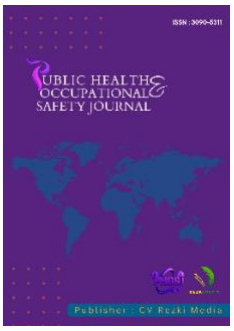

Occupational safety and health hazards among artisanal and small-scale gold miners at Mazowe Jumbo Mine, Zimbabwe: A mixed-methods cross-sectional study

Bridget Nyamombe[1*,A-F], Vincent Itai Tanyanyiwa[1,A-F]

[1] Department of Geography and Environmental Studies, Zimbabwe Open University, Zimbabwe

***Corresponding author:** Bridget Nyamombe; Zimbabwe Open University, Corner House, 5th Floor, Corner Samora Machel Avenue and Leopold Takawira Street, Harare, Zimbabwe; email: nyamombebridget@gmail.com

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ABSTRACT

Background: Artisanal and small-scale gold mining (ASGM) is associated with multiple occupational hazards that artisans are often unaware of.
Objectives: To identify the occupational hazards and risk factors among artisanal gold miners at Mazowe Jumbo mine, Zimbabwe.
Methods: The cross-sectional study employed Mixed-methods(Sep- Nov 2023). Purposive sampling of 34 miners from two sites (response rate was 100%). The interview was administered using questionnaires, structured interviews, field observations, and document review. Quantitative data were analyzed descriptively (frequencies and proportions), and qualitative data underwent thematic analysis.
Results: Heavy lifting was reported by 100% (34/34), manual handling by 91.2% (31/34), silica dust exposure by 91.2% (31/34), and contaminated water by 85.3% (29/34). Key risk factors included lack of PPE, financial pressure, and low OSH awareness. Field observations noted unsecured shafts, poor sanitation, and evidence of substance use on site.
Conclusions: ASG miners at Mazowe Jumbo Mine face multi-domain OSH hazards. We recommend targeted OSH training programmes, provision of PPE, improved sanitation, and monitoring/ formalization of ASGM activities.

Keywords: artisanal mining, hazards, occupational safety, mixed methods, Zimbabwe.

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INTRODUCTION

Artisanal and small-scale gold mining refers to the extraction of small amounts of minerals by individuals or small enterprises using basic tools and non-industrial methods (Matambo, 2024; Matsa et al., 2022; Singo et al., 2023). Artisans are exposed to various occupational risks and may experience fatal incidents due to noncompliance with safety requirements (Adu-Baffour et al., 2021). Global studies indicate that ASGM is associated with biological, environmental, ergonomic, psychological, physical, and chemical occupational safety and health hazards (Singo et al., 2022). In 2017, ASGM employed an estimated 14-19 million artisans globally (Matsa et al., 2022; Wireko-Gyebi et al, 2020). Prolonged inhalation of fumes and dust can lead to chronic bronchitis, asthma, and other respiratory illnesses (Podewils et al., 2022; Singo et al., 2022). Miners also face increased risks of accidents, collapse-related injuries (Wireko-Gyebi et al., 2020), and long-term health effects from exposure to dangerous chemicals such as mercury and cyanide (Kumah et al., 2020). Competing claims to mineral-rich territories can result in conflict, violence, and displacement (Matambo, 2024; Hilson & Maconachie, 2020).

Occupational Health and Safety involves efforts to prevent, control, and manage workplace hazards (Maweja et al., 2024). In Zimbabwe, more than 500,000 people participate in artisanal ASGM (Matambo, 2024), supporting the livelihoods of at least one million individuals (Matambo, 2024). High rates of accidents and illnesses make artisanal mining hazardous, highlighting the need for adequate health control measures (Maweja et al., 2024). The sector employs workers aged 18 to 25 (Baddiannah et al., 2022; Singo et al., 2022), who typically work in small groups and are confined to specific mines or quarries (Matambo, 2024; Singo et al., 2022). Previous studies describe hazardous conditions in Kadoma, such as a lack of PPE, unsafe pits, limited access to clean water and toilets, poor waste management, and poor access to health care. These factors contribute to accidents, sexually transmitted diseases, tuberculosis, malaria, and acute respiratory infections (Becker et al., 2021; Wanyana et al., 2020). Studies in Midlands and Matebeleland South found increased risks of silicosis (11.2%), tuberculosis (4.0%), and HIV (23.5%) among artisanal miners (Singo, et al., 2022; Wireko-Gyebi, et al, 2020).

