

Assessment of Workers' Knowledge and Views of Occupational Health Hazards of Gold Mining in Obuasi Municipality, Ghana

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ABSTRACT

Introduction: Small-scale mining in Ghana has been a major community and national concern due to its contribution to the destruction of farmlands and bodies of water, and to the loss of human life. Small-scale mining exposes workers to varying degrees of health hazards and problems.

Objectives: The study aimed to assess the knowledge and views of workers about the occupational health hazards and problems related to small-scale gold mining in Obuasi Municipality, Ghana, to help improve workers' safety at the mining sites.

Methods: A cross-sectional study was done between May and December 2011. Simple random sampling was used to select 150 small-scale miners take part in this study. The workers were asked about their knowledge and views of occupational health hazards and problems related to gold mining. Data were entered with EpiData Entry 3.1 and analyzed using Stata 11.

Results: Most workers (95, 63.3%) had low knowledge of occupational health and safety regulations. Multivariable logistic regression analysis showed that knowledge about regulations was associated with level of education (OR = 8.5; 95% CI: 7–10.5). The common effects of mining that workers expressed awareness of were land pollution (30%), water pollution (28%), air pollution (18.7%), and noise pollution (16%). The factors influencing exposure to health hazards related to mining were low educational levels (14%), little work experience (30.7%), incorrect handling of equipment or chemicals (26%), poor law enforcement (12.7%), and negligence (16.7%). In general, occupational lung disease (16%), occupational hearing loss (14%), heat illnesses (12%), eye infections (16%), malaria (24%), and skin infections (18%) were the most common health problems study participants mentioned.

Conclusion: High levels of occupational health hazards and problems related to gold mining exist among workers in private mines. Safety program should be offered as part of associated public health programs to limit the most significant risks. We further recommend education and training on regulations and the use of personal protective equipment.

Key words: Ghana, gold mining, hazards, health problems, occupational health, safety

DOI: <https://doi.org/10.3126/ijosh.v10i1.29880>

Introduction

A 2003 International Labour Organization (ILO) report estimated that about two million occupational fatalities are recorded in the world every year, with

Date of submission: 05.05.2020

Date of acceptance: 21.06.2020

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the highest proportion of these deaths being caused by work-related diseases.^{1,2} In a report published in 2006, Hämäläinen et al. estimated the global annual rate of occupational accidents, fatal and nonfatal, at 270 million.³ An area that is perceived to cause most occupational morbidities and mortalities in Ghana is small-scale mining. According to the ILO estimates, mining employs 1% of the global workforce that accounts for 8% of the global work-related fatalities.^{4,5} In Ghana, although small-scale mining contributes



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immensely to the nation's economy as it results to the creation of employment, investment opportunities, and revenue,⁶⁻⁸ but has been a significant contributory factor of causing occupational health hazards and problems as well as causing destruction to the environment.⁹ Gyekye (2006) reported that workers in small-scale mining are exposed to health risks and hazards. In Ghana, an estimated 15,702 per 100,000 occupational accidents and 1852 fatal accidents occurred in 2014.¹⁰

However, a national data on small-scale mining-related health hazards and problems in Ghana are not available making it challenging not only for researchers in the mining sector¹¹ to have literature to support their research findings but also to inform authorities in the fight against accidents associated with small-scale mining. Although, some studies conducted in Ghana reported on health hazards and problems of small-scale mining,¹¹⁻¹³ the data of these studies may not be a representation of the entire nation as the studies only reported on few mining sites. For instance, in Aubynn's (2011) study that reported 300 deaths of small-scale miners only covered few places like Akrokerri, Obuasi, Jacobu, Prestea, Kyekyewere, Kenyasi, Dunkawon-Offin, Subriso, Subriso Fante, and Dompooase¹⁴. Between June 2015 and August 2016, Nakua et al. also reported in their study conducted in four mining districts in Ghana that the injury rate associated with small-scale mining was 289 per 1000 workers.¹⁵ Studies have also indicated that details about occupational morbidities and mortalities are not well recorded¹⁶⁻¹⁹ and thus, making it challenging to inform the need to fight against health hazards and problems associated with mining. It is perceived that small-scale mining in Ghana has been a major focus at the community and national levels because it causes most of the morbidities and mortalities in mining communities.¹⁸

