



Contents lists available at ScienceDirect

Safety and Health at Work

journal homepage: www.e-shaw.net

Original article

Working in a Risky Environment: Coping and Risk Handling Strategies Among Small-scale Miners in Ghana



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ARTICLE INFO

Article history:

Received 13 July 2021

Received in revised form

20 February 2022

Accepted 21 February 2022

Available online 26 February 2022

Keywords:

Hazards

Personal protective equipment

Risk

Small-scale mining

ABSTRACT

Background: It is estimated that about 13 million artisanal and small-scale miners carry out their activities under harsh, precarious, unfriendly, and risky conditions. Yet, our understanding of the extent to which these workers use personal protective equipment (PPE) and navigate through the various risks and hazards they face is still limited. This article has two main objectives. First, it explores the extent of usage of PPE among artisanal and small-scale miners for the prevention of hazards and risks. Second, it examines the coping strategies used by these miners as a response to experiences of occupational injuries and risks.

Methods: A cross-sectional survey of small-scale miners was conducted in six communities across three districts in Ghana, West Africa. The mixed methods approach was adopted. A total of 148 small-scale miners participated in the study. Six focus group discussions (FGDs) were held across the six communities. The data were analysed using descriptive statistics. Chi-square tests were used to analyse the relationship between some socio-demographic characteristics (sex, age, and educational background) and the usage of PPE. Open-ended questions and responses from FGDs were analysed based on the content and verbatim quotations from miners.

Results: Findings suggest that 78% of the miners interviewed do not use the appropriate PPE citing reasons such as cost, and their personal discomfort associated with use of PPE. There was no significant relationship between socio-demographic characteristics (i.e., sex, age, education and major mining activity) and the usage of PPE. The study further revealed four main coping strategies used by miners to handle the risks. These are rest, taking unprescribed medication and hard drugs, registration with health insurance scheme and savings and investments.

Conclusion: This study shows that very few artisanal miners use PPE despite the significant hazards and risks to which they are exposed. The study recommends to the government to put in place measures to ensure that miners adhere to health and safety regulations before undertaking mining activities. This means that health and safety plans and use of PPE should be linked to the license acquisition process for miners.

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1. Introduction

Artisanal and small-scale mining (ASM)—a low-tech mineral extraction and processing—has witnessed considerable growth and

expansion over the past few years across Africa and the world. Some estimates suggest that about 15–30 million people are employed in the ASM sector across over 70 countries and produce 15%–20% of the global mineral output [1,2]. Emerging scholarly work, for example,

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[3–5] has shown that ASM contributes significantly to economic development of gold-rich countries such as Ghana in West Africa. Despite the contributions of the ASM to income generation, poverty reduction and rural development, operations of artisanal miners contribute massively to pollution of water bodies especially through the use of cyanide, mercury and other heavy metals. There is presently significant attention on engineering reforms in the sector because of its potential to contribute to environmental sustainability and the Sustainable Development Goals (SDGs) [6]. It has been argued that reforms of the ASM sector are crucial because of the sector's impact on the SDGs, especially the goals and associated targets related to no Poverty (SDG1).

ASM is, however, a risky business. In the large-scale mining (LSM) arena, growing attention to automation, technological improvement, companies' commitments to health and safety and tightened regulations have reduced the risks and hazards in the sector. But the same cannot be said of the ASM sector. It is estimated that about 13 million ASM workers from across 30 countries carry out their activities under harsh, precarious, unfriendly, and risky conditions, and with low pay [7]. Some studies suggest that the risk of accidents in ASM is believed to be 6–7 times higher than that in the LSM. Women and children are particularly about 90 times at risk of fatality [8]. Also, it has been found through a study in Ghana that the odds of sustaining injury were 3.19 times higher for ASM workers who go underground compared to those doing surface mining. Other studies e.g. [9,10], suggest that in countries such as Democratic Republic of Congo and Ghana, people working in ASM operations are exposed to considerable hazards. While there is a growing body of literature on occupational and health issues related to ASM, little attention has been paid to how miners handle risk, particularly in relation to the use of PPE, including hardhats, work boots, gloves, safety glasses, and nose masks. Furthermore, little is known about the extent to which artisanal and small-scale miners cope and navigate through the various risks and hazards that they face. To this end, this study set out with two main objectives. First, it seeks to explore the extent of use of PPE among artisanal and small-scale miners for the prevention of hazards and risks. Second, it seeks to examine the coping strategies used by artisanal and small-scale miners as a response to experiences of occupational injuries and risks.

