A Mixed-Method Investigations of Work, Government and Social Factors Associated with Severe Injuries in Artisanal and Small-scale Mining (ASM) Operations

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Abstract

The susceptibility of miners to severe injuries in Artisanal and Small-scale Mining (ASM) operations is significantly higher than in the larger-scale mining industry. However, the most prevalent and least studied safety aspects are the factors affecting the severe injuries and miners' awareness of the state of their health and safety. Severe injuries are ASM-related injuries that have resulted in more than two weeks lost workdays. This paper aims to demonstrate that severe injuries in ASM industry do not occur simply due to individual

personality but also because of other underlying factors like ignorance of illegality of the activity. The paper also reports on the injured miners' perception of the nature of health and safety. Two hundred and thirty-six miners from Migori County of Western Kenya ASM site were administered closed-ended structured survey questionnaires, followed by face-to-face qualitative interview of thirty-three severely injured mineworkers identified from the quantitative survey respondents. The survey results were analysed using logistic regression. While the interview results were subjected to thematic analysis, the identified themes confirmed or complemented quantitative findings as well as demonstrated the state of occupational health and safety (OHS) in ASM industry. The results showed that alcohol and drug usage, inadequate earnings, safety training, lack of hazard identification and risk control measures, lack of safety equipment, poor management-miners interaction, poor communication of safety concerns, and government support were indicators of poor safety culture influenced the recurrence of severe injuries. Research outcomes will support decision-making processes and implementation of programs in this industry.

Keywords: Artisanal and Small-scale Mining (ASM); severe injuries; risk factors; mixed method; logistic regression; deductive thematic analysis

1. Introduction

Artisanal and Small-scale Mining (ASM) continues to play a critical role in global metallic and non-metallic mineral deposits extraction. 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 (Ajith, 2020). 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 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, render the problematic estimation of the maximum extent of ASM socio-economic status (SES) (Hentschel, 2003).

Notwithstanding the fact that ASM has been practiced for several decades and its importance acknowledged internationally, the definition tends to vary from country to country – there is no universally accepted description. Individual countries that have enacted mineral and mining laws related to ASM have used size and extent of the mine site, capital, the number of workers, amount and/or value of minerals extracted, and technology (Hentschel, 2003). In this study, ASM is described as a type of mining method undertaken by an individual, a family, a community, or a small-scale cooperative in rural areas with crude or low-tech equipment to mine and process metals and minerals (Ajith and Ghosh, 2019a).

The latest report from the World Bank and International Finance Corporation (W.B.I.F.C) (2019) revealed that about 40 million people are employed in the ASM sector, thereby indicating a significant rise from the statistics hitherto informed by international labour office (ILO) of 11-13 million in 1999 (ILO, 1999). In addition, these reports also cited evidence of the operation's secondary or indirect sustenance benefits for millions of beneficiaries. The remarkable growth of ASM operation worldwide has been attributed to high levels of poverty and the ability to earn quick money (Franks, Ngonze, Pakoun, & Hailu, 2020; Hilson, Hilson, & Maconachie, 2018; Kumah, Hilson, & Quaicoe, 2020).

1.1 ASM-related injuries

Despite the incredible expansion in last few decades, the occupational health and safety (OHS) level of ASM industry has not improved, particularly in low and middle-income mineral-rich

countries. As early as 1999, an ILO report revealed that the likelihood of accidents is six to seven times more common in ASM industry compared to large-scale mining operation. Bansah et al. (2016) and Tsang, Lockhart, Spiegel and Yassi (2021) established that poor health and safety in ASM sectors results from lack of knowledge, awareness, expertise, government, and non-governmental supports, mine sites location – rural villages, illegality of most sites, and lack of regulations in some countries.

While the present of chemical, biological and psychosocial health risks have been documented among the ASM miners and bordering communities, the most direct imperilment of ASM operation is the risk of occupational injuries faced by mineworkers themselves (Ajith, Ghosh, & Jansz, 2020; Bansah, Yalley, & Dumakor-Dupey, 2016). Several ASM activities have a widespread presence of uncontrolled physical and ergonomic hazards, which often causes a prevalence of injuries (Smith, Bofinger & Collins, 2016). Recent studies that investigated ASM-related injuries in some countries found miners suffered different type physical injuries (Ajith & Ghosh, 2019a; Ajith, Ghosh, & Jansz, 2020; Calys-Tagoe, Ovadje, Clarke, Basu, & Robins, 2015; Kyeremateng-Amoah & Clarke, 2015; Long, Sun, & Neitzel, 2015).

The nature of physical injuries suffered by the ASM miners vary in degree of severity. The number of lost workdays has been used to determine whether the miners with injuries have experienced mild, moderate, or severe injuries (Calys-Tagoe et al., 2015). In this study, we defined mild injuries as those injuries that have resulted in less than one week lost workdays. While moderate injuries are those that have led miners to stay off work for more than one week but less than two weeks. Severe injuries are injuries that have resulted in more than 2 weeks of lost workdays. The ASM activities are predominately the sole source of living for most miners, particularly in Kenya – mineworkers are paid on daily wages and have no insurance cover and

enough support from the government (Ajith and Ghosh, 2019b). As a result, staying off work for more than two weeks has a severe impact on their SES and that of dependencies.

1.2 *ASM safety challenges and underlying parameters*

The underlying factors that influence the level of OHS in ASM, and subsequent different type of injuries are loosely understood. Occupational health and safety in ASM is a complex system due to its three components of human, technical and organisational (Domingues, Baptista, & Diogo, 2017). The complex interaction of human characteristics, technical and organization factors are causing safety challenges (Ajith & Ghosh, 2019b). Human characteristics mediate the risk of ASM-related injuries as well as contributed to the hazardousness of the sector (Ajith & Ghosh, 2019a; Ajith et al., 2020; Calys-Tagoe et al., 2015; Elenge, Leveque, et al., 2013; Long et al., 2015). However, identifying such factors alone do not address the continuous perilous state of the ASM working environment and its associated injuries and illnesses. Other socio-technical factors such as safety awareness and training, substances abuse, lack of social support, non-existence of job security, low earning, absence of personal protective equipment (PPE) and type of operating equipment which have been under-researched should be the focus of scholars and concerned government bodies. Therefore, it was imperative to statistically determine the role of these factors on recurrence of ASM-related severe injuries as well as thematically explore other social factors associated with poor OHS from qualitative interview results.

1.2.1 Safety awareness and training

Safety awareness and training are important factors for ascertaining the level of safety maturity of the organization and that of the workers. A safe workplace equips its workers to identify hazards and control them without compromising their own safety and that of co-workers. Well trained workers have more ability to be aware of hazard risks and may avoid being involved in

accidents and injuries in high-risk work environments, whilst untrained workers may be injured in the safest possible environment (Maiti, Chatterjee, & Bangdiwala, 2004). Although lack of safety awareness and training is documented in ASM-related literature, little information was gathered from the participants' firsthand accounts. Many of the researchers based their conclusions on the observatory data, without being subjected to direct miners' perceptions (Elenge & De Brouwer, 2011; Smith et al., 2016). This paper quantitatively and qualitatively presents miners' perceptions on the health and safety awareness and training.

1.2.2 Alcohol and drug usage

According to WHO (2020), 3.3 million people die each year because of the harmful use of alcohol, and "at least 15.3 million persons have drug use disorders". The report also revealed that illicit substances are widely used in the African Region. Culturally, traditional brews and many other alcoholic drinks as well as illicit drugs (i.e., cannabis) form part of the social-cultural norm, especially among the adult (Myadze, & Rwomire, 2020; Nwagu, Dibia, & Odo, 2017; Odejide, 2006). The use of illicit and drugs regularly over a sustained period can result in independence which is exemplified by a loss of control over the use and heightened prominence of use of the substance in an individual's life (Degenhardt et al., 2020). In ASM operations which are commonly located in rural areas, miners used substances such as Indian hemp, heroin, marijuana, paracetamol, traditional brew, and other alcoholic drinks to raise the level of physical activity or to treat bodily pains (Oramah, Richards, Summers, Garvin, & McGee, 2015).