Mining, whether surface or underground, involves the use of tools, equipment, and chemicals that are potentially hazardous to health and the environment. Mining operations expose workers and the entire mining community to risks related to the use of explosives and chemicals, and to the grit and dust generated in the course of mining activities.²⁰ Thus, irrespective of the economic contributions of small-scale mining, the practice comes at a significant cost. Miners are at risk of occupational injuries, working in harsh and risky environments, typically for low pay²¹ and mining operations cause considerable environmental damage.²² According to the ILO, miners working in smaller mines are 6–7 times more likely to experience occupational injuries than their counterparts involved

in large-scale operations.²³ This situation occurs in Ghana and in other countries where gold is found, and the problem tends to be worst at small-scale gold mines.²⁴

Despite the existence of interventions to control occupational health hazards and problems, major gaps remain in the health status of workers at small-scale mines between and within countries. While engineering controls are the preferred approaches to mitigating safety hazards in mines, these approaches are often ignored due to the inability of owners of small-scale mining companies to afford the equipment required to implement these approaches.²³ Therefore, the 60th World Health Assembly in 2007 endorsed the global plan of action on workers' health (2008–2017) to provide a political framework for the development of policies in all workplaces throughout the world.²⁵ This plan aimed to promote workers' health and prevent health problems by linking global occupational health to global public health.²⁵ Nevertheless, despite global interventions such as these, a lack of safety regulations, law enforcement, education, training, functional infrastructure, and equipment yet there is increased injuries related to gold mining in most low-middle-income countries, including Ghana.²⁶

Furthermore, mine workers, especially at gold mining companies, are vulnerable to occupational health hazards and problems because of inadequate knowledge on the use or manipulation of machines/tools, the use of substances, and low use of advanced personal protective equipment (PPE). The level of mechanization in small-scale mining in Ghana is also extremely low. Small-scale mining activities are carried out with inadequate safety precautions, and the techniques employed by small-scale miners are believed to be obsolete, which further exposes the workers to health hazards.²⁷ While engineering controls are the preferred methods of improving occupational risks in mines, it has been documented that the use of less popular alternatives, including the use of PPE such as hardhats, safety glasses, gloves, and work boots, also appear to be uncommon among small-scale miners.²⁸ A survey conducted in Ghana revealed that most small-scale miners have not been consistently using protective equipment²⁸ as well as following the requisite regulations. This raises questions about why even the least expensive and most common methods used to protect miners from injuries are not prevalent. In Ghana, employers are required to ensure their workers are not exposed to conditions that could lead to work-related injuries and illness²⁹ and workers are

entitled to compensations for injuries received within the workplace.³⁰ Workers are also required by law to be responsible for their safety, as required by their employers' standard operating.²⁰ Moreover, some studies have examined the health impacts of mining at the community level in Ghana. One study focused on Tarkwa, a gold mining community, while another was conducted in Obuasi and Tarkwa, before Ghana's independence in 1957. The results of these studies highlighted a common concern: educating mining communities and companies on the effects mining has on health, specifically that it increases the prevalence of morbidity and mortality associated with gold mining operations.^{31,32}

Residents of Obuasi Municipality in Ghana suffer from various health conditions that result from gold mining, with the region having a higher prevalence of infectious and chronic diseases. The water pits created by mining activities within the Obuasi Municipality serve as reservoirs where mosquitos breed, which leads to a higher prevalence of malaria. Additionally, cyanide and mercury used for gold processing are left to run into bodies of water, leading to an increase in skin diseases among those who use the water.³³ Similarly, patients in the Ashanti Goldfields Company (AGC) Hospital at Obuasi showed symptoms of arsenic poisoning, with arsenic introduced to bodies of water through AGC's gold mining operations.³⁴

Besides what has been reported in these studies, little is known about occupational health hazards and problems associated with small-scale mining in Ghana. Therefore, the present study was conducted to assess workers' knowledge and views of occupational health hazards and problems in small-scale mining in the Obuasi Municipality to improve workers' safety at the mining sites. We assessed workers' knowledge and views about several factors specifically related to gold mining: occupational health and safety regulations (OHSR), health hazards and problems, approaches to addressing health hazards and problems, experiences with common health problems, and accident history. It is important to assess workers' knowledge and views, as these factors are responsible for workers' health and safety at the workplace.