In 2019, artisanal mining increased in Mazowe District due to the abundance of gold reserves and high unemployment rates (Matambo, 2024). Mining laws and regulations are similar for both large mines and ASGM (Adu-ABaffour et al., 2021), and there are plans to formalize AGSM (Wireko-Gyebi et al, 2020). However, the informal nature of artisanal mining in Zimbabwe poses challenges for governance, regulation, and the enforcement of environmental and safety standards (Adu-Baffour et al., 2021; Jayaratne & Jayatilleke, 2020). Unregulated mining has led to environmental degradation, health and safety hazards (Becker et al., 2021; Wanyana et al., 2020), and the exploitation of miners, including child labour and human rights abuses (Becker et al., 2021). Miners are exposed to high dust concentrations, especially silica dust (Singo et al., 2022), resulting in increased risk of silicosis, a progressive and incurable lung disease (Hilson & Maconachie, 2020).

The Health Belief Model (HBM) encouraged individuals to take proactive efforts to protect their health and well-being by improving their perception of susceptibility, severity, benefits, and barriers. It also reinforces cues to action (Alyafei & Easton-Carr, 2024). The study posits that the Health Belief Model applies to ASGM (Alyafei & Easton-Carr, 2024), which relates to hazardous health hazards and work

environments (Wireko-Gyebi et al., 2020). Figure 1 illustrates the Health Belief Model.

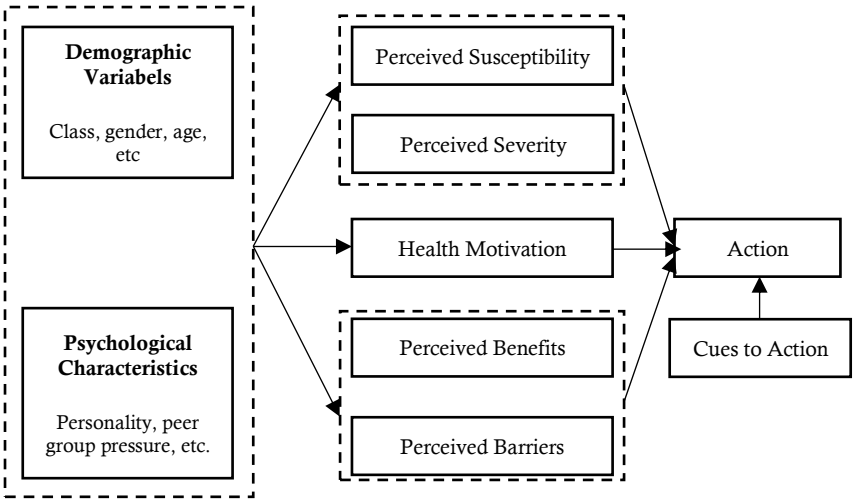

Figure 1. The Health Belief Model (Alyafei & Easton-Carr, 2024)

HBM provided a theoretical framework for understanding and analyzing the OSH hazards of artisanal miners. Its constructs guided the design of the interview guides, questionnaires, and observation guides (Alyafei & Easton-Carr, 2024). The constructs helped capture miners' beliefs, attitudes, and behaviors related to OSH hazards, facilitating interventions to improve their OSH practices. Furthermore, the continuous use and refining of this paradigm hold promise for promoting favourable health outcomes (Alyafei & Easton-Carr, 2024) and establishing a culture of prevention and wellness (Singo et al., 2022).

