermore, the miners reported a depletion of saving which, in fact, subsequently pushed them to sell their assets and enter debt. The findings concurred that the effect of injury on savings reflected on the outcomes of a study conducted by Subramanian et al. (1991), which indicated that in most cases the impacts of injuries at work were similar to those of no work. The study acknowledged that the financial demands due to additional medical needs impose a greater danger on the families' savings, thereby, making them unable to save money for future expenses. Several other studies (Morse et al., 1998; Cantor et al., 2001), in alignment demonstrated that injured workers and their families are forced by circumstances to mortgage or even sell off some or all of its properties in order to help settle the post-injury expenses.

It was revealed that the mining management extended help and support to very few participants towards covering their medical bills. However, the participants pointed out that the management only paid a partial bill leaving the bigger part of the bill for the injured worker. Correspondingly, Groves et al. (2007) conducted a study on the evident injuries in mining sites. The study findings indicated that in majority cases the organisations were found to incur both direct and indirect costs from workplace accidents and injuries. In several cases, the mine management helped in settling medical expenses for workers injured in their workplaces (costs of their treatment and costs of health). The families of the injured were found to experience considerable financial and emotional suffering and this evidences an impending need to better understand the relationships between occupational safety management style, safety practices and reflected injury records.

It was noted that the mining management was not legally obligated to cater to the medical bills resulting from mine injuries, and hence the participants had no other alternative but to assume responsibility towards their own medical bills. It was also established that the mine management lacked any compensation policies/programs for the employee welfare, specific to this aspect.

Mendelson (2003) noted in their discussion that the majority of workplace injuries are resolved within the time frame. The discussion also pointed out that a worker's compensation scheme projects comparatively poorer outcomes for pain management in the patients compared to those being treated for the same problem in a non-compensation environment.

Furthermore, regarding insurance, few participants responded being covered under insurance, which indeed helped them pay partial bills. However, the partial payment still left the large proportion of bills untended, thereby, forcing the participants to seek help from family and friends. The individuals who were not insured had to shoulder the complete burden of the medical bills. The findings were in alignment with Reville et al. (2001) study which found that private and social insurance helps mitigate the financial effects of workplace injuries on families, although with limited success. The treatment costs for injury show a great variance and, in most cases, and availability of insurance cover helps lessen the expenses burden on the families involved.

The participants also were found to seek medical assistance from traditional healers' due to lack of sufficient money. The findings correspond to a survey conducted by Hensler et al. (1991), which indicated that in most cases traditional healers were used as an option by people facing affordability issues as regards the medical costs, in addition to individuals who still believed in the power of the traditional healers.

As a consequence of the reduced economic position of injured persons and their families, the participants revealed lifestyle impacts (i.e., poor quality of life), alteration between the breadwinners' roles, withdrawal of children from school and debt, amongst others. The findings of the study correspond with the study conducted by Kalyani et al. (2014). Their study indicated the difference between the quality of life before and after injury. The study showed that family health and emotional support for the affected family from friends and family were among the key determinants of the quality of life for the injured person. In another study, the income of the family and its expenditure were studied before and after injury to determine the trend, the study correspondingly revealed that the income was less after injury while expenditure was found to be increasing, which apparently affected the quality of life of the injured person as well as the family (Prinja et al., 2015).

The changing of breadwinners' roles was also evidenced in the work belonging to Strunin and Boden (2004) where the authors revealed that injured workers with back problems encountered challenges in participating fully or partially in certain family roles. For instance, in the case of married couples, the study found out that in case the husband was injured the wife in most cases was forced to take up the role of a caregiver (i.e., attending to the needs of the injured as well as to provide the family's basic needs). The study revealed that these changes assumed a permanent or transitory status depending on the recovery process of the injured person. Research reveals that the majority of these injuries were inflicted on the males who are typically known to play a vital role in providing the basic needs to their families. Thus, the injury and associated debilitated condition affected his family to a great extent. The study findings corroborate the hypothesis that in some cases, the partners of injured participants have to take the lead in providing for the family.

The impact of injury on family finances was observed when the participants reported that they had to withdraw children from school and incur financial loans. Children were forced to drop from school because of lack of school fees affordability. Also, children were transferred from private schools to public schools. All these changes were attributed to the fact that the injured household head was the main breadwinner. The children were also forced to work at the mines over the school holidays in order to help meet family financial needs. The impacts of work-related injuries and illnesses on the breadwinner, thus have been evidenced to pose a great loss to the family. Proctor and Dalaker (2002) furthermore revealed that the families with one parent, faced worse impacts from work incapacitation due to injuries as the total earnings of the family are affected.

In addition to adverse economic consequences, the study also established a common exposure of the injured workers to mental and emotional trauma, as shared by the interviewed participants. The participants also revealed reduced self-esteem among the co-workers and as such, the injuries affected their relationship with those who misunderstood their circumstances. This finding is consistent with study conducted by Beedie et al. (2000), which revealed that negative mood states, such as depression (feelings of hopelessness and worthlessness), fatigue (feelings of mental and physical overexertion), confusion (feelings of bewilderment and uncertainty), anger (feelings of annoyance, aggravation, fury and rage) and tension (feelings of nervousness, apprehension and anxiety) are associated with debilitated performance.

Moreover, the participants expressed being stressed as well as depressed because of their current situation. The financing of the treatment through family earnings made some participants feel bad and regretful of being involved in the accident. This feeling, in fact, increased when the participants witnessed the family undergoing financial struggles without any immediate assistant. Resultantly, several participants shared that they contemplated committing suicide. The reflection on the accidents also made some participants blame themselves for being not sufficiently careful, or even engaging in mining activities, while others showed being emotionally vulnerable when recounting the events leading to the accident and associated adversity. The findings correspond to those of Chang et al. (2005); the study observed that workers suffering from industrial accidents had significantly high levels of anxiety and depression. Choi et al. (2002) also added that the prevalence of post-traumatic stress disorder among individuals involved in accidents or injury was high, and the symptoms persisted for a longer duration. Miners who experienced the death of their fellow workers were also evidenced to encounter major psychological problems. This depression related findings were also found in the study by Kang et al. (2017), wherein, the participants complained of feeling uneasy, having trouble sleeping and irritability. They were also found to have recurring memories of the accident. Additionally, the participants of the study also reflected on feelings of guilt, shock, and fear.

The current study also demonstrated that injured miners frequently engaged in substance abuse to either forget their problems or relieve themselves from pain. Abraham Maslow has put it succinctly: 'What we call normal in psychology is really a psychopathology of the average, so undramatic and so widely spread that we don't even notice it ordinarily'. William Berry, in his article, challenged people to look at their life and decide on escaping it or embracing it (Berry, 2011). The pattern of abusing drugs and consumption, were as such, majorly found to be used to forget all problems and situations, which is in fact, just a temporary escape.

The social relationship among family, friends and injured miners was also assessed to suffer as a consequence of ASM injuries. Some of the participants reported having been helped by their family and friends financially and emotionally. Mason Ellis in his article, indicated that support system of family, friends, and caregivers after an injury is very vital to recover and adapt to new life (Ellis, 2017). He also added that the characteristics of love, trust, and care also play an essential role. Correspondingly, family relationships and support from friends was found to be of importance to the wellbeing of the injured person, financially as well as emotionally.