2. Artisanal and small-scale mining (ASM): a risky and hazardous sector

According to [11] the hazards associated with small-scale mining (SSM) are caused by poor hygienic conditions, poor work postures and exposure to toxic chemicals such as mercury, arsenic, lead and gases from dynamite blasts. The physical hazards include all the negative effects of mining activities on the physical environment, where all the mining exploration and extractions take place [12]. The physical hazards manifest themselves in unacceptable levels of dust, noise, heat, vibration, fire, radiation, and poor hygienic conditions that can negatively affect the health of miners [13,14]. Some physical hazards may also include injuries as a result of falls, slips, and cuts.

Chemical hazards are the root cause of almost all risks associated with SSM [12]. Several chemicals such as mercury, arsenic and cyanide are used in SSM but the most used chemical is mercury (used for amalgamation), which is regarded by miners as the most efficient method for gold recovery [15,16]. A high dose of mercury exposure can cause a permanent damage to the central nervous system [17]. Exposure to chemical hazards can lead to health conditions such as stomach disorders, respiratory disorders, neurological damage, and cancer-related ailments [18,19,13]. More often than not, chemicals used by most miners end up spilling into water

bodies and other physical and environmental constituents which have wider direct and indirect effect on humans and other organisms.

Small-scale miners assume work positions that expose them to ergonomic hazards due to work postures adopted for a prolonged time, which has the tendency of causing some health effects, usually musculoskeletal disorders, injuries and sprains [13].

3. Materials and methods

3.1. Study design and setting

A cross-sectional survey of small-scale miners was conducted in six communities (i.e., Dadieso, Gyapa, Mim, Mpatasie, Gbanie Kejetia and Gbanie Obuasi) across three districts in Ghana (Fig. 1). The districts were Amansie West, Talensi and Wassa Amenfi East. These districts were selected for this study because they are known to be the hub for SSM within the Ashanti, Upper East and Western Regions of Ghana, respectively [11]. In the context of Ghana, ASM is mostly carried out by individuals with relatively low capital as well as low or no formal education. These operators often fail to obtain all the requisite documentation and licenses, which brand their activities as "illegal." The afore-mentioned districts have experienced serious environmental degradation as a result of intense mining activities. Mining in the Amansie West and Wassa Amenfi East districts is dominated by surface mining activities with few underground and alluvial mining whilst Talensi district is predominantly known for underground mining. Though these districts have been mined for over 20 years, there are still large deposits of gold yet to be exploited.

3.2. Research approach

The mixed methods approach was adopted for the study in order to combine the advantages of both quantitative and qualitative data collection and analysis. A total of 148 small-scale miners participated in the study, out of which 83.1% were men and 16.9% were women. These miners were selected using the convenient sampling approach, which means that miners were selected based on their willingness and availability. To participate in the study Semi-structured questionnaires with closed and open-ended questions were used as data collection instruments. The questionnaire was structured based on the following themes: socio-demographic characteristics, preventive measures for various hazards (physical, chemical and ergonomic) and risks (diseases and injuries), coping mechanisms for risks, health insurance and investments. Six focus group discussions (FGDs) were held across the six communities (two in each study district), and the FGD instruments were structured based on the same themes as the questionnaires. The questionnaire was designed in English and subsequently translated into the local languages (i.e. Twi and Frafra) during the interviews. The consent of the research participants was obtained after a trained interviewer explained the purpose of the study. Miners who did not consent to the study were not included. The participants were given code names in order to ensure anonymity.