Methods

Study Setting

The study was conducted in the Obuasi Municipality in the south-western part of the Ashanti Region of Ghana, as shown in Figure 1. Obuasi, the administrative capital

is home to AngloGold Ashanti's Obuasi Gold Mine, one of the nine largest gold mines in the world.³⁵ The most prevalent geology type in the area is Precambrian greenstone. Most of the population are Ghanaians, and the major occupational groups include service and sales workers, followed by plant and machine operators and assemblers.³⁵

Study Design

A cross-sectional study was conducted between May and December 2011 to assess workers' knowledge and views regarding the prevailing occupational health hazards and problems associated with small-scale gold mining in the Obuasi Municipality. A cross-sectional study was necessary due to the small sample size, inadequate time and resources for the study.

Sampling Procedure and Sample Size

A random sampling method was used in the city and a rural area, to ensure the inclusion of urban and rural respondents. Workers from three suburbs within Obuasi city were recruited from a list of residents who registered for the study; the selection method was repeated for workers from two rural communities. The sample included active, injured, and retired workers (pensioners), all above the age of 19, who had worked in small-scale gold mining. We defined active workers as those who were actively engaging in mining work, injured workers as those who had been affected by mining-related injuries, and pensioners as those who had retired from mining activities. We excluded respondents who were not or had not been employed at small-scale gold mines. Likewise, workers with less than one year of working experience were excluded from the study because they were considered to have too little knowledge about gold mining.

Overall, 150 respondents from five communities (rural and urban) participated in the study; 88 were active workers, 44 were injured workers, and 18 were pensioners. The sample size of 150 was calculated based on a confidence level of 95%, an 8% margin of error, and a proportion of 50% for an unknown proportion. Based on the 150 participants, the proportion would be 10:5:2. This means for every 10 active workers selected, 5 have sustained an injury from small-scale mining operations and 2 have retired. The sample size was calculated based on the following formula:

$$N = \frac{Z^2 P (100-P)}{E^2}$$

where N = sample size; P = expected proportion, with

P = 50% for unknown proportion; E = margin of error, set at 8% for this study; and Z = level of confidence, with Z = 1.96 for a 95% CI. Thus,

CI. Thus,

$$N = \frac{1.96^2 * 50(100-50)}{8^2}$$

N = 150

Data Collection

The first author and two trained research assistants from the Obuasi Municipality collected the data using a survey questionnaire that were self-administered as well as naturalistic observations. The naturalistic observations allowed us to record spontaneous behaviors of the study subjects in their natural surroundings based on what we observed. The interviews were conducted individually among the group of workers to record their knowledge and views about health hazards and problems associated with gold mining. Additionally, we used an observational checklist on OHSR as a data collection tool to collect data on OHSR. Respondents had the opportunity to select multiple options.

We administered 150 structured questionnaires to collect information on sociodemographic characteristics, occupational health history, and workers' knowledge about gold mining. The questions that focused on approaches to addressing health hazards and problems in mining each included eight answer options, and respondents could select multiple answers. The questions covered the following topics:

- The most common and significant factors influencing exposure to mining-related health hazards and problems
- The most common and significant occupational health problems experienced by workers involved with small-scale gold mining
- The most convenient way to address mining-related health hazards and problems

Occupational health and safety records and practices

Several questions, such as those relating to respondents' accident history, work status, and health history, included only "yes" and "no" answers to allow for easy responses.

Data Management, Monitoring, and Evaluation

Data were kept confidential. The quality of the data was controlled through a daily review of the data collection instrument in the field at the end of the data

collection process. Errors were identified and corrected throughout the study period and monitoring and evaluation took place from the beginning of the study. Regular follow-ups and supervision were performed to check the authenticity of the data.

Data Analysis

We used EpiData Entry 3.1 statistical software³⁷ for data entry, and Stata 11 statistical software³⁸ for data analysis. Furthermore, we used descriptive statistics in the form of cross tabulations, charts, graphs, and Pearson's chi-squared tests to test the statistical significance of the information. The analysis of the workers' knowledge regarding OHSR was grouped according to whether it was a *high level* of knowledge (good, average, and fair) or a *low level* of knowledge (low and poor). We defined high-level knowledge among workers based on their level of education (college or university), which influenced their ability to read, understand, and interpret the safety regulations. A low level of knowledge among workers was also defined based on workers' poor interpretations of the safety regulations and inability to read, write, and understand safety regulations, which was influenced by their low level of education (primary to secondary).

We used multivariable logistic regression to analyze the assessment of workers' knowledge about OHSR based on the demographic characteristics of the workers. The analysis included dependent variables, where the responses were summarized. The results indicated that knowledge about OHSR was associated with the level of education and working experience, and the ability to read and understand the regulations. Workers with a college or university education had a higher level of knowledge about regulations on mining than did workers with only primary to secondary school education (OR = 8.5; 95% CI: 6.6–10.5; see Table 1). The tendency for respondents to be in the group with low levels of education (primary to secondary education) was high (8.5), while workers with a college or university education had a low tendency to fall into the group with low levels of knowledge about OHSR.