Contrastingly, other participants cited the challenge of strained social relationships with their family members. Some of the participants' wives were not keen to assume the role of caretaker and provide care, and some children had to face bullying at the school because of one of their parent’s disability. Such incidences, naturally, caused a conflict of the injured mineworkers with their wives as well as lowering of self-esteem in the children. The findings established the social effects of injury as revealed in a study conducted by Kang et al. (2017). According to the study results, the workers subjected to industrial accidents experience significantly high anxiety and depression levels. A study conducted by Kaczmarek et al. (2012) found that accidents significantly affected the involved miners’ mental and social life. Among the miners who were involved in the coal mining disaster in Poland, it is evident that the miners who survived sustained major damage to their health.

Additionally, the participants highlighted that their injuries led to the loss of some friends, as, despite the frequent visits during the initial phase of injuries with the progression of time, the majority faded away. Thereby, the injured participants came to think of themselves as a burden and/or unwanted individual among his/her peers. However, few injured individuals continued to maintain some of their friendships. This pattern of loss of friends is aligned with the data compiled by Kang et al. (2017) showing that the majority of those affected by the accident felt a significant disconnection from other people. Consequently, this isolation posed an adverse effect on their recovery since one of the ways to cope with their feelings entails talking to friends and relatives. Somer and Szwarcberg (2001) conducted a study on the effect of injury on social life and indicated that injured individual often requires hospitalisation and rehabilitation. These two essential treatment mechanisms, were in fact, demarcated to cause separation from friends and family. As such, post-discharge the relationship levels (i.e., from hospital or rehabilitation centre) between the injured person and others was found to be on a different level.

## 6.7 Limitations, Conclusions, and Recommendations

This study is the first comprehensive qualitative analysis performed on the economic and social consequences faced by the ASM miners. The information gathered was based on the first-hand account from the participants. The study recommended future research to spend a significant amount of time with participants in order to optimally observe and document the daily struggles of injured ASM operators. In addition, the study recommends that quantitative data should be collected in the initial phase, with the purpose to complement qualitative data. This implies that the numerical values of past earning, present earning, savings, medical expenses’ records as well as ranging of social health and lifestyle ranging should be prioritised.

In conclusion, the study has demonstrated that ASGM operations in Migori County experienced several occupational injuries with serious post-injury economic and social implications. The majority of the participants interviewed reported reduced economic sufficiency as well as negative social health and lifestyle changes. The most cited causes of declined economic affordability include job changes and huge medical expenses. The participants also reported facing low self-esteem, loss of friends, depression, family issues, increased drug usage as well as reduced physical abilities to perform daily household roles. Considering these significantly high number of issues experienced by the injured miners, it is imperative that the Kenya government should initiate education-oriented programs for miners on the hazards and associated risks as well as issue miners with necessary PPE and permits. The study, in addition, recommends the development of legal programs that enforced compensation for individuals in the informal sector as well as provide necessary assistance to injured miners and their families.

# 7. GENERAL DISCUSSION AND RECOMMENDATIONS

## 7.1 Introduction

This concurrent embedded mixed method research was conducted to investigate *the recordable injuries that occurred in ASM operations and the accompanying undesirable post-injury negative impacts amongst the Osiri gold miners of Migori County of Kenya*. The purpose is to assist the government and non-governmental agencies to create awareness and develop sustained injury prevention and consequences management strategies. In addition, this research has enhanced understanding of the ASM safety culture, as well as other challenges.

This thesis focuses on two interdependent concepts, which have been studied as Level 1 and Level 2:

(i) Level one quantitatively characterizes the injury history, as well as evaluates the role of various risk factors in predicting the likelihood of recordable injuries, the likelihood of severe injury, and defines categories of the number of injuries sustained (frequency of injuries) using descriptive statistics, binary, and multinomial logistic regression.

(ii) Level two qualitatively explore mine safety issues, as well as post-injury economic and social challenges experienced by the severely injured miners and their families. The interview results were analysed using thematic analysis.

Each of the papers presented in this thesis has discussed the significance of the findings within the context of existing published literature. As such, the following chapter provides the answers to the research questions based on these findings and includes the recommendations, research summary, and areas of future research.

## 7.2 Key Findings and Conclusions Related to the Research Questions.

This section of the chapter provides answers to the research questions documented in the introduction chapter that has guided this research. The inferences are discussed in the following section.

### 7.2.1 Specific recordable injuries

The first research question in this study asked:

*What are the specific recordable injuries (that is, nature, bodily distribution and causes of injuries) experienced by miners?*

The published paper 1 presented as Chapter 4 provided answers to this research question. The research analysis revealed: The majority of the miners suffered from laceration recordable injuries (28%), contusion injuries (17%), fracture injuries (15%) and musculoskeletal pain (14%). Most of these injuries occurred in the hands and wrists (17%), arms and elbows (14%) and shoulders (12%). The common causes stated by the research participants were by a dropped object (38%), equipment (30%) and slip/fall (12%). The research concluded that recordable injuries that occur in ASM operation vary in nature, anatomical areas affected and mechanism of causations, as well as severity. Other published studies support this conclusion despite their previously mentioned limitations (Boniface et al. 2013; Calys-Tagoe et al. 2015; Elenge et al., 2013; Long et al., 2015; Lu, 2017). The focus on recordable injuries only in this research has brought to light the severity of the occupational injuries in ASM operations, reinforcing the need for educational awareness and development of targeted safety interventions.

### 7.2.2 Risk factors for likelihood of recordable injuries

Literature published on large-scale mining industries has demonstrated that the occurrence of an occupational injury is not simply a result of hazards, rather it involves a complex interplay of risk factors. The epidemiology triad model in Chapter 2 conceptualized injury events as an interaction between the agent and host within the appropriate environment. The adverse working conditions combined with individual and behaviour characteristics act together to increase the risk of miners experiencing occupational injuries. However, studies that have investigated injuries in ASM operations failed to examine the risk factors that contributed to the prevalence of injuries beyond physical hazards (Boniface et al. 2013; Calys-Tagoe et al. 2015; Elenge et al., 2013; Long et al., 2015; Lu, 2017).

This part of the research was aimed at understanding the contributing effects of various risk factors on the likelihood of recordable injuries. Research question two (2) asked:

*Is there any association between: (i) individual characteristics (age, gender, marital status,* *education level, and experience), (ii) behavioural-related risk factors (alcohol and drug usage), and (iii) job-related risk factors (shift hours, poor working conditions, poor management and supervision, job dissatisfaction and job stress) with the likelihood of recordable injury?*

The binary logistic analysis result shows that: The younger age group (18-34 years), males, less experienced miners, long shift hours, high-risk drug users, agreement to poor working condition, poor management and supervision, job dissatisfaction and job stress are the factors which emerged as strong indicators of the likelihood of recordable injuries. It was concluded that these risk factors were compounded by the presence of agents including physical and ergonomic hazards that increased the likelihood of the specific recordable injuries mentioned in section 7.2.1.