3.3. Data analysis

The data was analysed using descriptive statistics including averages, frequencies and percentages. The descriptive statistics were used to determine the usage of the various PPE and reasons for non-usage. The miners were asked if they were registered with any type of insurance, specifically the National Health Insurance Scheme (NHIS). Inferential statistics, namely Chi-square tests, were used to analyse the relationship between some socio-demographic

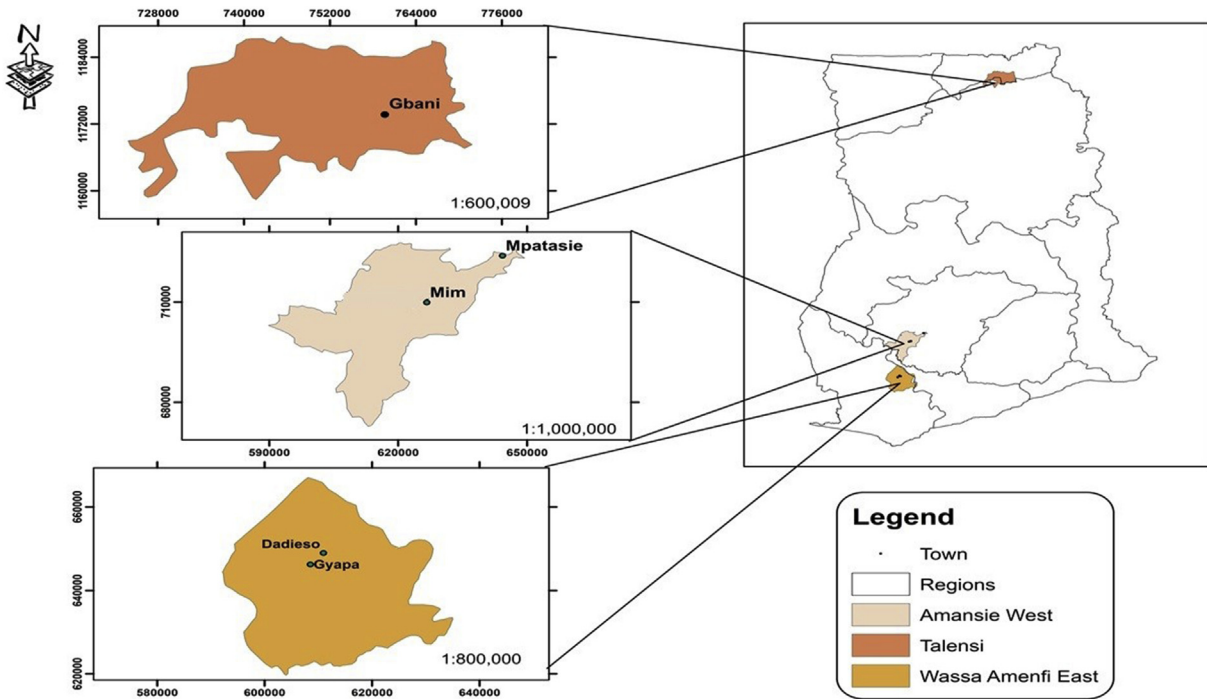


Fig. 1. Maps of Study Areas. Source: Department of Geomatic Engineering, Kwame Nkrumah University of Science and Technology

characteristics (sex, age, and educational background) and the usage of PPE. Significant relationships were recorded at $p < 0.05$. Data on other coping strategies specified by miners were categorized and analysed using percentages. Open-ended questions and responses from FGD were analysed based on the content and verbatim quotations provided by the respondents.

4. Results

4.1. Mechanisms for the prevention of hazards and risks

Out of the 148 small-scale miners, only 26.4% used some form of PPE such as Wellington boots, gloves and overalls. There was no significant relationship between socio-demographic characteristics (i.e. sex, age, education, and major mining activity) and the usage of PPE as indicated in Table 1 below.

4.1.1. Non-usage of PPE among SSM operators

The miners who did not use PPE assigned varied reasons as indicated in Table 2 below. It is worth noting that as many as 50% of the small-scale miners who did not use PPE deemed it to be unnecessary.

The use of PPE by the miners was mainly to protect themselves from injuries and inhalation of chemicals. During the FGD one miner in the Talensi district claimed that: “the use of PPE causes destruction in our work in the sense that it causes delay in our work. We also feel heavy putting on such things.” This reflects the perception of the majority of the small-scale miners since as many as 78% of the miners who did not use PPE either did not find it necessary or felt uncomfortable using it. Most of the small-scale miners did not perceive mercury as hazardous or dangerous to their health. Consequently (as shown in Fig. 2) they do not find it necessary to protect themselves.