Although studies in Kadoma and other provinces describe health outcomes and exposure, there is limited evidence on behavioural factors, site-level observations, and prevalence triangulation in Mazowe; this study fills that gap. Artisans lack knowledge of the OSH risks and hazards associated with their work. Therefore, this study aims to identify hazards in Mazowe, assess the risk factors contributing to these hazards, and develop recommendations to mitigate them, thereby contributing to a better understanding of the challenges faced by ASGM and informing strategies for mitigating risks and promoting a safer working environment.

METHODS

Study Design and Participants

This study was conducted from September to November 2023 in Mazowe, Mashonaland Central Province of Zimbabwe, where artisanal mining is prevalent (Matambo, 2024). Data were generated through triangulation and a mixed-method approach, which complements quantitative and qualitative methodologies (Roberts, 2020). Data were collected through questionnaires, field observations, structured interviews, and document review (Ahmad & Murad, 2020; Jayaratne & Jayatilleke, 2020; Mannan & Afni, 2020). The data collection tools were provided in both Shona and English. The study conducted two-site assessments with a total population of 170 (86 and 84 miners). The study adopted Tippett's rule of thumb (20% of the total population) for sampling and produced a sample of 34 out of 170. This sample was selected to provide a reasonable level of precision while still being manageable in terms of time and resources.

Ethical approval statement

The Zimbabwe Open University provided ethical clearance and authorized the study. Consent was sought from Mazowe Jumbo mine offices, shaft owners, local authorities, and all participants. Participants provided informed consent and participated voluntarily. The respondents were also informed of the confidentiality policy, regardless of any behavior observed outside the study's parameters. The enquirer was given a schedule for two weeks of meetings with the selected claims. The study adhered to ethical standards as outlined in the 2013 Declaration of Helsinki regulations.

Research Instruments

Quantitative data were collected through questionnaires administered to miners who had participated in ASGM for a minimum of six months. Two assistants were sought to assist with distributing the questionnaires. The questionnaire employed both open-ended and closed-ended questions (Jayaratne & Jayatilleke, 2020; Mannan & Afni, 2020; Nigg et al., 2020). Face-to-face, structured interviews were used to collect both quantitative and qualitative data (Jayaratne & Jayatilleke, 2020; Mannan & Afni, 2020; Roberts, 2020). Interviews were conducted with each selected individual through purposive sampling (Campbell et al., 2020). The key informants targeted include SHEQ officers, first aiders, overseer miners, and site managers.

Field observations employed a checklist designed to determine whether the claim had the necessary facilities to address OSH issues, such as first aid kits, shade, lights, restrooms, clean water, offices, and other required amenities. The observation guided what to notice or scrutinize, allowing all aspects to be explored. For a more thorough investigation, secondary data were also employed to supplement primary data. The investigator utilized site registers, training records, safety reports, published materials, and accident records. Thematic analysis allowed the investigator to employ a larger sample size that included women (Campbell et al., 2020). The enquirer was given a schedule for two weeks of meetings with the selected claims.

Data Analysis

Data from surveys and structured interviews were entered, cleaned, analyzed, and coded using MS Excel (Younas, et al., 2022; Nigg, et al., 2020). Qualitative data from field observations were examined using thematic analysis to assess the hazards and risks associated with artisanal mining. Descriptive statistics were calculated, and the results were displayed using frequency tables and narrative text (Musasa & Jerie, 2020). An Excel spreadsheet and pie charts were used to analyze the quantitatively obtained data and visually display the results.

RESULTS

The response rate was 100%. Recruiting 34 out of 170 respondents enabled us to gather rich and detailed data. This was due to the use of purposive sampling, where participants were deliberately selected based on the specific criteria relevant to the study objectives. This limited ability restricts the ability to make statistical inferences about the population, and future studies could consider complementing these findings with a quantitative approach to enhance generalizability. Table 1 below shows that most of the population comprises consenting adults aged 18 and above.