### 7.2.3 Risk factors for likelihood of severe injuries

The published paper 1, presented as Chapter 4, also compared the risk factors for the likelihood of recordable injuries and the likelihood of severe injuries. Specifically, the paper examined if the risk factors of the likelihood of recordable injuries also predicted the likelihood of severe injuries. Research question 3 inquired:

*Can the risk factors for the likelihood of recordable injuries also predict the severity of recordable injuries?*

The results of binary logistic regression suggested that some of the risk factors for the likelihood of recordable injuries also determined the severity of injuries. Severity is measured in multiple ways. However, in this research, severity was measured using the lost workdays, that is, injuries that resulted in more than 7 lost workdays were considered as major injuries. Based on the research findings, it was inferred that the risk factors for the likelihood of recordable injuries, except age group, drug usage, and poor working conditions, predicted the likelihood of severe injury. Whereas, a low education level (<year 8) was associated only with the likelihood of severe injury. Because of the link between risk factors for two outcomes, it was concluded that shielding workers from the risk of injury will also improve the probability of miners experiencing less severe injuries.

### 7.2.4 Risk factors for defined category of recordable injuries

Miners in a workplace can get injured one time or more than once. Therefore, the aim of published paper 2 presented as Chapter 5 was to evaluate the role played by various risk factors on determining the frequency of injuries occurring. The findings documented in this paper answer research question 4:

*What risk factors influence each defined category of the number of injuries sustained (frequency of injuries)?*

From the research results, it was concluded that the majority of the miners were reported to have suffered a single injury incidence rather than a multiple injuries event. The risk factors for a single injury were: Male gender, less than 3 years' work experience, working for more than 8 hours/day, agreement to poor working conditions, agreement to poor management and supervision, as well as the agreement to job stress. However, single workers (unmarried), low-risk drug users and dissatisfied workers were found to be more prone to multiple injuries incident. It was also inferred that the primary focus for any safe work interventions should be on the prevention of single injury events, which will subsequently stop multiple injuries.

#### 7.2.5 Distress economic impacts of recordable injuries

The respondents that had experienced serious injuries were asked:

W*hat are the economic impacts suffered by injured miners and their families in Migori County?*

The thematic analysis results showed that miners and their families suffer significant economic losses due to the injury. It was inferred that distress in the economic situation was caused by hefty medical bills, lack of compensation programs, and lack of safety-oriented mine management, as well as government support. The situation was further exacerbated by the depletion of savings, loans, and selling of assets to cover medical bills and daily upkeeps. Also, some of the seriously injured miners that returned to work demonstrated a tendency to work in lower-paid jobs due to the functional limitations. This resulted in forcing other family members, such as wives and kids to take up some additional responsibilities. Based on the research results, it was concluded that it is not only on-job tasks are that are affected but also off-job daily activities such as farming, fishing, etc. In conclusion, it is evident from the analysis that quality of life significantly changes with mining-related injuries; for example, children dropping out of school and families changing their meal intake frequency.

### 7.2.6 Social changes post-injury

It is not only the economic situation of injured persons and their dependencies that are impacted but also their social health and lifestyle. This necessitated the following research question:

*What are the social impacts suffered by injured miners and their families in Migori County?*

Research results established that injured workers experienced several psychosocial issues that spill over to affect their family members. The research concluded that the social impact factors suffered by miners and their families were mental distress, emotional impacts and for some of those who were not coping, increased substance abuse (mainly alcohol and drugs). There was a hybrid mix of social support that influenced social impacts.

## 7.3 Conclusions Related to the Research Aim

The aim of this research was to investigate the recordable injuries and associated risk factors, as well as economic and social consequences suffered by injured miners and their families in the Osiri Gold Mine in Migori County of Kenya. Miners in this area experienced recordable injuries with varying degrees of severity. The concept of epidemiology triad and Anatomy of Event guided the analysis and discussion of the causes of recordable injuries and this hybrid thesis report presents the outcomes. The research findings showed that recordable injuries that happened in ASM operations ranged from minor to major lost time injuries depending on the number of lost workdays and most miners were injured once, with few participants reporting recurring injury events. Though laceration and contusion were common occurrences, some of the least occurring injuries had caused permanent disabilities, which impacted the on-job and off-job performance of miners. The research established that both the upper and lower limbs of the body were frequently exposed to physical and ergonomic hazards that produced recordable injuries.

The interaction between the miners and hazards was found to be facilitated by several risk factors. The research determined that the likelihood of recordable injuries, the likelihood of severe injuries and the number of injuries sustained (single injury event and multiple injury events) is a result of agent-host-environment interaction. Both the binary and multinomial logistic regression revealed that various categories of individual characteristics, behavioural factors, and job-related factors predicted the outcomes. The research definitively identified a few risk factors for the likelihood of recordable injuries and predicted the likelihood of severe injuries. However, for the single and multiple injuries events (number of injuries sustained), the researcher could not draw similar conclusions. The research confirmed that miners became more aware and cautious after a single injury event, which led to a reduced risk of recordable injury recurrence.

In addition to the agent-host-environment model, the researcher has gone beyond the linearity test to determine fundamental and direct factors that cause a poor safety culture and subsequently recordable injuries. This is because the linearity test does not provide a complete picture of the event, rather complements it with thematic analysis guided by Anatomy of Event to explain "Why ASM-related recordable injuries occurred and why both miners and management failed to stop them?" From these perspectives, the research established several key indicators that attribute the lack of mine management commitment to safety to be the primary contributor to poor working conditions, resulting in recordable injuries with serious economic and social implications.

The research concluded that recordable injuries are not just severe because of physical trauma, but also because of their post-injury consequences. The research has demonstrated that the economic and social status of injured miners and their families tend to decline during the post-injury period. The negative role played by the mine management and lack of government support significantly impact the livelihood and lifestyle of injured persons and their families. Though many of the miners in this occupation are pushed by poverty, injury makes them more vulnerable. Therefore, the recommendations mentioned in Section 7.4 are critical for preventing injuries and for post-injury consequences management.

## 7.4 Recommendations

Compounded by the prevalence of physical and ergonomic hazards, several antecedents increase the risk of injuries in ASM operation. This analysis surveyed the recordable injuries and associated risk factors, as well as economic and social consequences suffered by injured miners and their families in Osiri Gold Mine in Migori County, Kenya. Thus, it bridges the knowledge gap resulting from limited research in investigating injuries in ASM operation. This research has established that the suitable environment factors (job-related factors which contributed to adverse working conditions), agent's factors (physical and ergonomic hazards) and host factors (individual characteristics and behavioural-related factors) interrelate together to facilitate the risk of injury occurrence in ASM operation. This research found it important to raise and spread awareness of these risk factors in ASM operation. In addition, the research identified several factors that contributed to poor safety culture, as well as distressful economic situations, and several psychosocial problems. The findings will be of particular advantage to public health and safety officers and injury prevention researchers to assist them in designing programs that are fit for ASM operations and their complex webs of problems. Projecting from these findings, the research recommends the following initiatives to improve the welfare and wellbeing of the miners and their associates:

- ✓ The researcher recommends occupational health interventions to reduce the occurrence of injuries among the miners. Firstly, the mine owners, government and non-governmental agents should be educated on the complex webs of problems associated with ASM operations. Secondly, mine owners, with assistance from concerning regulatory and public welfare bodies, should provide substantial safety awareness, safety training on hazards and controls. Also, it is equally pertinent to issue relevant personal protective equipment such as helmets, gloves, long sleeve shirts and steel-cap boots to miners to mitigate or prevent the risk of injury to the upper and lower limbs of the body.