Only 23.6% of the small-scale miners mentioned that they had some measures in place to avoid exposure to chemical hazards. The main action taken by the miners was to stay away during the roasting

Table 1

Personal protective equipment usage and socio-demographic characteristics

Characteristics	Usage of PPE		Total	p-value (χ^2)
	Number that used PPE	Number that did not use PPE		
Sex				
Male	35	88	123	0.385 (0.753)
Female	5	20	25	
Age (years)				
< 18	0	3	3	0.732 (2.789)
15–24	19	42	61	
25–34	15	39	54	
35–44	4	16	20	
45–54	1	6	7	
Above 54	1	2	3	
Education				
No formal education	12	25	37	0.895 (1.098)
Primary school	9	24	33	
Junior high school	10	32	42	
Senior high school	8	22	30	
Tertiary education	1	5	6	
Major Activity				
Crushing and grinding	1	10	11	0.100 (6.248)
Underground	10	19	29	
Sieving and washing	14	54	68	
Digging	10	15	25	

process to allow the wind to blow the fumes away (Table 3). According to them they usually experience cough when they inhale the fumes of the mercury that they use.

Physical hazards identified included dust that occurs during drilling, crushing, and milling, fumes from machinery and during gold roasting and open pits that accumulate water. Only 8.8% of the miners indicated that they used nose masks or cloth to protect themselves from dust, as the only measure against physical hazards. The miners did not use any PPE to protect themselves against noise, high temperatures, vibration and fire. Diggers and underground

Table 2
Reasons for non-usage of PPE among small-scale miners

Reason	Number	Percentage
Not necessary to use	55	50.5
Not convenient, uncomfortable to use or complicates and delays work	30	27.5
Expensive	10	9.2
PPE not provided by the site owner	5	4.6
Work with much care and experience	3	2.8
Other colleague miners do not use them	2	1.8
No education about usage	2	1.8
Mining tasks not dangerous/harmful	2	1.8
Total	109	100



Fig. 2. Application of mercury for amalgamation without the use of PPE. Source: Fieldwork, January–June 2018

Table 3
Miners' protection against chemical hazard

Action	Frequency	Percentage
Allow the wind to blow the fumes away	18	12.2
Cover nose and mouth with cloth	5	3.4
Wear gloves	12	8.0
Total	35	23.6

miners claimed they used canvas shoes (a canvas shoe is a casual shoe or sneaker made of canvas) instead of Wellington boots. Underground miners were asked if canvas protected them well but they revealed that due to the nature of the rocks no other boot or shoes could help the movement underground, hence the reason why they resort to canvas.

The miners suffered minor injuries including cuts, lacerations and contusions whilst major injuries included fractures. In terms of injuries, 54.7% of the miners indicated that they either visit the hospital or health center, 14.9% use herbal medicine, 27.7% allow injuries to heal naturally when they are minor and 2.7% indicated their choice of treatment depended on the extent of injury. Those who used herbal medicines claimed these gave faster relief compared to the medications prescribed by health professionals. Also, the miners who visited the health facilities said that they did so to avoid potential future complications from the injuries.

The miners indicated that they adopted several strategies to help protect themselves from the effects of ergonomic hazards. These strategies include 1) changes in posture every three hours (27%), 2) resting on particular days within a working week (27%), and 3) changes in work schedule every four hours (46%). Changes in posture and work schedules of miners were also done by undertaking mining tasks on a rotational basis.

4.2. Coping strategies adopted by small-scale miners

4.2.1. Rest

Miners adopt several strategies to cope with the risks associated with their work. The most fundamental mechanism all miners seem to appreciate is taking intermittent breaks or rest periods. In all the three study districts, miners spent one day at home once a week (taboo day), which some miners were not too happy with, but they still considered it to be an opportunity for them to rest.

4.2.2. Medication and hard drugs

Some miners indicated that because of the energy demand of their task, they take some medicine to boost their energy for work. Close to half (46.6%) of the miners take at least one form of medicine (Table 4). The dominant medicines used by miners were pain relievers specifically paracetamol, panafin, quick action, tramadol, and blood tonic (multi-vitamins). Approximately 13% of the miners used tramadol daily. On the average miners who use tramadol take as many as 10 of the 50mg tablets a day.