Alcohol and drug use can have adverse effects on the health and social aspects of miners (Westermeyer, 2020). However, the lack of safety awareness and training contributes to the abuse of drugs and alcohol in ASM operations (Smith et al., 2016). Despite the prevalent, little

information has been captured so far to relate it with the sector's OHS issues as well as pervasiveness of health-related problems, notably ASM-related injuries.

Drugs and alcohol-intoxicated increases the risk of workplace injuries. This is because substance use causes cognitive impairment, slow reactive times, affect decision-making and consequentially this can cause occupational injury (Leistikow, Martin, Jacobs, & Rocke, 1998; Kendrick et al., 2012; Kumar, 2011). Therefore, it is equally important to understand whether miners come to work intoxicated, consumed substances before or during work. This information will provide the policymakers with information to design guided policies as well as enforce the absence of drug and alcohol usage in this risky working environment.

1.2.3 Lack of Social support

The artisanal and small-scale mining working environment is considered hostile due to the lack of government surveillance and protection policies (Bansah, 2019). Miners in ASM operation are known to be faced with bullying from their co-workers and miner owners. For example, it was found that workers who borrowed money from their employers or middlemen, often up in an abusive working relationship, particularly if the workers do not refund the money as soon as possible (Hilson, 2012). Also, children and women tend not to get a lot of support from their employers. As a result, they are exposed to exploitation (Hentschel, 2003). However, studies in ASM operation failed to link these factors to reoccurrence of severe injuries or qualitatively determine from the seriously injured participants experience whether there is lack of social support. Increasing evidence from underground mines or large-scale mining operations suggested a positive relationship between poor management-worker interaction and work-related injuries (Bhattacherjee, 2014; Bhattacherjee, Kunar, Baumann, & Chau, 2013; Maiti, Snehamoy Chatterjee, & Bangdiwala, 2004; Paul, Maiti, Dasgupta, & Forjuoh, 2005; Paul & Maiti, 2008).

1.2.4 Lack of Job security

The majority of the ASM operators participate in the activity on a seasonal basis, and for those involved permanently, they are employed on a causal basis (Verbrugge, 2016). In addition, the sector has no structured paying mechanism, and most miners are paid based on the amount of ore the mined in a day (Hilson et al., 2018). As a result, there is no job security for almost all the ASM operators (Hentschel, 2003). Studies that have investigated the relationship between temporary work and occurrence of workplace injuries have provided inconsistent evidence. A review conducted in 2005 revealed that 7 out of 13 studies found a direct relationship between precarious workers and risk of occupational injuries; while the rest of the studies failed to detect significant differences between the precarious and non-precarious worker (Virtanen et al., 2005). In the mining industry, there is limited information on the contributing effects of job security on mining-related injuries. Therefore, it was imperative to evaluate this factor against the recurrence of severe injuries in ASM sector.

1.2.5 Inadequate earnings (wages)

The association between earnings from working in the ASM industry and occurrence of injuries has never been examined, though earnings have been linked with job satisfaction or dissatisfaction in underground mines or large-scale mining operations (Paul & Maiti, 2007; Ghosh, Bhattacherjee & Chau, 2004). Therefore, there is a need to establish the relationship with ASM-related injuries. Miners in ASM operations are largely poverty-driven and their pay is substandard (Hilson, 2012). As a result, some miners work at the mine but also do non-mining activities to add to their income (Gilbert, 2017). Published literature on the ASM industry has not attempted to examine the contributing factor of miners' earnings to work related injuries occurrence despite the riskiness of the occupation.

1.2.6 Personal protective equipment (PPE) and technical issues

The use of appropriate operating equipment and technical know-how as well as provision and use of PPE at the workplace is a responsible of the employing organization. However, in ASM operations, miners lack technical skills, used low-tech equipment and most of the miners do not wear safety equipment (Boniface, Museru, Munthali, & Lett, 2013; Calys-Tagoe, Ovadje, Clarke, Basu, & Robins, 2015; Long, Sun, & Neitzel, 2015). The technical challenges, rudimental equipment, and lack of PPE in this industry has been recognized as increasing the risk of injuries and other health-related problems (Elenge & De Brouwer, 2011). Nevertheless, the statistical examination of the relationship has never been undertaken, neither have researchers obtained information from qualitative interviews. Thus, it is necessary to evaluate the contributing effects of using, or not using, safety equipment on the occurrence of work-related injuries in ASM operations.

Although much is known about poor health and safety standards of ASM operations, considerably less is known about the fundamental factors beyond the role of individual characteristics on the risk of injuries, prevalence of hazards, low productivity, lack of investment/capital, illegality and rural setting of the activity (Ajith, Ghosh and Jansz, 2020; Ajith and Ghosh, 2019a; Ajith and Ghosh, 2019b). The past and present studies that have established poor health and safety standards were based on observatory data and survey of the practitioners and government officials, but not firsthand account from the miners and their leaders (Smith et al., 2016 & Bansah et al., 2016). Therefore, the aim of this research was to determine which factors are responsible for severe injuries as well as poor OHS in ASM operations. Specifically, the research investigated the factors that continue to increase the risk of severe injuries in ASM site of Migori County. The results of this study can be used to informed decision-making processes that will subsequently reduce the recurring of ASM-

related injuries. Overall, the study results will enhance understanding of OHS in ASM operations.

2. Materials and methods

2.1 Ethics Approvals

This study was approved by the Curtin University Human Research Ethics Committee (HRE2017- 0534), Strathmore University Institutional Review Board (SU-IRB 0163/18) and Government of Kenya.

The present research has been conducted using a concurrent embedded mixed methods design. The mixed methods typology allows nesting of both quantitative and qualitative research as well as simultaneous collection of the datasets as shown in figure 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 & Zhang, 2009). In this research, the qualitative approach has been embedded in the primary approach (i.e., the quantitative). The main purpose of this design was to apply the quantitative method to statistically investigate concomitant contributing risk factors of severe injuries beyond personal characteristics. The next step was to identify severely injured miners and conduct qualitative face-to-face interviews to better understand the other social cultural factors and technological deficiencies that influence the nature of poor health and safety in ASM operation. The rationale for using a concurrent embedded strategy in this study, which was identified by Greene, Caracelli and Graham (1989) as a form of 'development', implies that samples from one phase represent the sample frame for another phase of the study as shown below.