- ✓ The mine management and miners must be trained on how to identify and control hazards. Risk assessment tools that are specific to ASM operations must be developed and enforced to protect the miners. For example, job assessment hazards commonly used in developed countries can be adopted by the mine owners and applied in their situations to reduce the frequency of accidents.

- ✓ The mine management must be educated on the worldwide accepted good mining safety standards, as well as local established occupational safety and health standards.

- ✓ The government must attempt to remove the barrier in obtaining permits and encourage proper surveillance and documentation of mining accidents and injuries. This move can prevent miners from engaging in illegal activities that are loosely controlled and lack government assistance. All the local ASM operators should be registered and their tenement given a specific identifier.

- ✓ Miners must be made aware of the risk of working for extended hours. Since the tasks in this activity are labour-intensive, miners should be working a maximum of 8 hours/day with frequent breaks to reduce fatigue and stress.

- ✓ Miners need to be educated on and made aware of the dangers of working under the influence of substances and encouraged to desist from operating equipment or participate in hazardous activities while under the influence. The mine owners should ensure that devices that predict the intoxication levels are available on-site, and frequently used by the employees.

- ✓ In addition, the mine owners must be held accountable for poor working conditions, work-related incidents, accidents, and injuries.

- ✓ If the miners are injured, legal support must be provided to the injured miners to compel their employer to compensate for any damages. This can be made possible through the legalization of all ASM operations and enforcement of local or international regulation. All the mine owners should be pursued to insure themselves in case of a severe or fatal injury occurring at the mine site. These recommendations will reduce the distressful economic situation and negative social health and lifestyle changes suffered by injured miners.

## 7.5 Areas for Further Study

Though this thesis has provided a comprehensive analysis of recordable injuries and associated consequences, it presents a few limitations that need further study.

- ✓ Firstly, the data on injuries was collected through self-reporting, as a result, future research should consider contacting local medical centres or hospitals and systematically available records. This information should be analysed in conjunction with the survey data.

- ✓ Secondly, the mining tasks conducted by the injured and uninjured miners need to be observed separately, followed by qualitative interviews and analysis performed. This will help to understand miners' perception of safety, work practices, and safety culture.

- ✓ A longitudinal study needs to be carried out in Migori County to better understand the economic and social challenges. This will require capturing of related quantitative data, as well as interviews with local officials and mine owners.

- ✓ Although this thesis has identified number of risk factors associated with ASGM-related injuries, further in-depth study is required to better understand how safety culture, organizational and human performances as well as the impact of cognitive and motivational biases in decision-making on mine safety influence the occurrence of injuries and related distresses.

- ✓ In addition, ASM-related studies that investigate the cognitive and motivational biases in decision-making on mine safety should also examine the de-biasing mechanisms.

## 7.6 Research Summary

This thesis has significantly contributed to the understanding of recordable injuries in ASM operation by demonstrating that:

- ✓ The injuries suffered by miners range from minor to major injuries, such as amputation, lacerations, contusions, etc.
- ✓ In the qualitative interview, some of the seriously injured miners reported experiencing unfortunate cases of fatalities during the accidents. Therefore, injuries in ASM operations should not be taken lightly as they can have serious health and life implications.
- ✓ The likelihood of a recordable injury is a result of several factors in addition to the existing physical/ergonomic hazards (agent factors).
- ✓ Some of the predictors of the likelihood of recordable injury also influence the risk of severe injuries.
- ✓ Many miners were injured once, with a few sufferings multiple injuries incidences. There was a strong association between one injury and various risk factors. No single risk factor was found to predict miners experiencing multiple injuries.
- ✓ Recordable injuries have a direct impact on the quality of life and the psycho-social lifestyle of injured miners and their families. Therefore, proper post-injury management strategies

should be devised to protect the welfare of injured miners and their dependents.

- ✓ Interviewed seriously ill and / or injured miners believed that the lack of safety training, awareness and safety equipment increased the risk of recordable injuries.
- ✓ The key cognitive biases identified for occurrence of ASM-related accidents and injuries were overconfidence, omission of important variables and myopic problem representation. While the motivational biases were group thinking, confirmation biases, desirability of options/choice, and undesirability of a negative event or consequence.

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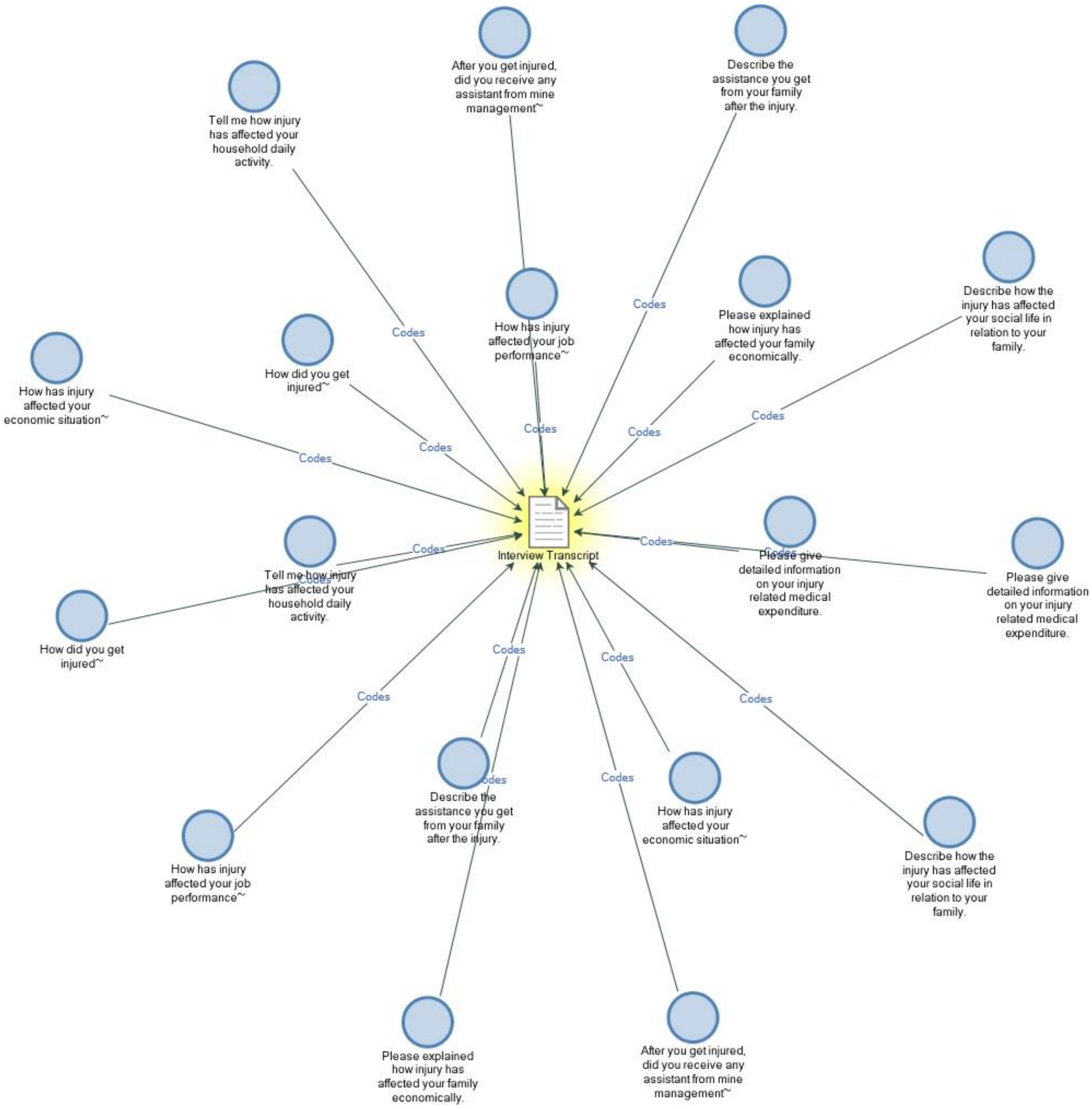
# APPENDICES

## i. Appendix A. Word Cloud

## ii. Appendix B. Research Questions Exploratory Diagram



## **iii.** Appendix C. Authors Statement of Contributions

To Whom It May Concern

I, Michael Mayom Ajith, contributed:

- 75% of the study design and report to the publication entitled *“Comparison of parameters for likelihood and severities of injuries in artisanal and small-scale mining (ASM)”*. Dr. Apurna Ghosh supervised the study and reviewed the manuscript.