Ethical Considerations and Trustworthiness

We obtained ethical approvals and permissions from the Obuasi Municipal Health Directorate. Furthermore, we obtained informed consent from the participants to meet the research criteria related to autonomy. To allow participants to make informed choices, we explained the aims and advantages of the study to them. The study participants had 14 days to confirm

participation in the study by signing a consent form. We further informed participants that they had the liberty to withdraw from the study at any point without any threat and that they could complete and sign a withdrawal form and submit it to the first author.

Results

A total of 150 small-scale gold miners in the Obuasi Municipality were included in the study. All the study subjects completed the study between May and December, 2011. The results of this study are presented here.

Sociodemographic Characteristics of the Study Participants

Table 2 summarizes the sociodemographic characteristics of the people who constitute the study sample. Most were males (98%), active workers (58.7%), and 31–35 years old (32%). Of the respondents, 51.3% were married and 45.3% single. Overall, 62.7% lived in urban areas and 74.7% had completed primary to secondary education compared with college or university education (38%).

Workers' Knowledge of OHSR

Most workers had low knowledge about OHSR in the workplace. We asked the workers which general regulations they knew of regarding gold mining operations and the environment, health and safety, the use of chemicals and equipment, and material safety data sheets. We used two indicators—*low level* of knowledge (low and poor) and *high level* of knowledge (good, fair, and average)—to measure their responses as recorded through the survey questionnaires. We observed that 63.3% of the workers had a low level of knowledge about OHSR compared to 36.7% who had a high level of knowledge.

Workers' Knowledge and Views about OHSR According to Educational Level

The results showed significant differences in the levels of knowledge about OHSR in respect of educational levels ($p < 0.01$) among the workers. However, workers with primary to secondary education (73.2%) had lower knowledge of OHSR than workers with a college or university education (34.2%). Workers with higher knowledge levels about OHSR were the workers with higher levels of education (26.8%) compared with workers with lower knowledge levels about OHSR (65.8%) who fell within the workers with lower levels of education.

Workers' Awareness of Health Problems Caused by Gold Mining

Most workers (72.7%) stated that gold mining causes health problems, while 27.3% disagreed. However, the researcher observed that the workers who had been living in one mining community for a longer period had more advanced awareness about the health problems caused by mining.

Workers' Approaches to Addressing Health Hazards Related to Gold Mining

Results from workers' approaches to addressing health hazards and problems related to gold mining are presented in Table 3.

Workers generally had a poor approach to this topic, possibly linked to their inability to afford medical care due to financial constraints. Slightly more workers (20%) accepted that gold mining has health effects than reported offering assistance to others (17.3%). The same number of workers were willing to undergo further treatment when testing positive for mining-related health problems than were unable to seek medical attention due to financial constraints (10.7%). Finally, 10.7% were willing to be screened, while 12.7% feared being screened.

Factors Influencing Exposure to Occupational Health Hazards

Several factors are associated with the exposure to occupational health hazards and problems associated with gold mining in the Obuasi Municipality (Figure 2).

Workers reported that the most significant exposures to mining health hazards and problems may be attributed to limited work experience (31%) and the poor handling of equipment and chemicals (26%). However, proportionally, few participants reported poor enforcement of mining and safety laws (13%) as being a factor of exposure. In general, we observed that the most significant factors were not associated with educational level (14%).

Workers' History of Health Problems Related to Gold Mining

Most workers (72%) reported that they had experienced health problems that may be associated with gold mining. Workers reported that those with less working experience and lower educational levels are more prone to mining-related accidents than workers with more years of experience and higher education levels.

The Most Common and Significant Occupational Health Problems Workers Experienced

Gold mining contributes greatly to health hazards and problems in the Obuasi Municipality. Malaria, skin infections, and occupational lung disease (OLD) were the most widely reported health problems, as shown in Figure 3.

Workers' Accident History by Work Status

The findings showed that there is no significant association between accident history and work status ($p = 0.21$). Among the group of workers, active workers (73.9%), injured workers or workers suffering from mining-related health problems (84.9%), and

pensioners (88.9%) reported similar proportions of mining-related accidents. The results show that more accidents had occurred among the retired workers.