A 55-year-old miner confirmed the use of tramadol among the youth in the Amansie West district caused destruction to the individuals. According to him.

“A lot of the youth take tramadol thinking that they get extra energy to work, but they end up behaving abnormally at the worksite. In the absence of other workers some injure themselves or fall into open pits and drown.” Amansie West district.

Apart from this drug, other miners coped with their work through the consumption of alcohol. About 10% of respondents consumed alcohol because they claimed it gave them some strength and energy so as not to feel the pain and tiredness of their work. Those who do not take alcohol said alcohol does a lot of harm because it makes people unable to work. It rather makes them misbehave and talk without controlling themselves. The category

Table 4
Medication as a coping strategy

Medication	Frequency	Percentage
Pain killers (Paracetamol, panafin, Quick action)	38	25.7
Tramadol	19	12.8
Marijuana	7	4.7
Blood tonic (multi-vitamins)	5	3.4
Total	69	46.6

of respondents who take blood tonic (multi-vitamins) perceive it as a form of energy and appetite booster. Some miners were of the view that they can sometimes get drowned in their work and skip meals so taking blood tonic (multi-vitamins) makes them feel hungry so that they can stop working to attend to their need for food.

It is worth noting that 53.4% of all respondents do not take any medication. Those who do not take these medications claim that they try to have enough rest before the next day's work. Some of these miners further indicated that other people's experiences had indicated to them that once you start taking medication, you will not be able to stop, as you have to keep taking them daily in order not to feel weak or exhausted. They also indicated that the human body gets used to these medications (especially the pain relievers) and thus the medications do not work or relieve pain after some time.

The rock crushers and grinders were the biggest culprits when it came to the consumption of pain relievers whilst diggers and underground miners were the worst in terms of tramadol and marijuana usage (Table 5).

The incidence of tramadol consumption among diggers/underground miners was attributed to the fact that digging and underground mining are the most difficult tasks in the mining chain, which is energy sapping hence the need for additional energy via the consumption of tramadol. Moreover, 96% of all miners alluded to the consumption of energy drinks on a daily basis. Some brands of energy drinks consumed by miners included 5-star, Rush, Storm, and Blue Jeans energy drinks.

4.2.3. Registration with the National Health Insurance Scheme (NHIS)

Miners resorted to alternate means of treatment other than visiting the hospitals because they had not registered with the NHIS. Almost half of the respondents (49%) had not registered with the NHIS. Three main reasons why the miners had not registered with the NHIS were because according to them, the scheme was poorly managed (22%), the scheme was expensive (13%) or it was not necessary to register (14%).

The miners were of the opinion that the NHIS was poorly managed, because when one visits the hospital with it, they do not get the required treatment. They also felt looked down upon by health professionals, especially the nurses. They ignore them to attend to those who do not possess the NHIS cards. Reference was also made to the inception of the scheme where "better" medications were given to the sick. They claim that this was no longer the case, as the NHIS cardholders were mostly given low-cost medications. One miner said

"We already know the medication we will be given anytime we visit the health facility so instead of wasting our time, we rather keep the medications in mind and buy from the drug store whenever we are sick or rather tell the drug store attendant our symptoms so they give us better medications that meet our specific health needs"- Small-scale miner, Amansie West district.

Table 5
Coping among SSM operators

Work type	Pain relievers	Tramadol	Marijuana	Blood tonic
	%	%	%	%
Diggers/Underground Miners	8.1	10.8	2.7	0
Crushers/Grinders	10.1	0.7	0.7	0.7
Washers/Sievers	7.5	1.3	1.3	2.7
Total	25.7	12.8	4.7	3.4

Others perceived registration with the scheme was not necessary because they do not become ill. Even though they agree that sickness is inevitable, they also believe that if they take good care of themselves, they would not become ill. Therefore, registering under the NHIS is considered a waste of resources (money and time). Another reason given by the miners as to why the scheme was not necessary is that though the scheme seems to be working according to the government, the cash and carry system is actually what is in operation. The scheme is also considered as expensive by miners when compared to their earnings and the type of medicines they get.