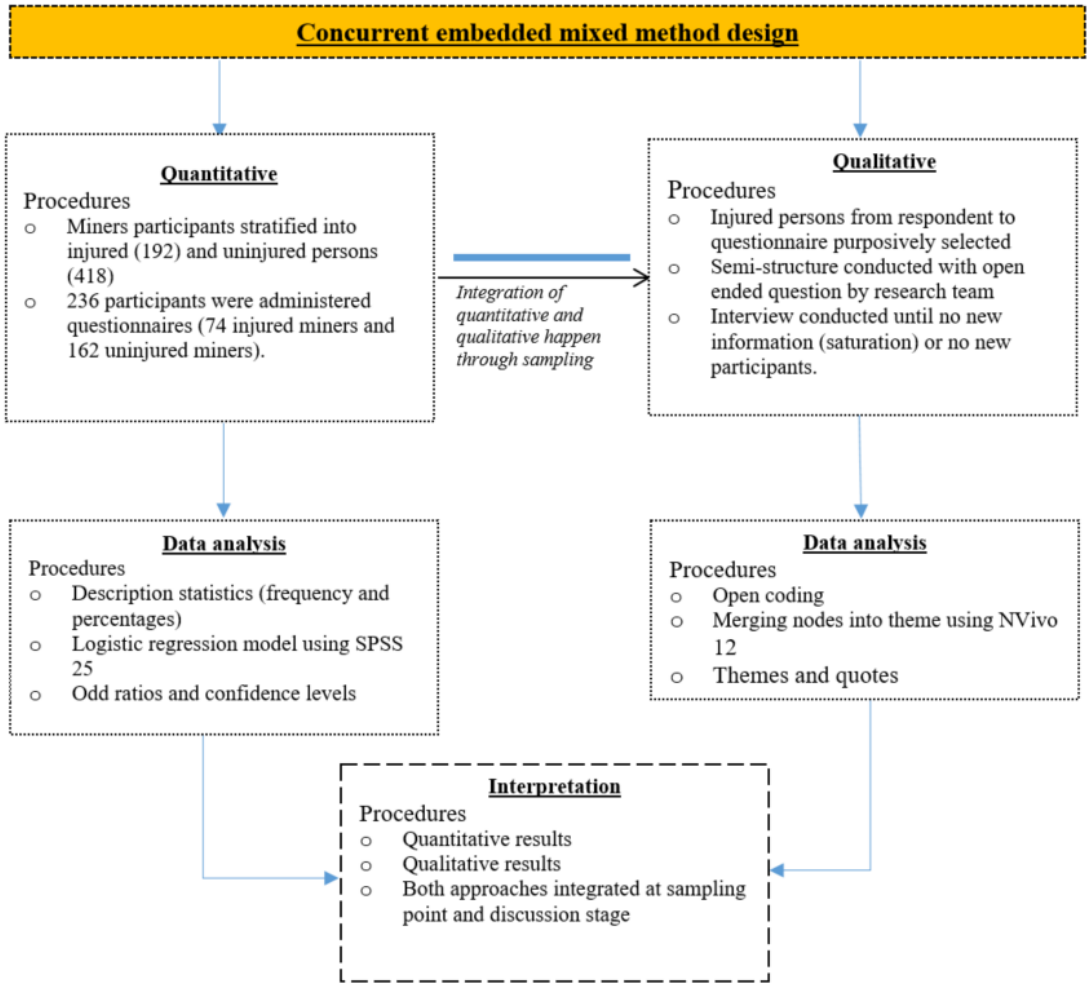

Figure 1. Visual representation of concurrent embedded mixed method approach

2.2 Quantitative phase

This mixed method study was carried out in Osiri artisanal and small-scale gold mining (ASGM) operations in Migori County, situated in western Kenya, neighbouring Lake Victoria to the west and the Republic of Tanzania to the south (Ajith & Ghosh, 2019a). For the quantitative phase, 236 legal miners, of which 74 were cases and 162 controls, were recruited. The cases were miners with injuries while the controls were miners with no injuries. Included in the survey were miners that were above 18 years old and freely consented to participate but excluded were supervisors, management and local government officials.

The sample size was determined using Kothari's (1990) formula, whereby we first find out the population based on Z values, sample proportion and confidence level.

$$\text{Sample size} = \frac{Z^2 * (p) * q}{e^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; [1]$$

- 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.

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

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

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. The population was stratified into injured and uninjured stratum with 192 and 418 miners, respectively. The samples within each group was calculated as follows:

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

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:

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

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

For the quantitative phase, the data collection commenced with consulting and obtaining permission to conduct the survey. Several meetings were held as a part of sensitization, familiarization, and invitation for participations. In these meetings, the research team registered all the eligible participants and issued them with pseudonym names. We used pseudonym names to protect participants and their personal information. Following the registration, a meeting was held on site with the miners and convenience date, time and venues were agreed for the research work.

During the data collection, the participants were allocated into one of two groups. One group was composed of injured miners and the other group was made up of uninjured miners. The researcher selected the miners to complete the multi-item structured closed-ended questionnaire by firstly identifying a starting random number in each group, and then systematically selected the rest until we achieved 74 injured and 162 uninjured miners. The participants were given the option to complete the questions by themselves or be assisted by the research team. If assisted, the researcher read out the questions and answers, then wrote down the participant responses without directing them. The survey was conducted in one sitting and each questionnaire took less than 1 hours to be completed, and was either administered in English, Kiswahili or Luo native language.

2.3 Qualitative phase

During the interview phase, 33 severely injured miners out of 74 surveyed injured participants were purposively selected. This target was achieved through saturation. The selected injured participants were interviewed until no new themes or ideas emerged from further recruitments. Only severely injured miners who responded to the survey were recruited. This was intended

to understand the circumstance within which such injuries occurred as well as these miners' opinions on the working conditions and if there was good management/supervision.

Severely injured Participants identified were contacted using the telephone number provided in the questionnaire and asked whether they consented to face-to-face interview participation. The date, time and venue were agreed with those that gave their consent. During the interview, the research questions were readout, and participants were given time to respond without directing their responses. The interview was conducted using the notepad, whereby the researchers wrote down verbatim responses of the participants. These verbatim responses were then read out to the participants to ascertain their accuracy and validity prior to moving to the next question. In spite of the time-consuming feature of notetaking, the process also entailed numerous intrinsic advantages as likened to audio recordings. As well as providing a safeguard mechanism for equipment failure, the note-taking process also permitted instantaneous authentication of the captured data (Ranney et al., 2015). Each interview took less than 60 minutes and was conducted in Kiswahili.

2.4 Data analysis

2.4.1 Statistical analysis

First, some of the questionnaires completed in Kiswahili and Luo language were translated back into English for consistency. The survey data was then coded and subjected to descriptive analysis using SPSS version 25. The participants respond to ASM-related injuries was coded as "No = 0" and "Yes = 1". Miners with mild injuries were combined with those with no injuries and coded as a "No severe injury group" as shown in table 3. While those with moderate and severe injuries were coded as "Yes severe injury group".

During the descriptive statistical analysis, we also assessed the significant of socio-technical factors as shown in table 3. This was to check whether the factors were associated with the occurrence of severe injuries. Then, each variable was entered into binary logistic regression model and categories with $p<0.05$ (pre-determined level of significance) noted. This examination of the single variable against the dichotomized severe injuries resulted in crude odd ratios (COR) and confidence level at 95%. All the variables were then entered into the multivariate model using binary logistic regression and adjusted odd ratios (AOR) as well as variables confidence levels that were generated as shown in tables 6. The multivariate model good-for-fitness was determined as shown in table 4.

2.4.2 Thematic analysis

Next, the qualitative interview results were subjected to thematic analysis (as shown in figure 2) using NVivo 12 to determine other key indicators of safety level which were lacking or statistical insignificant (Ajith and Ghosh, 2019b). In this study, the coding process was pre-determined, which is sometime referred to as deductive approach. Pre-determined coding can be based on another researcher's decisions or key concepts derived from a theoretical construct or research questions. In this study, prior questions asked during the semi-structured interview were used in the coding. In addition, Braun and Clarke' (2006) interactive step by step guide was used. The responses to each question were read and reread line by line a number of times in order to fully absorb the data. The words, phrases, sentences, and specific quotes were coded to help identify key emerging themes. The themes that emerged from these responses were reviewed and aligned with overall objectives, after which the full story was developed.