Health and Safety Records, Practices, and Environmental Health and Sanitation

The findings showed that most workers did not follow OHSR in the workplace. For instance, 59% did not perform any risk assessments, 62% did not have a first aid kit, and 68% did not have material safety data sheets. Table 4 provides a summary of the findings based on observation and workers' opinions as recorded in the observational checklist.

Table 1: Multivariable Logistic Regression Analysis of Association Between Workers' Demographic Characteristics and Knowledge of Occupational Health and Safety Regulations (N = 150)

| Characteristic | Low | High | Odds Ratio | 95% CI |
|----------------------------|-----|------|------------|--------------|
| Sex | | | | |
| Male | 93 | 54 | 1 (Ref) | |
| Female | 2 | 1 | 1.98 | (0.11–35.16) |
| Work Status | | | | |
| Pensioners | 11 | 7 | 1 (Ref) | |
| Active workers | 31 | 31 | 1.04 | (0.92–3.0) |
| Injured | 53 | 35 | 1.52 | (0.59–3.86) |
| Age Group (y) | | | | |
| 20–25 | 8 | 10 | 1 (Ref) | |
| 26–30 | 12 | 9 | 1.9 | (0.46–7.82) |
| 31–35 | 36 | 12 | 3.8 | (1.12–13.17) |
| 36–40 | 12 | 10 | 1.71 | (0.43–6.79) |
| 41–45 | 11 | 5 | 4.19 | (0.74–23.69) |
| 46–50 | 8 | 6 | 2.52 | (0.54–11.84) |
| > 50 | 8 | 3 | 3.69 | (0.58–23.35) |
| Educational Level | | | | |
| University/college | 12 | 25 | 1 (Ref) | |
| Primary–secondary | 82 | 30 | 8.54 | (6.56–10.5) |
| Work Experience (y) | | | | |
| 1 – 5 | 41 | 22 | 1 (Ref) | |
| >5 | 54 | 33 | 1.14 | (0.82–3.1) |
| Marital Status | | | | |
| Single | 51 | 26 | 1 (Ref) | |
| Married | 41 | 27 | 0.65 | (0.29–1.42) |
| Divorced | 3 | 2 | 1.43 | (0.16–12.91) |
| Residence | | | | |
| Urban | 62 | 32 | 1 (Ref) | |
| Rural | 33 | 23 | 0.73 | (0.34–1.58) |

Table 2: Sociodemographic Characteristics of Study Participants (N = 150)

| Characteristics | Number of Participants | Percentage of Participants (%) |
|------------------------------|------------------------|--------------------------------|
| Worker | | |
| Active worker | 88 | 58.7 |
| Injured worker | 44 | 29.3 |
| Pensioner | 18 | 12 |
| Sex | | |
| Male | 147 | 98 |
| Female | 3 | 2 |
| Age Group (y) | | |
| 20–25 | 18 | 12 |
| 26–30 | 21 | 14 |
| 31–35 | 48 | 32 |
| 36–40 | 22 | 14.7 |
| 41–45 | 16 | 10.7 |
| 46–50 | 14 | 9.3 |
| 51+ | 11 | 7.3 |
| Educational Level | | |
| Primary–secondary | 112 | 74.7 |
| College/university | 38 | 25.3 |
| Worker Experience (y) | | |
| 1–5 | 87 | 58 |
| > 5 | 63 | 42 |
| Marital Status | | |
| Married | 77 | 51.3 |
| Single | 68 | 45.3 |
| Divorced | 5 | 3.3 |
| Residence | | |
| Urban | 94 | 62.7 |
| Rural | 56 | 37.3 |

Table 3: Workers' Approaches to Addressing Health Hazards and Problems Related to Mining (N = 150)