4.2.3.1. *Savings and investments.* Savings and investments are viewed as ways by which people cope with situations by planning for the future. Some miners claim ASM activities are strenuous and very risky and as a result, they spend their money when they get it. Others said they saved for the future. Those who spend all their money do so, because they do not know when they will sustain injuries or lose their lives. Approximately 45.3% of the respondents saved with various financial institutions in the district capitals. The main reasons why miners saved were 1) educational purposes (18.2%), to accumulate money to start a business (14.2%), accumulate money to acquire property (6.1%) or to cater for unforeseen circumstance (6.8%). The essence of savings according to a miner in the Wassa Amenfi East district was to cushion miners against shocks because they do not always get gold in abundance. In actual fact, it was realised that they sometimes make losses if they dig a whole pit and do not get any gold, considering the expenses they incur such as hiring of excavators, purchase of fuel, payment of casual workers, etc. Miners who did not save gave the following reasons: money from mining is too little to save; mining is risky hence the need to enjoy benefits when money is acquired, financial institutions are not reliable and money from mining is pumped into agriculture which is the minor economic activity for some miners.

5. Discussions

The Sustainable Development Goals (SDGs) has set a target to substantially reduce the number of deaths and illnesses from hazardous chemicals, air, water, and soil pollution and contamination by 2030 [20]. The SDGs further enjoin countries to ensure that they protect labour rights and promote safe and secure working environments of all workers, including migrant workers, particularly women migrants, and those in precarious employment [20]. It is a common knowledge that health and safety is affected by complexity of factors, including regulatory frameworks, human and organizational performance, safety and organizational culture, cognitive and motivational biases in decision-making process of both management and workers and growing complexity of operational and business environment [21–23]. Legal and regulatory framework are usually out of the control of a mining enterprise. However, sound legal and regulatory framework contributes to a safe operation and safe closure, monitoring and inspections. An adequate performance in enterprise's functions has been found to bring a safe environment for workers to plan, absorb, recover and adapt to change; while attention to improve human and organizational performance help to minimise accidents and disasters [21,9,10].

Miners are expected by governments to take preventive measures against the hazards to which they are exposed. A few of the miners try to protect themselves from physical and chemical hazards by using nose masks and gloves. Some resort to intermittent rest breaks and changing work posture and schedules to mitigate their exposure to ergonomic hazards, while others wear helmets

and Wellington boots to protect themselves from injuries. Unfortunately, just as observed by [24, 26], and in other studies [3], the use of PPE such as nose masks, gloves, helmets, overalls, boots, and hearing protection aids was virtually absent at the ASM sites. The use of PPE among the artisanal miners in the study areas was generally very low. Only about 26% of the miners wore gloves, nose masks, and Wellington boots. The number of miners who wore PPE though small was slightly higher than those reported by [25]. This study on human exposure to mercury among small-scale miners in Burkina Faso revealed that none of the respondents wore boots, and only 2% used gloves while 12% used nose masks, which were even inappropriate for protection against mercury vapours.

The miners' socio-economic status was not related to the use of PPE. For example, even though more than 70% of the miners had some level of formal education, they did not use PPE, implying that the level of education of the miners did not influence the use of PPE. This could mean that even the educated miners had little understanding of why they should wear the protective clothing even though they knew the risks associated with their work. The implication here is that education with strict enforcement of the law requiring the use of PPE could ensure compliance. Admittedly monitoring and enforcement is easier with LSM than ASM because the latter is scattered and mostly unregistered. Education on the need for PPE among the small-scale miners is still necessary because the health impacts of mining activities are often difficult to detect until several years after the onset of mining [27].

According to [28] artisanal miners in the Tarkwa-Nsuaem district of the Western region of Ghana, do not use PPE because of cost, lack of knowledge about PPE, non-availability of PPE on the market, and non-enforcement of health and safety regulations. A comprehensive approach towards the promotion of the use of PPE cannot ignore the issues of cost, availability and comfort or convenience to the user. The use of pieces of cloth and rugs as coping strategies to ward off dust and chemical fumes instead of the recommended PPE was observed in the study areas. This observation points to the issue of cost and availability of the PPE.