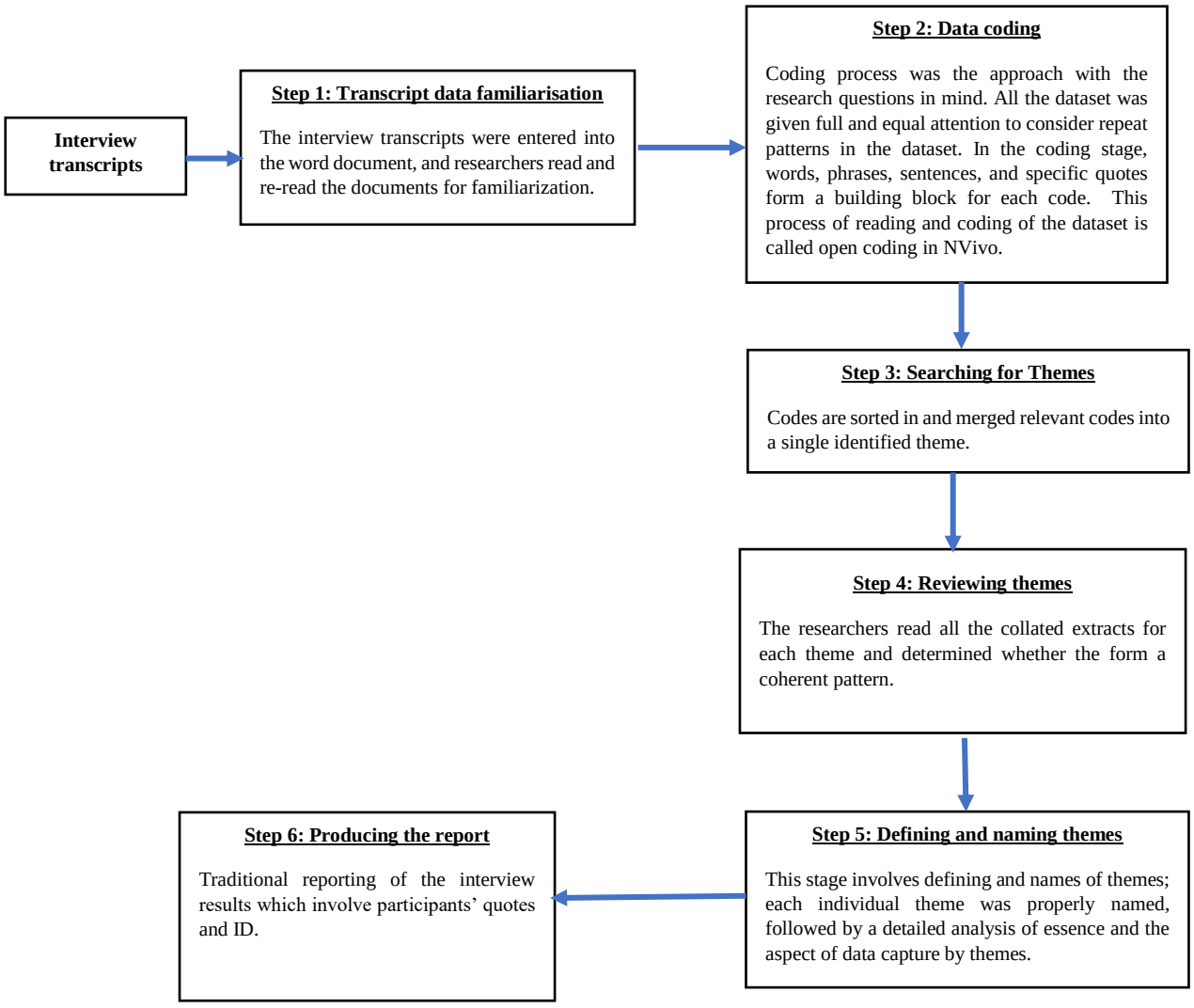

Figure 2. Step by step deductive thematic analysis of qualitative dataset (Braun & Clarke, 2006).

3. Results

The results of the present study are presented under subheadings of statistical and thematic analysis results.

3.2 statistical analysis results

Table 1 summarizes the nature of injuries suffered by the miners and the number of lost workdays. Laceration (28%), contusion (17%), fracture injuries (15%), and musculoskeletal pain (14%) were common occurring injuries in this ASM site. The majority of miners with laceration and contusion injuries took less than 30 days to recover while those with serious

injuries such as fractures, dislocation, amputation, and musculoskeletal pain took more than 30 days.

Table 1: Nature of injuries and number of lost workdays

Nature of injuries	Frequency of injuries sustained	% of distribution	Lost workdays (No. of injured miners versus no. of days off work)				Total no. of injured miners
			1-6 days	7-13 days	14-29	Over 30 days	
Contusion	29	17%	8	4	1		13
Laceration	48	28%	2	6	13		21
Puncture wound	20	12%	4		1	4	9
Fracture	26	15%				11	11
Musculoskeletal Pain	24	14%				10	10
Dislocation	10	6%				4	4
Amputation	9	5%				4	4
Burn	2	1%		1	1		1
Facial	1	1%					1
Total	169	100%	14	11	16	33	74

Table 2 presents classification of injuries based on the severity. Of 236 participants (both uninjured and injured miners), 162 miners had 0 lost workdays and were classified as “no injury”. While injuries that made miners to stay off work for one day to less than one week was considered “mild” (14 miners). The injuries that resulted in more than one week to less than two weeks of lost workdays were classified as “moderate” (11 miners). Finally, injuries that have led to more than 2 weeks were categorized as “severe” (49 miners).

Table 2. Classification of injuries based on the number of days lost

No. of lost workdays	Classification of injuries	No. of miners
0 day	No injury	162
1-6 days	Mild	14
7-13 days	Moderate	11

14 + days	Severe	49

Table 3 presents results of frequency distribution of participants' responses to various factors against the occurrence of severe injuries. The table also shows Pearson Chi-square p values for each of factor against the severe injury. Six of the fourteen factors have direct relationship ($p<0.05$) with the severe injury events.

Table 3. Participants distribution of severe injuries per categories and significance levels (N = 236)

Alcohol drug use and other social cultural factors	Categories	**Severe injury**		Pearson Chi-square p values
		No	Yes	
1. Consuming of alcohol just before work.	Yes	107 (69.9%)	46 (30.1%)	0.026
	No	69 (83.1)	14 (16.9%)	
2. Coming to work with alcohol hangover.	Yes	118 (77.6%)	34 (22.4%)	0.147
	No	58 (69.0%)	26 (31.0%)	
3. Consuming alcohol while working.	Yes	60 (65.9%)	31 (34.1%)	0.016
	No	116 (80.0%)	29 (20.0%)	
4. Use of drugs just before work.	Yes	64 (71.1%)	26 (28.9%)	0.337
	No	112 (76.7%)	34 (23.3%)	
5. Coming to work with drugs hangover	Yes	90 (81.8%)	20 (18.2%)	0.017
	No	86 (68.3%)	40 (31.7%)	
6. Using drugs while working.	Yes	85 (78.7%)	23 (21.3%)	0.181
	No	91 (71.1%)	37 (28.9%)	
7. Lack of safety awareness and training.	Agree	107 (67.3%)	52 (32.7%)	0.000
	Disagree	69 (89.6%	8 (10.4%)	
8. Lack of knowledge on hazard identifications and controls.	Agree	102 (73.4%)	37 (26.6%)	0.614
	Disagree	74 (76.3%)	23 (23.7%)	
9. Lack of safety of equipment.	Agree	109 (68.1%)	51 (31.9%)	0.001
	Disagree	67 (88.2%)	9 (11.8%)	
10. Miners interest not protected by mine management.	Agree	120 (69.4%)	53 (30.6%)	0.002
	Disagree	56 (88.9%)	7 (11.1%)	
11. Poor working relationship with mine management.	Agree	113 (73.4%)	41 (26.6%)	0.562
	Disagree	63 (76.8%)	19 (23.2%)	
12. Lack of job security	Agree	114 (74.0 %)	40 (26.0%)	0.790
	Disagree	62 (75.6%)	20 (24.4%)	
13. Nervousness at work	Agree	141 (75.4%)	46 (24.6%)	0.570
	Disagree	35 (71.4%)	14 (28.6%)	

14. Inadequate earnings	Agree	117 (77.5%)	34 (22.5%)	0.172
	Disagree	59 (69.4%)	26 (30.6%)	

***P<0.05** point to the positive association between key indicator of poor safety cultural factors and risk of severe injuries; while p>0.05 showed inverse relationship.*

Presented in table 4 is a good-for-fitness test for multivariate analysis. In binary logistic regression, there are no universally excepted means for determining model good-for-fitness test (Hosmer, 2000). Nevertheless, SPSS version 25 package has built-in function for Hosmer and Lemeshow good-for-fitness test that is widely accepted. The results in table 4 showed that our multivariate model adequately fitted data as the Chi-Square significance level is greater than 0.05.

Table 4. Hosmer and Lemeshow good-for-fitness test

Chi-square	df	Significant level
7.707	8	0.463

Significance level less than 0.05 showed unfitted model while greater than 0.05 indicator adequate fitting of the model

Table 5 showed COR of risk factors against the risk of severe injuries. The results showed that severe injuries in ASM operation was directly associated ($p<0.05$) with number of risk factors except coming to work with alcohol hangover, use of drugs just before work, using drugs while working, lack of knowledge on hazard identifications and controls, poor working relationship with mine management, lack of job security, nervousness at work, inadequate earnings.