- 80% of the study design and report writing to the publication entitled *“Economic and social challenges faced by injured artisanal and small-scale gold miners in Kenya”*. ’. Dr. Apurna Ghosh supervised the study and reviewed the manuscript.

- 65% of the study design and report the publication entitled *“Risk Factors for the Number of Sustained Injuries in Artisanal and Small-Scale Mining Operation”*. Dr. Apurna Ghosh and A/Prof. Janis Janz supervised the study and reviewed the manuscript.

Michael Mayom Ajith Date 19/03/2020

I, as a Co-Author, endorsed that this level of contribution by the candidate indicated is appropriate.

Dr. Apuma Ghosh Date 19/03/2020

A/Prof. Janis Jansz Date 19/3/2020

# iv. Appendix D. Safety Science Permission



**RE: Enquiry: Permission to reproduce publications**

Pringle, Chris (ELS-OXF) <c.pringle@elsevier.com>
Tue 27/08/2019 5:11 PM

**To:** Michael Ajith <michael.ajith@postgrad.curtin.edu.au>
**Cc:** George Boustras <G.Boustras@euc.ac.cy>

Dear Michael,

As the Executive Publisher responsible for Safety Science, I am happy to confirm that you are entitled to do as you request. Our policy on sharing articles is on the Elsevier website here:
https://www.elsevier.com/about/policies/sharing
Specifically, it states:
'Theses and dissertations which contain embedded Published Journal Articles (PJAs) as part of the formal submission can be posted publicly by the awarding institution with DOI links back to the formal publication on ScienceDirect'.

Thank you for publishing your work in Safety Science and for checking with us about this question. Best of luck with your thesis report!

Kind regards,
Chris

Chris Pringle, MILT
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United Kingdom

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-----Original Message-----
From: George Boustras <G.Boustras@euc.ac.cy>
Sent: 26 August 2019 19:56
To: michael.ajith@postgrad.curtin.edu.au
Cc: Pringle, Chris (ELS-OXF) <c.pringle@elsevier.com>
Subject: RE: Enquiry: Permission to reproduce publications

*** External email: use caution ***

## v. Appendix E. Safety and Health at Work Permission

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**Re: Permission to Reproduce Publication (SHAW_390)**

ES

editorial office SHAW <shawedoffice@gmail.com>
Wed 22/01/2020 11:10 AM
Michael Ajith

Dear Michael Ajith,

Eic replied as below on Jan 15, 2020.
Please see below message.

Thanks and regards,
SH@W Editorial Office

==========================================================================================================

Dear Michael Ajith,

Congratulations on successful defending your thesis. Safety and Health at Work only allows a dissertational content to be publish in its journal without restriction of dupication and vise versa. Thus, you can freely use your articles in SHAW to your dissertation. Thank you again for publication of your work at SHAW. We hope to have your continous contribution.

Kind regards,

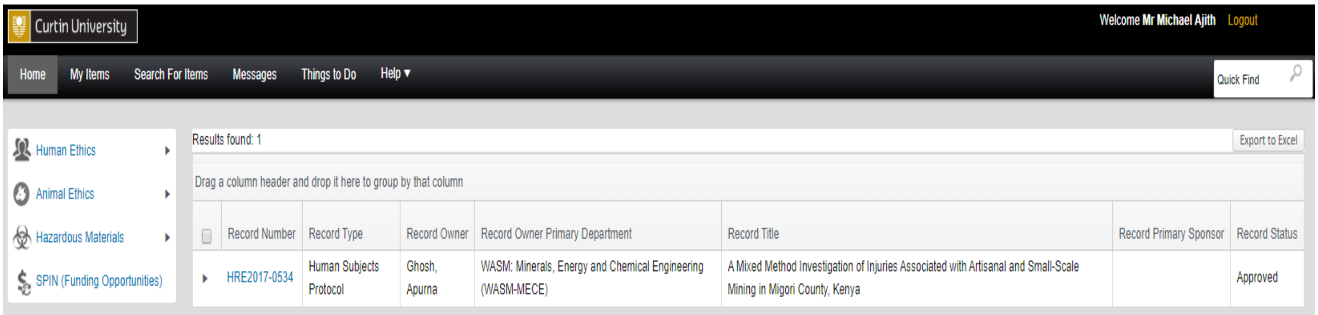
Seong-Kyu Kang

Editor-in-Chief, Safety and Health at Work

2020년 1월 21일 (화) 오후 1:39, Michael Ajith <michael.ajith@postgrad.curtin.edu.au>님이 작성:

> **Dear Editorial Board,**
>
> **I am requesting to include my journal articles entitled** *"Risk Factors for Number of Sustained Injuries in Artisanal and Small-scale Mining Operation"* (Article reference: SHAW390) into my PhD thesis report.
>
> I am doing a PhD through publication, and the paper i published in your journal form an important part of my thesis. Therefore, i will appreciated if you can allow me to include it in my thesis report.
>
> Thank you for your consideration!
>
> Yours sincerely.
>
> Michael Ajith

## vi. Appendix F. Curtin University Human Research Committee Ethics Approval



## vii. Appendix G. Ethics Approval from Strathmore University in Kenya

Strathmore
UNIVERSITY

SU-IRB 0163/18

20th February 2018

**Michael Mayom Ajith**
Western Australian School of Mines
95 Egan St, Kalgoorlie WA 6430

Email: mayom999@yahoo.com

Dear Michael Ajith,

**REF** **Protocol ID:** SU-IRB 0163/18
**A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.**

We acknowledge receipt of your application documents to the Strathmore University Institutional Ethics Review Committee (SU-IERC) which includes:

1. Research Proposal dated 19th February 2018
2. Participant Information and Consent form English and Luo, Version 2 dated 14th February 2018
3. Study Flyer in English and Luo
4. Study Interview Questionnaire English
5. Study Survey Questionnaire English
6. Study budget
7. CV
8. Curtin University Ethics Approval Letter

The committee has reviewed your application, and your study *"A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya."* has been granted **approval**.

This approval is valid for one year beginning **20th February 2018** until **19th February 2019.**

In case the study extends beyond one year, you are required to seek an extension of the Ethics approval prior to its expiry. You are required to submit any proposed changes to this proposal to SU-IERC for review and approval prior to implementation of any change.