Table 1. Socio-demographic Characteristics of Participants (n=34)

Characteristics		n (%)
Demographicsample in Mazowe Jumbo Mine 34 (100)	**Demographicsample in Mazowe Jumbo Mine 34 (100)**	**Demographicsample in Mazowe Jumbo Mine 34 (100)**
Gender n (%)	Male	28 (82.4)
Gender n (%)	Female	6(17.6)
Age n (%)	18-35 years	21 (61.8)
Age n (%)	36-50 years	12 (35.3)
Age n (%)	51> years	1(2.9)
Marital status n (%)	Single	6(17.6)
Marital status n (%)	Married	21 (61.8)
Marital status n (%)	Divorced, separated, widowed	7(20.6)
Education level	No formal education	12 (35.3)
Education level	Primary level	4 (11.8)
Education level	Ordinary level	10 (29.4)
Education level	Certificate	4 (11.8)
Education level	Diploma	3(8.8)
Education level	Tertiary	1(2.9)
Working experience	<3 years	17 (50)
Working experience	4-6 years	17 (50)
Possession of mining cards	Yes	24 (70.6)
Possession of mining cards	No	10 (29.4)
Mazowe Resident	Yes	17 (50)
Mazowe Resident	No	17 (50)

Based on Table 1, the high proportion of married individuals (21/34), 61.8% suggested that respondents had family responsibilities, which may influence their work decisions. The lack of educational qualifications among the majority (12/34) 35.3% suggests potential vulnerability and limited access to alternative employment opportunities. This demographic profile can inform the development of support services tailored to their specific needs.

The most prioritized hazards were heavy lifting, as indicated by 34 respondents (100%), while bullying and workplace violence, as well as silica dust, were reported by 31 of the 34 respondents (91.2%) respectively (Table 2). Workplace violence was linked to losses of ore, gold, equipment, and shafts (n = 29, 85.3%), as supported by qualitative data (Table 2). Noise was prevalent on-site with machinery. Few workers at these sites used ear protection or gloves, and the noise levels were too high for ear protection alone to be effective. Hearing issues were reported, and these results highlight the urgent need for targeted interventions to mitigate these hazards, ensuring a safer working environment.

Table 2. Occupational Safety and Health Hazards among Miners

Hazards Faced By Artisanal Miners	n	%
Ergonomic hazards		
Manual handling,	31	91.2
Awkward posture	28	82.4
Heavy lifting	34	100
Repetitive motion	27	79.4
Excessive force	29	85.3
Confined spaces	17	50
Physical hazards		
Cave-ins and collapses	17	50

Flying objects and debris	19	55.9
Falling	17	50
Rock falls	13	38.2
Psychological hazards		
Bullying and violence	31	91.2
Trauma from previous accidents	13	38.2
Loss to theft	29	85.3
Stress	31	91.2
Prostitution	14	41.2
Childlabour	16	47.1
Environmental hazards		
Extreme temperatures	22	64.7
Slippery grounds	21	61.8
Un-closed pits	13	38.2
Water pollution	11	32.4
Mechanical and electrical hazards		
Crushing entanglements	6	17.6
Human entrapment	4	11.8
Sharp objects	16	47.1
Unsecured shafts	19	55.9
Respiratory hazards		
Silica dust	31	91.2
Vapours	13	38.2
Fumes	17	50
Chemical hazards		
Mercury toxicity	18	52.9
Contaminated water	29	85.3
Contaminated food	17	50
Biological hazards		
Infectious diseases	9	26.5
Animal attacks	3	8.8

Based on Table 3, most artisans (14/34) 41.2% rarely report accidents at work, conduct a stop and fix, and (11/34) 32.4% conduct safety checks before commencing work. The high-risk factors influencing hazards include lack of training and educational awareness, inadequate access to PPE, financial pressure due to personal values and goals, and working conditions. The study noted the irregularities in the SHE talks. These findings highlight potential gaps in safety practices and reporting mechanisms among artisanal miners.