Table 5. Risk factors and COR risk for severe injuries

Alcohol, drug use and other social cultural factors	**Categories**	**COR and confidence level**	**Significant level indicates by p values**
Consuming of alcohol just before work	Yes	2.12 (1.08 – 4.14)	0.028
	No[RC]		
Coming to work with alcohol hangover	Yes	1.56 (0.64 – 0.35)	0.149
	No[RC]		
Consuming alcohol while working	Yes	2.07 (1.14 – 3.75)	0.014
	No[RC]		
Use of drugs just before work	Yes	1.34 (0.74 – 2.43)	0.338
	No[RC]		

Coming to work with drugs hangover	Yes	0.48 (0.26 – 0.88)	0.018
	No[RC]		
Using drugs while working	Yes	0.67 (0.367 – 1.21)	0.182
	No[RC]		
Lack of safety awareness and training	Agree	4.19 (1.88 – 9.36)	0.000
	Disagree[RC]		
Lack of knowledge on hazard identifications and controls	Agree	1.17 (0.64 – 2.13)	0.614
	Disagree[RC]		
Lack of safety of equipment	Agree	3.48 (1.61 – 7.53)	0.002
	Disagree[RC]		
Miners interest not protected by mine management	Agree	3.53 (1.51 – 8.26)	0.004
	Disagree[RC]		
Poor working relationship with mine management	Agree	1.20 (0.64 – 2.25)	0.562
	Disagree[RC]		
Lack of job security	Agree	1.09 (0.59 – 2.02)	0.790
	Disagree[RC]		
Nervousness at work	Agree	0.82 (0.40 – 1.65)	0.570
	Disagree[RC]		
Inadequate earnings	Agree	0.66 (0.36 – 1.20)	0.173
	Disagree[RC]		

Significance level with p<0.05 indicated strong relationship between key indicators of poor safety cultural factors and likelihood of severe injuries, while no relationship is shown by p>0.05.

However, in the multivariate model, many of the risk factors as shown in table 6 became predictive ($p<0.05$) of the severe injury event.

Table 6. Risk factors and AOR risk for severe injuries

Alcohol, drug use and other social cultural factors	**Categories**	**AOR and confidence level**	**Significant level indicates by p values**
Consuming of alcohol just before work	Yes	4.34 (1.70 – 11.13)	0.002
	No[RC]		
Coming to work with alcohol hangover	Yes	0.30 (0.13 – 0.69)	0.005
	No[RC]		
Consuming alcohol while working	Yes	2.29 (1.09 – 4.82)	0.029
	No[RC]		

Use of drugs just before work	Yes	2.84 (1.04 – 7.77)	0.043
	No[RC]		
Coming to work with drugs hangover	Yes	0.75 (0.31 – 1.80)	0.513
	No[RC]		
Using drugs while working	Yes	0.36 (0.12 – 1.08)	0.069
	No[RC]		
Lack of safety awareness and training	Agree	4.28 (1.08 – 17.01)	0.039
	Disagree[RC]		
Lack of knowledge on hazard identifications and controls	Agree	0.22 (0.08 – 0.61)	0.003
	Disagree[RC]		
Lack of safety of equipment	Agree	4.00 (1.00 – 16.02)	0.050
	Disagree[RC]		
Miners interest not protected by mine management	Agree	3.41 (1.32 – 8.81)	0.011
	Disagree[RC]		
Poor working relationship with mine management	Agree	2.25 (0.67 – 7.63)	0.192
	Disagree[RC]		
Lack of job security	Agree	2.13 (0.49 – 9.33)	0.314
	Disagree[RC]		0
Nervousness at work	Agree	0.85 (0.36 – 1.99)	0.703
	Disagree[RC]		
Inadequate earnings	Agree	0.17 (0.42 – 0.69)	0.013
	Disagree[RC]		

Significance level with p<0.05 indicated strong relationship between key indicators of poor safety cultural factors and likelihood of severe injuries, while no relationship is shown by p>0.05

3.3 Thematic analysis results

The application of mixed methods in this study has provided strength and minimized weakness in both approaches. Some of the qualitative interview results confirmed quantitative findings thus illustrating that both approaches are critical for evaluation of other social-technical factors for workplace injuries. The direct quotes were taken from participants' transcripts to validate the developing key themes:

3.3.1 Safety awareness and training

This theme assessed miners' opinion about the health and safety awareness and training. The theme focused on provision and wearing of PPE, equipment training as well as health and safety awareness and training. Some of the injured miners reported lack of safety awareness training prior being injured. While others lamented the lack of equipment training and provision of safety gears as quoted below:

> *"I have never had health and safety training not to mention safe use of the mining equipment. I learned how to operate with time, and accidents here are normal occurrences" (P002)".*

> *"The second injury was caused by the equipment…., regarding this second accident, I blamed it on lack of training. I have never been trained on how to operate hand-held drill or other equipment" (P001).*

> *"I was not wearing any personal protective equipment neither have I been provided one before (P017)".*

3.3.2 Incident and accident documentation and reporting

This theme asked participants whether incidents and accidents were reported. Given that mining hazards and accidents are widely prevalent, the research attempted to understand whether there are available mechanisms for reporting and recording these events. Surprisingly, it was revealed that mine owners do not report mine accidents and associated consequences, as evidenced by below quotes:

"Regarding recording accidents, 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)".

3.3.3 Hazard assessment

This theme assessed the participants' opinion about work area inspection in order to identify hazards and possibly put in place control mechanisms. This theme has helped to confirm that quantitative findings, whereby it was found that Lack of knowledge on hazard identifications and controls contributed to occurrence of severe injuries among the miners. Some of the interviewed participants have revealed lack of inspection prior to commencement of work.

"I never looked around for hazards while working and there is no safety equipment (P002)".

"We had no knowledge on the safe work conditions" (P029).

3.3.4 Production superseded safety

This theme tried to understand mine management commitment to the wellbeing of miners by determining whether material movement was more important than safety. This theme has validated the quantitative finding that "miners' interest not protected by mine management". The interview results have reported important of production over safety. They reported being told to concentrate on production than their wellbeing as quoted:

"The mine owner encourages production more than safety. We always take about production target without thinking of safe operation. Majority of us are lucky not be seriously injured" (P008).

3.3.5 Communication of safety concerns

In addition to lack of priority given to safety, the research also attempted to assess whether or not the mine owners discussed any safety concern in the morning or any other time of the operation. The theme of communication of safety concern also validated that the quantitative finding that "miners' interest not protected by mine management" as well as working under the influence of alcohol and drugs. The thematic analysis results also showed that safety issues are rarely discussed between the mine owners and miners.

> *"……no talk of safety even when accident occurred" (P003).*

> *"The mine owners and ……. rarely discussed safety concerns raised" (P033).*

3.3.6 Government support

This theme evaluated the participants' opinion on the help provided by the government beyond mine owners and whether the operate with permits. The results showed that no assistance is provided by the government to make improvements in their existing situation concerning health and safety and that the government only has loose surveillance of the working areas. Participants reported that government inspectors occasionally visit sites when there is accidents if significant magnitude – fatality.

> *"…….local government does not provide any training, not to mention gloves, boots, etc" (P016).*

3.3.7 Accountability

This theme assessed whether or not participants believed that there is accountability when an accident occurred, or miners were injured. The thematic analysis suggested no one, including

mine management, was held accountable for poor working conditions and occurrence of accidents including those that resulted in major lost time injuries.

> *"I observed cases where people were killed in the shaft, and the next morning, mine owners asked some individuals to go back and continue working without safety precautions" (P002).*

> *"When accidents happened, a lot of people go about their business, as it has become normal routine" (P004).*

4. Discussion

According to the authors' knowledge, for the first time, a mixed-methods approach has been applied to determine the factors that contributed to artisanal and small-scale mining related severe injuries beyond personal characteristics. The study also demonstrated that qualitative interview findings can complement quantitative results. Some risk factors were not captured in the quantitative survey analysis but the qualitative interview analysis.

The current case-control study results can be used to inform the decision-making process for improving perilous ASM working conditions and this will increase the universal call for enhanced OHS standards in ASM activity. It will provide information for policymakers to design policies that are tailored toward the key findings of inferential and thematic analysis presented previously under results.