SU-IERC should be notified when your study is complete.

Thank you

Sincerely,

ASalim
Amina Salim
**Regulatory Affairs Fellow**

STRATHMORE UNIVERSITY ★ INSTITUTIONAL REVIEW BOARD ★
APPROVED

**viii.** Appendix H. Research Permit

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/18/13815/21845**

Date: **20th March, 2018**

Michael Mayom Ajith
Curtin University
**AUSTRALIA.**

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on ***"A mixed method investigation of injuries associated with artisanal and small-scale mining in Migori County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Migori County** for the period ending **20th March, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Migori 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.

**DR. STEPHEN K. KIBIRU, PhD.**
**FOR: DIRECTOR-GENERAL/CEO**

Copy to:

The County Commissioner
Migori County.

The County Director of Education
Migori County.

# ix. Appendix I. Participants Information Sheet

***A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.***

**PARTICIPANT INFORMATION STATEMENT**

| | |
|---|---|
| **HREC Project Number:** | HRE2017-0534 |
| **Project Title:** | A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya. |
| **Chief Investigator:** | Dr. Apurna Ghosh Lecturer, Department of Mining Engineering and Metallurgical Engineering. |
| **Student researcher:** | Michael Mayom Ajith |
| **Version Number:** | Version 1 |
| **Version Date:** | 12/DEC/2014 |

**Research Background**

Artisanal and small-scale mining (ASM) is causing a lot of health problems to many people who depend on it for survival. For example, In Migori County, over 30 deaths were reported by media between 2013-2016. Limited studies in sub-Saharan African countries such as Ghana, Congo, Tanzania etc., have explored this problem and conceded that ASM accidents and injuries are a rising problem. However, these studies only classified the injuries and their causations without considering potential impact on the individual, families and communities. To fill this knowledge gap, this research sought to investigate the social and economic consequences of the workers due to ASM-related injuries in Migori County, Kenya. The findings will help the mine, community and county leaders to create more awareness and develop some preventable measures.

**Who is doing the Research**?

- This study is being conducted by Michael Mayom Ajith to obtain a Doctor of Philosophy at Curtin University and participation in this study will cost nothing to you.

**Why am I being asked to take part?**

This study is trying to find information about the mining injuries in your mine site and how injury has affected your lifestyle and income.

**Your Eligibility and role**

- You must be over 18 years old and working in mining,
- You must voluntarily give consent.
- You will be needed to complete a self-administered questionnaire which will take less than 40 minutes.
- If identify with serious injuries, you will be invited for interviewed which will take less than 1 hour.
- Your socio-demographic characteristics, work related factors and job stress will capture using questionnaires. While social and economic impact of injuries will be capture during interview.
- The researcher will be available to assist in completing questionnaire and will collect them once finish.

**Will I provide my personal information?**

- No, only participants that have been identified to have serious injuries and voluntarily consent to participate in face-to-face interview will be asked to provide telephone numbers. The intent is to organize the interview at your place of convenience. This information will be deleted immediately after you the validated data.

**Are there any benefits' to being in the research project?**

- There will be no benefits to you personally but findings will help the mine, community and county leaders to create more awareness and develop some accidents and injuries preventable measures.

**Are there any risks, side-effects, discomforts or inconveniences from being in the research project?**

- The primary foreseeable risks in this study include; potential loss of job through dismissal and harassment (economic vulnerability), intense emotional distress, potential of self-harm due to recollection of traumatic events and inconvenience.
- We have obtained letters from your management, workers representatives and "Rieko Kenya" which guaranteed that your will not be dismissed or harassed from work.
- If you are experiencing any emotional distress such as feeling of anxiety, senses of guilt, hopelessness and depression we will stop the interview and start at your convenience.
- If you are feeling like harming yourself or someone else during the research, we will organize counselling with Rieko Kenya to help you. If you are feeling like harming yourself or someone else after the research, please contact Rieko Kenya +254 729 864 061 and they will assist you.
- If you feel like you are being socially victimized by management or workmates, please contact Rieko Kenya +254 729 864 061 and they will assist you.

- The survey and interview will be conducted at your convenience.

**<u>Who will have access to my information</u>?**

- The information collected will be anonymous and treated with confidentiality. Only the research team and the Curtin University Ethics Committee will have access to the collected information.
- Electronic data will be password-protected and hard copy data (including video or audio tapes) will be in locked storage.
- The information which will be collected in this study will be kept under secure conditions at Curtin University for 7 years after the research is ended and then it will be destroyed/kept indefinitely.
- You have the right to access, and request correction of your information in accordance with relevant privacy laws.
- The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

**<u>Will you tell me the results of the research?</u>**

- We are not able to send you any results from this research because I did not collect your personal information to be able to contact you.
- The results will be available in publications and websites.

**<u>Do I have to take part in the research project?</u>**

- No, taking part in a research project is voluntary.

**<u>What happens next and who can I contact about the research?</u>**

- If you voluntarily decided to participate, I will ask you to sign the consent form and give you a copy of this information and the consent form for your reference.
- At the start of the questionnaire, there is a checkbox to indicate you have understood the information provided here in the information sheet.
- Please contact Mr. Michael Ajith regarding any further information or questions on this e-mail, Michael.ajith@postgrad.curtin.edu.au.
- Supervisor contact, Dr. Apurna Ghosh, Apurna.Ghosh@curtin.edu.au.

***A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.***

Curtin University Human Research Ethics Committee (HREC) has approved this study (HRE2017-0534). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

If you cannot contact the Curtin University Human Research Ethics Committee (HREC), please contact Rieko Kenya on +254 729 864061 or email info@riekokenya.org to make confidential complaint about the study.

# x. Appendix J. Consent Form



**CONSENT FORM**

| | |
|---|---|
| **HREC Project Number:** | HR2017-0534 |
| **Project Title:** | A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya |
| **Chief Investigator:** | Dr. Apurna Ghosh Lecturer, Department of Mining Engineering and Metallurgical Engineering. |
| **Student researcher:** | Michael Mayom Ajith |
| **Version Number:** | Version 1 |
| **Version Date:** | 24/05/2015 |

- I have read the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) – updated May 2015.
- I understand I will receive a copy of this Information Statement and Consent Form.

| | |
|---|---|
| Participant Name | |
| Participant Signature | |
| Date | |

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

| | |
|---|---|
| Researcher Name | |
| Researcher Signature | |
| Date | |

Curtin University Human Research Ethics Committee (HREC) has approved this study (HR2017-0534). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

## xi. Appendix K. Recruitment Materials

Curtin University

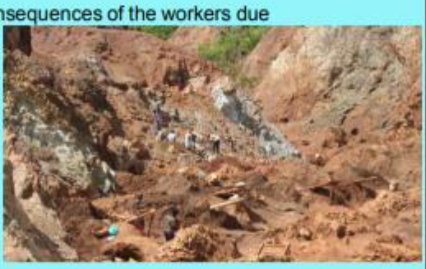
**ANNOUNCEMENT! ANNOUNCEMENT! ANNOUNCEMENT!**
**RESEARCH STUDENT FROM CURTIN UNIVERSITY OF AUSTRALIA IS UNDERTAKING RESEARCH ON ARTISANAL MINERS' INJURIES IN YOUR MINE SITE**

**Research Title:** A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.

Artisanal and small-scale mining (ASM) related injuries refers to physical injuries which resulted from ASM activities.