Table 3. OSH hazards Perception Survey

Characteristic	**Yes N (%)**	**No N (%)**	**Rarely N (%)**
Do you oftenreport accidents/ incidents at work?	5 (14.7%)	15(44.1%)	14(41.2%)
When accidents occur, do you stop working to investigate the cause?	9(26.5%)	10(29.4%)	15(44.1%)
Do you conduct safety checks before work commences?	9(26.5%)	14(41.2%)	11(32.4%)
Do you always wear PPE and constantly follow safety rules at work?	(n)	(100%)	
Yes	7	20.6%	
No	10	29.4%	
rarely	15	44.1%	

never	2	5.9%
If not yes, what could be the reason	(n)	(100%)
Not interested	4	14.8%
It is for bigger mines and industries	5	18.5%
It is not popular	3	11.1%

DISCUSSION

The study aimed to identify the hazards and risk factors among ASGM and develop recommendations for mitigation. Artisans reported encountering health and safety issues, including musculoskeletal disorders, injuries, respiratory problems, and hearing impairments, as highlighted by previous studies (Singo et al., 2022).

Musculoskeletal issues reported include lower back and neck pain, wrist and joint pain, and muscle stiffness. A study on occupational safety and health in abattoirs in Zimbabwe indicated that poor work posture, characterised by excessive force and repetitive movements, contributes to muscle fatigue and injury (Jerie & Matunhira, 2022; Olasupo et al., 2023). Implementing ergonomic interventions such as proper lifting techniques, regular breaks, and improved mechanisation can help mitigate the risks of musculoskeletal disorders.

The findings also highlighted that artisanal miners experience a range of respiratory illnesses, including coughs, wheezes, asthma, and chest problems (Moyo et al., 2021; Podewils et al., 2022). Workers stated that they suffer from head injuries, cuts, lacerations, and other injuries. Eyesight is likely affected by silica dust, and individuals may experience difficulty seeing distant objects.

Field observations revealed the absence of proper offices, first aid kits, and facilities for storing explosives. Mine collapses were prevalent, and injuries and fatalities resulted from a lack of risk mitigation techniques. Previous studies reported 42 ASGM fatalities in Zimbabwe in 2019 (Singo et al., 2022). Miners are attacked by bio-creatures (Matambo, 2024), including snakes and lice (inda). The study showed that artisanal miners also experience infections, rashes, and diseases like malaria, cholera, HIV/AIDS, STDs, and diarrhoea (Jerie & Matunhira, 2022).

The study's findings highlight the significant challenges faced by artisanal miners, including limited access to PPE, negative perception of PPE, a hazardous working environment, and substances such as cyanide and mercury. Although 24/34 (70.6%) claimed to have a mining card, 85.3% reported inconsistent use of PPE. The study found that the wearing of PPE in ASGM is perceived as a nuisance, showing the need to address cultural beliefs in the mining environment. The lack of personal protective equipment (PPE) and poor working conditions exacerbate these risks, with miners reporting injuries and illnesses. The study emphasizes the importance of PPE subsidies in reducing exposure to hazards and establishing surveillance systems to monitor and track cases of silicosis and mercury poisoning (Maweja et al., 2024).

This study indicates that artisans lack knowledge of OSH issues, and formal training or certification does not guarantee constant adherence to safety protocols in practice. However, research conducted by Maweja et al. (2024) states otherwise. In his research in DRC, an artisanal miner who possesses a professional mining card has a deeper understanding of the Occupational Health and Safety (OHS) hazards and the safety and mining regulations.

Economic and financial pressures are also significant concerns for artisanal miners, with 85% of respondents citing personal values and goals as a major

contributor to stress, particularly among married miners. Additionally, the study found that miners often labor quickly and take shortcuts, putting themselves at greater risk of accidents. Artisans struggle and lose their ore to theft by criminal gangs (Mashurugwi or Mabhudhi), a derogatory term widely attributed to artisanal miners, promoting negative preconceptions and stigma (Matambo, 2024; Matsa et al., 2022). A study by Maconachie (2022) demonstrated that informal activities can have detrimental socioeconomic, health, and environmental effects, trapping miners and communities in cycles of poverty and excluding them from government help and protection.