4.1 *Factors influencing severe injuries*

Misuse of alcohol and drugs in ASM operation is a common phenomenon. This is mainly because the activity is labour-intensive, and miners often suffer body pain and injuries. Consequently, they relied on alcohol and drugs for pain management, calmness, and endurance

(Elenge, Leveque, & Brouwer, 2013). However, the results of this study suggested that consumption of alcohol just before work (AOR =4.34, p =0.002), coming to work with alcohol hangover (AOR =0.30, p =0.005), consuming alcohol while working (AOR =2.29, p =0.020) and use of drugs just before work (AOR =2.84, p =0.043) influenced the occurrence of severe injuries. Corresponding research has demonstrated that workers that consumed alcohol or drugs away from their place of work, and do not turn-up until consumption effects have dissipated are unlikely to experience a workplace accident (Pidd, Roche, & Buisman-Pijlman, 2011). These authors also mentioned that intake just prior to start or during working hours has a direct impact on workers' safety. A recent study that has attempted to understand the role of alcohol and drugs on ASM-related injuries found high-risk alcohol users to be insignificant and high-risk drug users to be significant (Ajith & Ghosh, 2019a). This classification failed to evaluate the effects of substance before, during and after work. Ajith and Ghosh (2019a) defined high-risk miners or users as those miners that came to work intoxicated with alcohol or drugs or those that consumed substances at work. Alcohol and drugs reduced concentration, coordination, judgment, and reaction times, which lead to accidents (Pidd et al., 2011). The research recommended for the management to be conducting pre-work substance test to lessen the risk of miners being injured. This should be implemented in alignment with the safe work policies.

In addition, the risk of severe injuries in ASM operation increased with lack of safety awareness and training (AOR=4.28, p<0.039) as well as lack of safety equipment (AOR 4.00, p<0.050). Corresponding studies carried out in Ghana have shown that injuries could have been prevented with safety equipment, health and safety training, and dangers awareness (Calys-Tagoe et al., 2015; Long et al., 2015). Health and safety training, and provision of safety equipment in workplaces is important for protecting the wellbeing of miners. Mineworkers in ASM operation do not wear PPE while working due to financial constraints and ignorance from the mine

owners. During the survey, it was observed that mineworkers operate equipment without simple PPE such as gloves, helmet, steel cap boots etc. Therefore, this finding recommended mine owners and government official to train and provide safety equipment if reoccurring of injuries in ASM operation is to be stopped.

The lack of knowledge of hazard identifications and risk controls has also been identified to influence the occurrence of severe injuries. The results suggested that miners without knowledge of hazard identifications and risk controls have a higher risk (AOR 0.22, $p<0.05$) of severe injuries compared to those that are skilled. This study agrees with a past study conducted in the Democratic Republic of Congo (DRC), where the authors found prevalent hazards without risk controls (Elenge & Brouwer, 2011). Therefore, it is recommended that ASM miners must be provided with the necessary tools and skills to reduce or eliminate hazards and the risk of being injured.

In this study, we assessed miners feeling towards their management, and results suggested that miners who agreed that their employers do not consider their interest had a higher risk (AOR 3.41, $p<0.011$) of experiencing a severe injury than those who disagreed. These findings agree with plethora of studies on management commitment to safety and perception of workers (McGonagle et al., 2016; Michael, Evans, Jansen, & Haight, 2005). The authors determined that miners that have positive views on their working conditions tend to be safety cautious and have compliance to workplace safety procedures. Contrastingly, lack of safe commitment from the management generate negative feelings toward operational safety which can be translated to a workplace accident occurring, thus corresponding with this study's findings. Therefore, this study recommended mine owners to provide necessary safety training assistances and address any safety concerns often raised by the miners as this will improve the organizational culture and subsequently reduced the risk of accidents.

Our study also found that miners that agree to lower earnings had a higher risk (AOR 0.17, $p<0.05$) of having a severe injury than those who disagreed. The link between earnings and occurrence of workplace injuries has been reported in various publications (Berecki-Gisolf, Tawatsupa, McClure, Seubsman, & Sleigh, 2013; Piha, Laaksonen, Martikainen, Rahkonen, & Lahelma, 2012). Poor earnings can produce job dissatisfaction which has been identified to be a predictor of occupational injuries in the mining industry (Ghosh, Bhattacherjee, & Chau, 2004; Li, Chen, & Wu, 2001; Paul & Maiti, 2008). In ASM operation, miners are paid wages, and the amount given depends on whether they have moved enough dirt to be processed and what amount of minerals was recovered. There are no structured payment schemes. Thus, some miners go unpaid sometime, which results in job dissatisfaction and the risk of severe injuries.

4.2 Emerging underlying factors responsible for poor OHS in ASM operation

This section discussed key themes that emerged from thematic analysis. The results either complement or confirm the quantitative results. They also explained ASM's poor OHS conditions.

4.2.1 Communication of safety concerns

Most of the interviewed miners with severe injuries have cited a lack of communication of safety issues in their mine sites. As a matter of fact, no participant mentioned they had safety talks either before, during, or after work with their management. The link between the lack of safety support and workplace injury has been well documented. Yanar, Lay, and Smith (2019) revealed that OHS vulnerability and lack of supervisor support play a critical in facilitating workplace injury. Safety behaviour of supervisors or management has direct implications on the mine safety culture and frequency of incidents and accidents (Ajith and Ghosh et al. 2019b).

In large-scale mining, miners and management engaged in what is called “safety pre-start”, whereby workers raise any safety concerns in their mine site. If there is any safety issues or identified hazards, based on the hierarchy of control, the team can decide whether to eliminate (completely remove the hazard), substitute (replace the hazard), put in engineering control in place (isolate miners from the hazard), administrative control (change way people work) or provide PPE. Artisanal and small-scale mines operators should adopt safety OHS policies that are governing large-scale mining operations.

4.2.2 Safety awareness and training

This theme is consistent with quantitative results that identified a lack of knowledge on hazard identifications and controls as well as a paucity of safety equipment directly related to the occurrence of severe injuries. Also, this result confirmed the statistical results, which found a lack of safety awareness and training to be associated with the occurrence of severe injuries. Therefore, this research recommends that mine owners and government officials develop policies that target safety awareness and training in ASM operation.

4.2.3 Incident and accident documentation and reporting

In the current study, the theme of “incident and accident documentation and reporting” was also identified. Some of miners reported that artisanal and small-scale mine management does not record and report incidents and accidents that occurred. As a result, many events go unnoticed by the government and concerned bodies. Not reporting and recording reduces the ability to conduct root causes analysis to comprehend “why the accident happened” and “why it was not prevented” (Komljenovic, Loiselle, & Kumral, 2017) and as a result, limited the ability to reduce or eliminate any potential future mishaps due to the same or similar causes. The lack of sufficient and reliable information continues to give safety unconscious mine

operators a free-ride to do what they consider is in their best interest with less consideration on the workers wellbeing (Smith et al., 2016).

While there are concerns linked with the collection and documentation of ASM-related data, in this research, both instrument use and data collection strategy adopted guaranteed the reliable and validity of the data collection. It was a part of ethics requirement that participants must not be coerced, bribe or trick into providing favourable responses. In addition, participants were given option to voluntary withdraw during the data collection process. Therefore, information collected was not subjected to any biases. This research finding calls for a standardized approach to document and report incidences, accidents and health-related problems that occurred in ASM operation.

4.2.4 Lack of Hazard assessment Practice

Workplace inspection and risk assessment of work areas play a central role in mitigating possible mishaps. It is a policy in major large-scale mining operation to conduct work area risk assessments by identifying the potential hazards and putting in-place risk controls. Therefore, the thematic and inferential analysis findings in this study supported the need for sensitization of artisanal and small-scale miners on the dangers associated with their working environment. The research also emphasised educating mine owners on how to identify hazards and apply risk controls using international suitable risk assessment tools such as those employed in LSM operation.

4.2.5 Production superseded safety

The research also showed mine management prioritizing “production over safety”. According to the interviewed miners, mine owners and supervisors tend to ignore safety talks and focus

on the production. This indicates a lack of awareness on safe mining practices and mine management responsibility to protect the health and safety of the mine workers.