One other reason that has not been sufficiently reported in the literature so far is that the available PPE is often not comfortable to use and can obstruct work and cause delays in carrying out their work. This implies that the designs of PPE must take into consideration the comfort of the users. Thus PPE meant for use in the tropics must consider heat and humidity as factors in their design and manufacture. If miners believe the use of particular PPE is likely to affect their work they will certainly not use it.

Beyond the use of PPE, miners adopt some coping strategies. Miners adopted strategies to protect themselves from the effects of ergonomic hazards such as musculoskeletal disorders and also cope with the risk of injuries. Strategies to safeguard their health against the effects of ergonomic hazards included changes in work posture and work schedules, frequent rest and the intake of medication. The intake of medication in all the study areas was noted to be self-medication. Self-medication was predominant in Ghana [29] because of limited access, since one out of every four people lived outside a 15 km radius of a doctor. The reason for self-medication among the small-scale miners in this study was not an issue of distance. In this study, the self-medication rate among small-scale miners was almost 47%. This rate of self-medication in the study districts is likely to have some short-term or long-term negative effects on miners health. The use of tramadol and marijuana among small-scale miners in this study implies an abuse of drugs (mostly banned.) This is because it is illegal to grow or consume marijuana and also consume tramadol without a doctor's prescription in Ghana. The abnormal behaviour exhibited by the youth who consume tramadol is similar to effects of the drug reported by the World Health Organisation [30]. According to this WHO report

overdose of tramadol can cause several health effects such as respiratory problems, seizures, mental and physical disorders. A study from [31] confirms that miners resorted to harmful coping mechanisms such as drug and alcohol abuse, which complicated their health conditions.

Also, 14.9% of the miners who were injured resorted to the use of herbal medicine for treatment. This finding is similar to a study by [32] on risk management in gold mining. According to [32], the most common cases of hand and arm injuries and inflammation of joints were treated with the use of traditional healing methods such as the application of locally made balms. Although coping mechanisms are necessary, it is imperative for miners to get used to the preventive measures rather than relying on the coping measures. These coping strategies may also have some side effects that may not be evident in the short-term.

Concerning safety nets and insurance, this study has revealed that almost half (i.e., 49%) of the miners had not registered with the NHIS implying the use of the cash and carry system where patients were made to pay for health services at the point of access. In situations where miners get seriously ill or injured and they are required to pay for treatment at the point of access, they may unfortunately not be able to pay since about 55% of them have no savings. Insuring one's life was a way of safeguarding oneself against health risks because insurance is an important risk-financing tool [10].

The low rate of PPE usage and relatively high rate of intake of medications and hard drugs requires that miners insure their lives by way of savings and health insurance in order to finance ill-health, which is usually unforeseen and unpredictable.

6. Conclusion

This study has revealed that as part of measures to cope with the risks of ASM, some miners take drugs that are illegal and also abuse over the counter pain relievers. It has also brought to the fore that some miners are not interested in registering with health insurance packages and saving part of their earnings as safety nets for them in case of injuries and diseases. The study has revealed that some miners do not use PPE because it is not comfortable. The majority of the miners do not use PPE because they do not see the need to use it irrespective of their levels of education.

There is therefore, the need for the producers of PPE to vary their designs to meet the different conditions of users, while considering the cost. It is our conviction that if the cost, availability, and appropriateness of the PPE in terms of design are taken into account, the small-scale miners will wear the PPE to improve their health conditions and minimise the risk of injuries and diseases. It is important for the government to put in place measures to ensure that miners adhere to health and safety regulations before undertaking mining activities. It is therefore, recommended that the use of PPE is made a pre-requisite for undertaking any mining activity. This means that the use of PPE should be linked to the license acquisition process where officials will inspect the PPE before the miners start work. There is also the need to educate miners on the dangers associated with self-medication so that miners will avoid future health problems as a result of the medications they take.

Funding

The author(s) disclose receipt of the following financial support for aspects of the research of this article: We are grateful to DANIDA for funding this research through the SHEATHE project (16-P03-GHA), hosted by the Kwame Nkrumah University of Science and Technology (KNUST).

Conflicts of interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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