**Aim of Research**

The aim of this study is to investigate the socio-economic consequences of the workers due to ASM-related injuries.



- Do you engage in mining activity?
- Are you over 18 years? Yes/No

If yes, we would like to survey and interview you. Your role is to provide information on the injuries and socio-economic consequences. We will issue questionnaires to you and conduct interview based on the questionnaire items.

**Consent to Participate**

Participation in this study is voluntary and we will ask you to sign consent form to confirm your voluntary participation.

**Contact details for this research**

Michael Ajith, the researcher, can be contacted over **phone number +61470211658** or by email: **Michael.ajith@postgrad.curtin.edu.au** to provide you with access to the documents (detail Participant Information Sheet, Consent Form, and Questionnaires). Any clarification regarding the privacy of information or further information related to this research can be obtained from Michael Ajith.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HRxxx_2017). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

If you cannot contact the Curtin University Human Research Ethics Committee (HREC), please contact Rieko Kenya on +254 729 864061 or email info@riekokenya.org to make confidential complaint about the study.

*Please feel free to send an Email to Michael Ajith/or call him!!!*

## xii. Appendix L. Structured Questionnaire

**Survey Questionnaire for Quantitative Study**

**A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.**

**Introduction**

The objective of this research is to enhance comprehensive understanding of the artisanal and small-scale mining (ASM) affiliated recordable injuries, as well as corresponding socioeconomic consequences run down on workers in Osiri mine of Migori county, Kenya so that government and local community can device preventable mechanisms and create awareness.

As a participant, your personal information such as sociodemographic characteristics, alcohol and drug usage, injury history as well as related contributing risk factors will be captured using this instrument. To participate in this research, you must meet all the following criteria. Please verify if you will be able to put a tick (√) or cross (X) mark in all the boxes to meet the inclusion criteria.

- □ You must be a artisanal and small-scale miner
- □ You must willingly give written consent.
- □ You must be 18 years and above.

Questionnaire ID NO --------------------------------

Telephone number -----------------------------------

Date of Survey --------/-----/-------------

**Section I: Sociodemographic Characteristics**

This section consists of questions about your sociodemographic characteristics. Please read all the questions and answer them accordingly. Please place x or √ to mark one answer for each question.

1. How old are you (years)?
   - 18-24 ( 1 )
   - 25-34 ( 2 )
   - 35-44 ( 3 )
   - 45-54 ( 4 )
   - 55 and above ( 5 )
2. What is your gender?
   - Male ( 1 )
   - Female ( 2 )
3. What is your marital status?
   - Married ( 1 )
   - Single ( 2 )
4. What is your education level?
   - Never gone to school ( 1 )
   - Primary school (1-8) ( 2 )
   - High school (9-12) ( 3 )
   - Tertiary Education ( 4 )
5. How many years of mining experience do you have?
   - Less than six months ( 1 )
   - 6 months – 1 year ( 2 )
   - 1-3 years ( 3 )
   - 3-5 years ( 4 )
   - Over 5 years ( 5 )
6. How many hours per shift do you work at this mine site?
   - Less than 8hrs per shift ( 1 )
   - 10hrs per shift ( 2 )
   - 12hrs per shift ( 3 )
   - More than 12hrs per shift ( 4 )

**Section II: Alcohol and Drug Consumption**

This section consists of questions about alcohol and drug consumption measures and associated consequences. Please read all the questions and answer them accordingly. Question 8-14 are about alcohol consumption measures and consequences, while question 15-21 are drug usage measures and consequences. Please place x or √ to mark one answer for each question.

7. Have you ever tried to consume drinks containing alcohol such as beer, wine etc.?
    - Yes ( 1 )
    - No ( 2 ) [Skip Qs 8-13]
8. How often do you come to work just after consuming alcohol such as beer, wine etc.?
    - Never ( 1 )
    - Monthly ( 2 )
    - Weekly ( 3 )
    - Daily ( 4 )
9. How often do you come to work with hangover from previous drinking of alcohol such as beer, wine etc.?
    - Never ( 1 )
    - Monthly ( 2 )
    - Weekly ( 3 )
    - Daily ( 4 )
10. How often do you consume alcohol such as beer, wine etc., while working?
    - Never ( 1 )
    - Monthly ( 2 )
    - Weekly ( 3 )
    - Daily ( 4 )
11. Have you ever faced any near miss incident as a result of consuming alcohol?
    - Never ( 1 )
    - Yes, but not in this years ( 2 )
    - Yes, during the last few years ( 3 )
12. Have you ever faced work-related accident as a result of consuming alcohol?
    - Never ( 1 )
    - Yes, but not in this years ( 2 )
    - Yes, during the last few years ( 3 )
13. Have you or someone else ever been injured at work as a result of consuming alcohol?
    - Never ( 1 )
    - Yes, but not in this years ( 2 )
    - Yes, during the last few years ( 3 )
14. Have you ever in your life taken marijuana or opium?
    - No ( 1 ) [Skip Qs 15-20]
    - Yes ( 2 )
15. How often do you come to work just after taking marijuana or opium?
    - Never ( 1 )
    - Monthly ( 2 )
    - Weekly ( 3 )
    - Daily ( 4 )

16. How often do you come to work with hangover from previous smoking of marijuana or opium?
    - ❖ Never ( 1 )
    - ❖ Monthly ( 2 )
    - ❖ Weekly ( 3 )
    - ❖ Daily ( 4 )
17. How often do you smoke marijuana or opium while working?
    - ❖ Never ( 1 )
    - ❖ Monthly ( 2 )
    - ❖ Weekly ( 3 )
    - ❖ Daily ( 4 )
18. Have you ever faced near miss incident as a result of smoking marijuana or opium?
    - ❖ Never ( 1 )
    - ❖ Yes, but not in this years ( 2 )
    - ❖ Yes, during the last few years ( 3 )
19. Have you ever faced work-related accident as a result of smoking marijuana or opium?
    - ❖ Never ( 1 )
    - ❖ Yes, but not in this years ( 2 )
    - ❖ Yes, during the last few years ( 3 )
20. Have you or someone else ever been injured at work because you were intoxicated from marijuana or opium?
    - ❖ No ( 1 )
    - ❖ Yes, but not this years ( 2 )
    - ❖ Yes, during the last few years ( 3 )

**Section III: ASM Work-related Factors and Job Stress Questions**

This section consists of questions about ASM work conditions, ASM site management, ASM job satisfaction and job stress. Please read all the questions and answer them accordingly. Please place x or √ to mark one answer for each question in the tables.