4.6 Lack of Government support and accountability

Other themes captured by the qualitative interview results, but not in the quantitative analysis findings, were "lack of government support" and "accountability". Some miners reported not receiving any government support and have a belief that mine management are not accountable for any incidents and accidents that happened in ASM operation. This perception is informed by lack of inspections and government commitment to investigate the accidents and hold the mine owners accountable. In addition, miners attributed absence of health and safety training, and safety gear being nonexistence to government oversight. Miners reported being told to return to work immediate after accidents, thus, showing complete disregard for safety. Similarly, a study conducted in Kenya has demonstrated that mine management do not care or compensated seriously injured miners after investigating the economic and social impacts post-injury (Ajith & Ghosh, 2019b). Therefore, proper government surveillance is required in order to improve the safety of workers in ASM operations. The government should start by enforcing recording and reporting of ASM-related incidents and accidents in order to obtain reliable information for developing focussed policies. This will improve accountability among the mine operators including the management, and subsequently result in developing a more positive safety culture.

5. Conclusions, recommendations, limitations, and future area of study

The complementing of quantitative approach with qualitative results demonstrated that a lack of health and safety training, lack of incident and accident documentation and reporting, lack of working areas inspection and mine owners' prioritization of production over safety consequentially led to severe injuries in ASM operations. These qualitative findings have

validated the quantitative analysis results, where it was found that consuming of alcohol just before work, coming to work with an alcohol hangover, consuming alcohol while working, use of drugs just before work, coming to work with drugs hangover, using drugs while working, no health and safety training, lack of knowledge on hazard identifications and controls, lack of safety of equipment, miners interest not protected by mine management and inadequate earnings predicted severe injuries. Following the theme of absence of government support and accountability, the present study advocates for a comprehensive approach toward ASM operation that will address key indicators of poor safety culture by developing targeted policies. The government and non-governmental organizations (NGOs) must adopt bottom-up approach in which mine operators including mine management are trained, and educated on dangers and risk controls, followed by proper investment on production operations.

Using 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. 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.

- 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.
- Mine owners must be held accountable for poor working conditions, work-related incidents, accidents, and injuries.
- The research encourages public discussion on ASM formalization and the reasons behind miners operating outside the established framework – if available, particularly in rural areas of mineral-rich developing countries.

Although this study has provided important information on poor safety practices on ASM operation, there are some limitations which required 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 reviewing 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 being performed. This will help to understand miners' perception of safety, work practices, and safety culture.

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References

Ajith, M. (2020). A Mixed Method Investigation of Injuries Associated with Artisanal and Small-Scale Mining in Migori County, Kenya (PhD Thesis). Curtin University. http://hdl.handle.net/20.500.11937/80405.

Ajith, M. M., Ghosh, A. K., & Jansz, J. (2020). Risk Factors for the Number of Sustained Injuries in Artisanal and Small-Scale Mining Operation. Saf Health Work, 11(1), 50-60. doi:10.1016/j.shaw.2020.01.00.

Ajith, M. M., & Ghosh, A. K. (2019a). Comparison of parameters for likelihood and severities of injuries in artisanal and small-scale mining (ASM). *Safety science, 118*, 212-220. doi:10.1016/j.ssci.2019.04.010

Ajith, M. M., & Ghosh, A. K. (2019b). Economic and social challenges faced by injured artisanal and small-scale gold miners in Kenya. *Safety Science, 118*, 841-852. doi:https://doi.org/10.1016/j.ssci.2019.05.058

Bansah, K. J. (2019). From diurnal to nocturnal: Surviving in a chaotic artisanal and small-scale mining sector. *Resources policy, 64*, 101475. doi:https://doi.org/10.1016/j.resourpol.2019.101475

Bansah, K. J., Yalley, A. B., & Dumakor-Dupey, N. (2016). The hazardous nature of small scale underground mining in Ghana. *Journal of Sustainable Mining, 15*(1), 8-25. doi:https://doi.org/10.1016/j.jsm.2016.04.004

Berecki-Gisolf, J., Tawatsupa, B., McClure, R., Seubsman, S.-a., & Sleigh, A. (2013). Determinants of workplace injury among Thai Cohort Study participants. *BMJ Open, 3*(7), e003079. doi:10.1136/bmjopen-2013-003079

Bhattacherjee, A. (2014). Association of some individual and occupational factors with accidents of dumper operators in coal mines in India. *Journal of ergonomics, s5*. doi:10.4172/2165-7556.S5-001

Bhattacherjee, A., Kunar, B., Baumann, M., & Chau, N. (2013). The role of occupational activities and work environment in occupational injury and interplay of personal factors in various age groups among Indian and French coalminers. *International Journal of Occupational Medicine and Environmental Health, 26*(6), 910-929. doi:10.2478/s13382-013-0165-4

Boniface, R., Museru, L., Munthali, V., & Lett, R. (2013). Occupational injuries and fatalities in a tanzanite mine: Need to improve workers safety in Tanzania. *The Pan African medical journal, 16*, 120-120. doi:10.11604/pamj.2013.16.120.3420.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi:10.1191/1478088706qp063oa

Calys-Tagoe, B., Ovadje, L., Clarke, E., Basu, N., & Robins, T. (2015). Injury Profiles Associated with Artisanal and Small-Scale Gold Mining in Tarkwa, Ghana. *International Journal of Environmental Research and Public Health, 12*(7), 7922-7937. doi:10.3390/ijerph120707922

Creswell, J. W., & Zhang, W. (2009). The application of mixed methods designs to trauma research. *J Trauma Stress, 22*(6), 612-n/a. doi:10.1002/jts.20479.

Degenhardt, L., Charlson, F., Ferrari, A., Santomauro, D., Erskine, H., Mantilla-Herrara, A., Whiteford, H., Leung, J., Naghavi, M., Griswold, M., Rehm, J., Hall, W., Sartorius, B., Scott, J., Vollset, S., Knudsen, A., Haro, J., Patton, G., Kopec, J., Carvalho Malta, D., Topor-Madry, R., McGrath, J., Haagsma, J., Allebeck, P., Phillips, M., Salomon, J., Hay, S., Foreman, K., Lim, S., Mokdad, A., Smith, M., Gakidou, E., Murray, C. and Vos, T., 2020. The Global Burden Of Disease Attributable To Alcohol And Drug Use In 195 Countries And Territories, 1990–2016: A Systematic Analysis For The Global Burden Of Disease Study 2016.

Domingues, M. S. Q., Baptista, A. L. F., & Diogo, M. T. (2017). Engineering complex systems applied to risk management in the mining industry. *International Journal of Mining Science and Technology*, *27*(4), 611-616. doi:https://doi.org/10.1016/j.ijmst.2017.05.007

Elenge, M., & Brouwer, C. (2011). Identification of hazards in the workplaces of Artisanal mining in Katanga. *International Journal of Occupational Medicine and Environmental Health*, *24*(1), 57-66. doi:10.2478/s13382-011-0012-4

Elenge, M., Leveque, A., & Brouwer, C. (2013). Occupational accidents in artisanal mining in Katanga, D.R.C. *International Journal of Occupational Medicine and Environmental Health*, *26*(2), 265-274. doi:10.2478/s13382-013-0096-0

Franks, D. M., Ngonze, C., Pakoun, L., & Hailu, D. (2020). Voices of artisanal and small-scale mining, visions of the future: Report from the International Conference on Artisanal

and Small-scale Mining and Quarrying. *The extractive industries and society, 7*(2), 505-511. doi:10.1016/j.exis.2020.01.011

Ghosh, A., Bhattacherjee, A., & Chau, N. (2004). Relationships of Working Conditions and Individual Characteristics to Occupational Injuries: A Case-Control Study in Coal Miners. *Journal of Occupational Health, 46*(6), 470-480. doi:10.1539/joh.46.470

Gilbert, K. (2017). Artisanal and Small-Scale Gold Mining in Cameroon: Poverty Loop and Vulnerability of Women. *Women + environments international magazine*(98/99), 29-30.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (2016). Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational evaluation and policy analysis, 11*(3), 255-274. doi:10.3102/01623737011003255

Hentschel, T. (2003). *Artisanal and small-scale mining : challenges and opportunities / Thomas Hentschel, Felix Hruschka, and Michael Priester*. London: London : IIED : WBCSD.

Hilson, G. (2012). Poverty traps in small-scale mining communities: the case of sub-Saharan Africa. *Canadian Journal of Development Studies / Revue canadienne d'études du développement, 33*(2), 180-197. doi:10.1080/02255189.2012.687352

Hilson, G., Hilson, A., & Maconachie, R. (2018). Opportunity or necessity? Conceptualizing entrepreneurship at African small-scale mines. *Technological forecasting & social change, 131*, 286-302. doi:10.1016/j.techfore.2017.12.008.