Irregular SHE talks noted indicated a lack of management support. Scholars have suggested that the lack of official agreements or documentation limits the enforcement of labour regulations, raising concerns such as child labour and unfair remuneration (Wireko-Gyebi et al., 2020). The unsafe behavior of artisans is a worrying trend that needs to be addressed. The fact that such behavior is expected of them or considered acceptable indicates a perceived threat/ risk (Singo et al., 2022; Wireko-Gyebi et al., 2020). The study emphasizes the importance of OSH training for miners in reducing accidents and health risks through collaboration between NGOs and the government (Singo et al., 2022).

ASGM in Zimbabwe makes a vital contribution to the informal economy, providing jobs to people who face widespread unemployment (Matambo, 2024). There is no easy fix for the complex issue of miners' OSH issues, hence a methodical management strategy is required to reduce OSH hazards (Joe-Asare & Stemn, 2023; Singo et al., 2022; Wireko-Gyebi et al, 2020). The findings of our study, which were also confirmed by other studies, are that comprehensive interventions should be implemented to address the challenges faced by artisanal miners. It also highlights the importance of formalizing ASGM to improve working conditions and reduce environmental degradation through environmental remediation, such as clean-up campaigns and ecosystem restoration (Joe-Asare & Stemn, 2023). It is possible to improve the health and safety outcomes of artisanal miners and promote sustainable livelihoods.

Limitations of the study

The study employed purposive sampling, capturing only the experiences of participants who had engaged in ASGM within the past six months, potentially excluding those who had started mining more recently. The study relied on self-reported data, which may be subject to biases. It also focused on two sites and a small sample size. This may not be representative of the entire ASGM sector at Jumbo mine. The study only used questionnaires, without incorporating biomarkers such as urine or blood samples and air measurements, to assess silica exposure and measure health outcomes, which limits the study's ability to quantify the health impacts of ASGM. Future studies could involve more sites and robust samples, as well as biomarkers and air measurements, to reduce selection biases and quantify health outcomes and occupational hazards.

CONCLUSIONS

Our findings report that OSH hazards prevalent at MJM included poor work environment, unsecured shafts, silica dust, contaminated water, awkward posture, manual handling, heavy lifting, flying objects, slippery grounds, theft, and violence, among others. Artisanal miners are susceptible to a variety of occupational diseases

and injuries, including musculoskeletal disorders, diseases, respiratory illnesses, injuries and fatalities, and psychological issues. This study also needs to be applied to other sites in Mazowe, considering that ASGM exists in several countries.

We recommend further longitudinal studies with larger samples, including biomarker testing (Hb), spirometry, and air quality measurements (PM2.5/silica). Implementing effective HIRA and refresher training courses, mandatory PPE provision, regular SHE talks, and mobile screening clinics can help prevent future injuries. Moreover, environmental remediation efforts, formalization of ASGM, and silica/ mercury surveillance systems should be implemented through NGOs and government collaborations to mitigate the long-term effects of ASGM. Recommendations for essential steps include clear accident reporting structures, improved mechanization, provision of proper explosives storage facilities, access to clean water, and sanitation to reduce musculoskeletal illnesses and enhance a safe working environment.

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DATA AVAILABILITY

The authors declare that artificial intelligence–based tools were used to support language editing, text organization, and refinement of clarity during the manuscript revision process. The use of these tools did not influence the study design, data collection, data analysis, or interpretation of results. All scientific content, analyses, and conclusions remain the sole responsibility of the authors.

AI DISCLOSURE STATEMENT

Artificial intelligence tools were used solely to assist with language refinement and manuscript editing. The authors take full responsibility for the content and integrity of the study.

FUNDING

This study did not receive any funding.

CONFLICT OF INTEREST

The author affirms that this research was conducted with complete independence and integrity and is free from any conflicts of interest with any organization, institution, or individual. No financial, professional, or personal affiliations could have influenced the study's design, data collection, analysis, or interpretation. This declaration ensures the objectivity and credibility of the research findings, thereby reinforcing its contribution to the safety of artisanal and small-scale miners.

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