| Work Conditions | Strongly agree | Agree | Don't know | disagree | Strongly disagree |
|---|---|---|---|---|---|
| 21. I often faced risk of injury because of doing physical demanding tasks. | 5 | 4 | 3 | 2 | 1 |
| 22. I often faced risk of injury because I am always working in an awkward or cramped position. | 5 | 4 | 3 | 2 | 1 |
| 23. I often faced risk of injury because my tasks are always quiet repetition. | 5 | 4 | 3 | 2 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 24. Constant bending/twisting exposed me to injuries. | 5 | 4 | 3 | 2 | 1 |
| 25. Lack of hazards identifications mechanism and control measures in this mine site exposed me to injuries. | 5 | 4 | 3 | 2 | 1 |
| 26. Lack of personal protective equipment (PPE) exposed me to hazards and associated injuries. | 5 | 4 | 3 | 2 | 1 |
| 27. Lack of health and safety training put me at high risk of accidents and injuries. | 5 | 4 | 3 | 2 | 1 |
| | | | | | |
| Management and Supervision | Strongly agree | Agree | Don't know | disagree | Strongly disagree |
| 28. I am not treated with honesty and dignity in this workplace. | 5 | 4 | 3 | 2 | 1 |
| 29. The management does not consider suggestions from me or other workers. | 5 | 4 | 3 | 2 | 1 |
| 30. The interest of the workers is not protected at this workplace | 5 | 4 | 3 | 2 | 1 |
| 31. There is no recognition of good performance at this workplace | 5 | 4 | 3 | 2 | 1 |
| 32. My superiors only care about their own interest, not for their workers. | 5 | 4 | 3 | 2 | 1 |
| 33. There is no flexibility of the break here at this workplace. | 5 | 4 | 3 | 2 | 1 |
| | | | | | |
| Job Satisfaction | Strongly agree | Agree | Don't know | disagree | Strongly disagree |
| 34. My working relationship with superior is good. | 5 | 4 | 3 | 2 | 1 |
| 35. I feel good about my working conditions. | 5 | 4 | 3 | 2 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 36. I receive recognition for my job. | 5 | 4 | 3 | 2 | 1 |
| 37. I feel closed to my workmates. | 5 | 4 | 3 | 2 | 1 |
| 38. I feel secured about my job. | 5 | 4 | 3 | 2 | 1 |
| 39. Overall, this job is good for my physical health. | 5 | 4 | 3 | 2 | 1 |
| 40. I am satisfied with the earnings from my job. | 5 | 4 | 3 | 2 | 1 |
| | | | | | |
| Job Stress | Strongly agree | Agree | Don't know | disagree | Strongly disagree |
| 41. I feel nervous because of my job. | 5 | 4 | 3 | 2 | 1 |
| 42. My job drives me right up the wall a lot of time. | 5 | 4 | 3 | 2 | 1 |
| 43. Working here leaves me little time for other activities. | 5 | 4 | 3 | 2 | 1 |
| 44. I frequently get the feeling that I am married to the job. | 5 | 4 | 3 | 2 | 1 |
| 45. I have too much work and too little time to do my job. | 5 | 4 | 3 | 2 | 1 |
| 46. I am not happy with working situation of the mine. | 5 | 4 | 3 | 2 | 1 |

**Section IV: Injury History**

This section consists of questions about your injuries history, frequency and severity of injuries and associated causations. In questions 47-52, please mark only one answer for each question. In question 53-54, please indicate the number of times each injured type occur in each part of your body (anatomical areas) and how many times each injury causation mechanisms have caused each injury type.

47. How many times have you experienced work-related injuries that have resulted in you seeking medical attention or lost time from work?
    - ❖ Never ( 1 ) [Stop completing Qs 48-53]
    - ❖ Once ( 2 )
    - ❖ Twice ( 3 )

- ❖ Thrice ( 4 )
- ❖ Four times ( 5 )
- ❖ Five times ( 6 )
- ❖ Six times ( 7 )
- ❖ Seven times ( 8 )
- ❖ Eight times ( 9 )
- ❖ Nine times and over ( 10 )

48. On average, how many times off work did you have because of injury?
    - ❖ A day ( 1 )
    - ❖ Less than a week ( 2 )
    - ❖ Between 1 week and 2 weeks ( 3 )
    - ❖ Between 2 week and 1 month ( 4 )
    - ❖ More than 1 month ( 5 )
49. Does your injury restrict you from performing your daily activity (at work, home, hobbies etc.)?
    - ❖ Not at all ( 1 )
    - ❖ Sometime ( 2 )
    - ❖ Always ( 3 )
50. Apart from visible physical injury, do you experienced any other pain that affect your body's movement?
    - ❖ Yes ( 1 )
    - ❖ No ( 2 )
51. Did you see any doctor or any medical practitioner because of this pain?
    - ❖ Yes ( 1 )
    - ❖ No ( 2 )
52. Does this pain restrict you from performing your daily activity (at work, home, hobbies etc.)?
    - ❖ Not at all ( 1 )
    - ❖ Sometime ( 2 )
    - ❖ Always ( 3 )

53. The table below showed the frequencies of injuries with relation to the part of your body (anatomical areas). Please indicate in the box how many times did each mentioned injury type happened with relation to part of your body.

| Anatomical Areas | Injury Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Contusion | Laceration | Puncture wounds | Fractures | Musculoskeletal Disorders | Dislocation | Amputation | Facial injury | Burns |
| Head | | | | | | | | | |
| Facial | | | | | | | | | |
| Neck | | | | | | | | | |
| Shoulders | | | | | | | | | |
| Back | | | | | | | | | |
| Arms/Elbows | | | | | | | | | |
| Hands/wrists | | | | | | | | | |
| Thumbs | | | | | | | | | |
| Hips | | | | | | | | | |
| Legs | | | | | | | | | |
| Feet /Ankles | | | | | | | | | |

54. The table below showed the frequencies of injuries type with relation to the causes of injuries. Please enter in the box how many times did each injury type happened with relation to causes of injuries.

| Type of Injuries | Cause of injuries | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Equipment | Struck by object | Slip/trip fall | Explosions | Entrapment | Heavy loads/Repetitive tasks | Working in awkward position | Chemicals |
| Contusion | | | | | | | | |
| Laceration/cut | | | | | | | | |
| Facial injury | | | | | | | | |
| Puncture wounds | | | | | | | | |
| Fractures | | | | | | | | |
| Burns | | | | | | | | |
| Amputation | | | | | | | | |
| Dislocation | | | | | | | | |
| Musculoskeletal Disorders | | | | | | | | |

## Thank you!

**Please could you handover the survey to researcher only**

# xiii. Appendix M. Semi-structured Questionnaire

Semi-structured Qualitative Interview Questionnaire

**A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya.**

**Introduction**

The objective of this research is to enhance comprehensive understanding of the artisanal and small-scale mining (ASM) affiliated recordable injuries, as well as corresponding socioeconomic consequences run down on workers in Osiri mine site of Migori county, Kenya so that government and local community can device preventable mechanisms and create awareness.

As a participant, you will be required to provide information pertaining socio-economic challenges which resulted from recordable injuries. To participate in this research, you must meet all the following criteria. Please verify if you will be able to put a tick (√) or cross (X) mark in all the boxes to meet the inclusion criteria.

- ☐ The participant must have completed Phase I survey
- ☐ Must have recordable injuries
- ☐ Must provide consent form to be interviewed

Questionnaire ID No. --------------------------------

Date of Survey --------/-----/-------------

Semi-structured Qualitative Interview Questionnaire

The following questions are about the socio-economic challenges you are facing post injury.

1. Has injury affected your economic situation?

2. How has injury affected your job performance?

3. Please explained how injury has affected your family economically.

4. Please give detailed information on your injury related medical expenditure.

**5.** After you get injured, did you received any assistant from mine management?

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**6.** Describe the assistance you get from your family after the injury.

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**7.** Describe how the injury has affected your social life in relation to your family, community, co-workers, friends and employer.

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**8.** Tell me how injury has affect your household daily activity.

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# Thanks for your participation!