Hosmer DW. 2000 Applied logistic regression / David W. Hosmer, Stanley Lemeshow. Second edition.. ed. Lemeshow S, editor. New York: New York : Wiley.

International Labour Office (ILO). 1999. Social and labour issues in small-scale mines, Report for discussion at the Tripartite Meeting on Social and Labour Issues in Small-scale Mines. Geneva, 17 May 1999.

Kothari CR. 1990. Research Methodology: Methods and Techniques. 2nd Ed. New Delhi: New Age International (P) Ltd.; 1-361 p. 87-222.

Komljenovic, D., Loiselle, G., & Kumral, M. (2017). Organization: A new focus on mine safety improvement in a complex operational and business environment. *International Journal of Mining Science and Technology, 27*(4), 617-625. doi:https://doi.org/10.1016/j.ijmst.2017.05.006

Kumah, C., Hilson, G., & Quaicoe, I. (2020). Poverty, adaptation and vulnerability: An assessment of women's work in Ghana's artisanal gold mining sector. *Area (London 1969), 52*(3), 617-625. doi:10.1111/area.12639

Kumar, A. (2011). Individual and social factors associated with workplace injuries. *International Journal of Human Science, 8*, 627.

Kyeremateng-Amoah, E., & Clarke, E. E. (2015). Injuries among Artisanal and Small-Scale Gold Miners in Ghana. *Int J Environ Res Public Health, 12*(9), 10886-10896. doi:10.3390/ijerph120910886

Leistikow, B. N., Martin, D. C., Jacobs, J., & Rocke, D. M. (1998). Smoking as a Risk Factor for Injury Death: A Meta-Analysis of Cohort Studies. *Preventive Medicine, 27*(6), 871-878. doi:10.1006/pmed.1998.0374

Li, C. Y., Chen, K. R., & Wu, C. H. (2001). Job stress and dissatisfaction in association with nonfatal injuries on the job in a crosssectional sample of petrochemical workers. *Occupational Medicine, 51*(1), 50-55. doi:10.1093/occmed/51.1.50

Long, R., Sun, K., & Neitzel, R. (2015). Injury Risk Factors in a Small-Scale Gold Mining Community in Ghana's Upper East Region. *International Journal of Environmental Research and Public Health, 12*(8), 8744-8761. doi:10.3390/ijerph120808744

Maiti, J., Chatterjee, S., & Bangdiwala, S. (2004). Determinants of work injuries in mines - an application of structural equation modelling. *Injury control and safety promotion, 11*(1), 29-37.

McGonagle, A. K., Essenmacher, L., Hamblin, L., Luborsky, M., Upfal, M., & Arnetz, J. (2016). Management Commitment to Safety, Teamwork, and Hospital Worker Injuries. *Journal of hospital administration, 5*(6), 46-52. doi:10.5430/jha.v5n6p46

Michael, J. H., Evans, D. D., Jansen, K. J., & Haight, J. M. (2005). Management commitment to safety as organizational support: Relationships with non-safety outcomes in wood manufacturing employees. *Journal of Safety Research, 36*(2), 171-179. doi:https://doi.org/10.1016/j.jsr.2005.03.002

Myadze, T. and Rwomire, A., 2020. Alcoholism In Africa During The Late Twentieth Century: A Socio-Cultural Perspective. [online] Ijbssnet.com. Available at: <https://ijbssnet.com/journals/Vol_5_No_2_February_2014/1.pdf> [Accessed 20 September 2020].

Nwagu, E. N., Dibia, S. I. C., & Odo, A. N. (2017). Socio-cultural norms and roles in the use and abuse of alcohol among members of a rural community in Southeast Nigeria. Health Education Research, 32(5), 423-436. doi:10.1093/her/cyx058.

Odejide, A. O. (2006). Status of Drug Use/Abuse in Africa: A Review. International Journal of Mental Health and Addiction, 4, 87-102. doi:10.1007/s11469-006-9015-y

Oramah, I. T., Richards, J. P., Summers, R., Garvin, T., & McGee, T. (2015). Artisanal and small-scale mining in Nigeria: Experiences from Niger, Nasarawa and Plateau states. *The Extractive Industries and Society, 2*(4), 694-703. doi:10.1016/j.exis.2015.08.009

Paul, P., Maiti, J., Dasgupta, S., & Forjuoh, S. (2005). An epidemiological study of injury in mines: implications for safety promotion. *International Journal of Injury Control and Safety Promotion, 12*(3), 157-165. doi:10.1080/15660970500088763

Paul, P., & Maiti, J. (2007). The role of behavioral factors on safety management in underground mines. Safety Science, 45(4), 449-471. doi: 10.1016/j.ssci.2006.07.006

Paul, P. S., & Maiti, J. (2008). The synergic role of sociotechnical and personal characteristics on work injuries in mines. *Ergonomics, 51*(5), 737-767. doi:10.1080/00140130701747483

Pidd, K., Roche, A. M., & Buisman-Pijlman, F. (2011). Intoxicated workers: findings from a national Australian survey. *Addiction, 106*(9), 1623-1633. doi:10.1111/j.1360-0443.2011.03462.x

Piha, K., Laaksonen, M., Martikainen, P., Rahkonen, O., & Lahelma, E. (2012). Socio-economic and occupational determinants of work injury absence. *European Journal of Public Health, 23*(4), 693-698. doi:10.1093/eurpub/cks162

Ranney, M., Meisel, Z., Choo, E., Garro, A., Sasson, C., & Guthrie, K. (2015). Interview-based Qualitative Research in Emergency Care Part II: Data Collection, Analysis and Results Reporting. *Acad. Emerg. Med., 22*(9), 1103-1112. doi:10.1111/acem.12735

Smith, N. M., Ali, S., Bofinger, C., & Collins, N. (2016). Human health and safety in artisanal and small-scale mining: an integrated approach to risk mitigation. *Journal of cleaner production, 129*, 43-52. doi:10.1016/j.jclepro.2016.04.124.

Tsang, V., Lockhart, K., Spiegel, S., & Yassi, A. (2021). Occupational Health Programs for Artisanal and Small-Scale Gold Mining: A Systematic Review for the WHO Global Plan of Action for Workers' Health. Retrieved 1 January 2021.

Verbrugge, B. (2016). Voices from below: Artisanal and small-scale mining as a product and catalyst of rural transformation. *Journal of Rural Studies, 47*, 108-116. doi:10.1016/j.jrurstud.2016.07.025

Virtanen, M., Kivimäki, M., Joensuu, M., Virtanen, P., Elovainio, M., & Vahtera, J. (2005). Temporary employment and health: a review. *International Journal of Epidemiology, 34*(3), 610-622. doi:10.1093/ije/dyi024.

Yanar, B., Lay, M., & Smith, P. (2019). The Interplay Between Supervisor Safety Support and Occupational Health and Safety Vulnerability on Work Injury. Safety And Health At Work, 10(2), 172-179. doi: 10.1016/j.shaw.2018.11.001.

Westermeyer, J., 2020. UNODC - Bulletin On Narcotics - 1987 Issue 2 - 002. [online] United Nations : Office on Drugs and Crime. Available at: <https://www.unodc.org/unodc/en/data-and-analysis/bulletin/bulletin_1987-01-01_2_page003.html> [Accessed 20 September 2020

World Health Organization (WHO). (2020). Substance Abuse. WHO | Regional Office for Africa. [online] Available at: <https://www.afro.who.int/health-topics/substance-abuse> [Accessed 20 September 2020].

World Bank and International Finance Corporation (W.B.I.F.C) (2019). *Mining and Development: Treasure or Trouble? Mining in Developing countries*. http://siteresources.worldbank.org/INTOGMC/Resources/treasureortrouble.pdf. [Accessed 17/07/2019].

World Bank (2013). *Artisanal and small-scale mining.* Available at: http://www.worldbank.org/en/topic/extractiveindustries/brief/artisanal-and-small-scale-mining [accessed 30/09/2016].