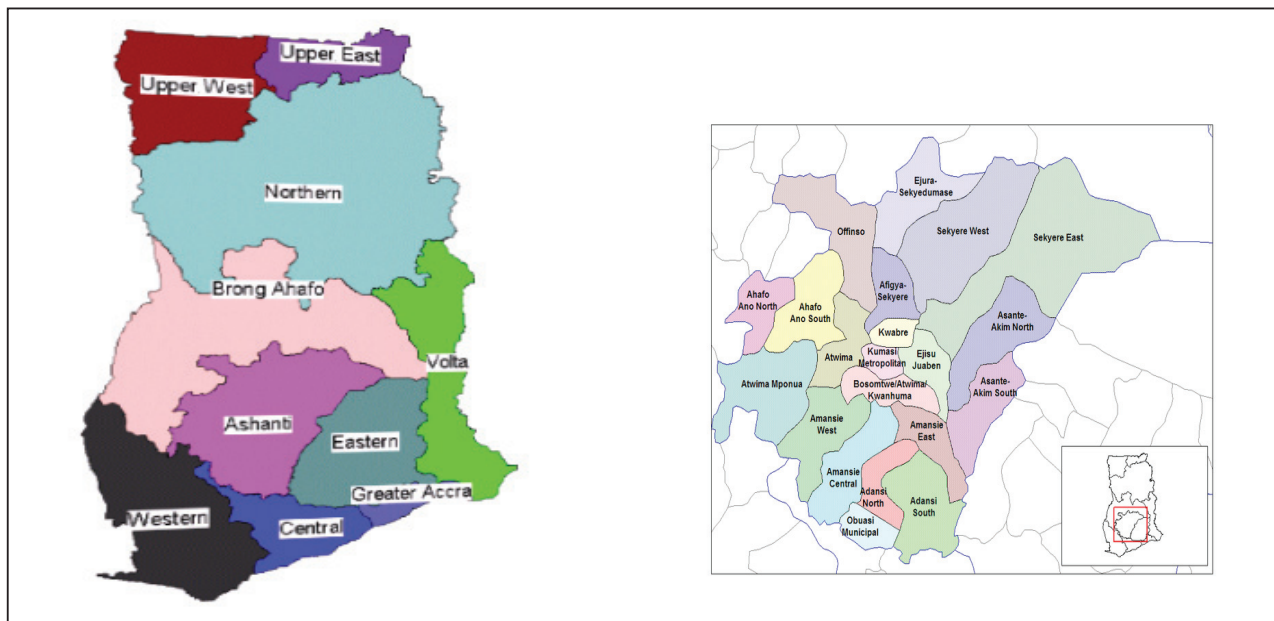
| Attitudes and practices | Number of Participants | Percentage (%) | Cum. Percentage (%) |
|-----------------------------------|------------------------|----------------|---------------------|
| Accept that mining affects health | 30 | 20 | 20 |
| Willing to be screened | 16 | 10.7 | 30.7 |
| Going for further treatment | 16 | 10.7 | 41.3 |
| Facing financial constraints | 16 | 10.7 | 52 |
| Offering assistance to others | 26 | 17.3 | 69.3 |
| Self-reporting symptoms | 13 | 8.7 | 78 |
| Fear being screened | 19 | 12.7 | 90.7 |
| Ask for screening | 14 | 9.3 | 100 |
| Total | 150 | 100 | |

Table 4: Health and Safety Records, Practices, and Sanitation based on Workers' Knowledge

| Features | Present | Absent |
|--|--------------|--------------|
| Records | | |
| Individual workers | 114 (76%) | 36 (24%) |
| OHS ¹ board | 47 (31.33%) | 103 (68.67%) |
| Licensed OHS board | 78 (52%) | 72 (48%) |
| Accident reports | 82 (54.67%) | 68 (45.33%) |
| Inspection reports | 51 (34%) | 99 (66%) |
| Medical checkup | 70 (46.67%) | 80 (53.33%) |
| Risk assessment | 61 (40.67%) | 89 (59.33%) |
| Health and Safety | | |
| First aid kit | 57 (38%) | 36 (24%) |
| Firefighting equipment | 59 (39.33%) | 91 (60.67%) |
| Emergency exit | 80 (53.33%) | 70 (46.67%) |
| Warning signs | 80 (53.33%) | 70 (46.67%) |
| Proper electrical systems | 59 (39.33%) | 91 (60.67%) |
| Instructions on chemicals | 100 (66.67%) | 50 (33.33%) |
| Labeling on containers | 94 (62.67%) | 56 (37.33%) |
| Material safety data sheets | 48 (32%) | 102 (68%) |
| Environmental Health and Sanitation | | |
| Adequate cleaning systems | 93 (62%) | 57 (38%) |
| Good floors | 117 (78%) | 33 (22%) |
| Regular inspections | 86 (57.33%) | 64 (42.67%) |
| Suitable protective equipment | 96 (64%) | 54 (36%) |
| Adequate ventilation | 81 (54%) | 69 (46%) |
| Adequate machine guards | 100 (66.67%) | 50 (33.33%) |
| Adequate work rooms | 108 (72%) | 42 (28%) |
| Adequate storage | 71 (47.33%) | 79 (52.67%) |
| Risk assessment | 89 (59.33%) | 61 (40.67%) |

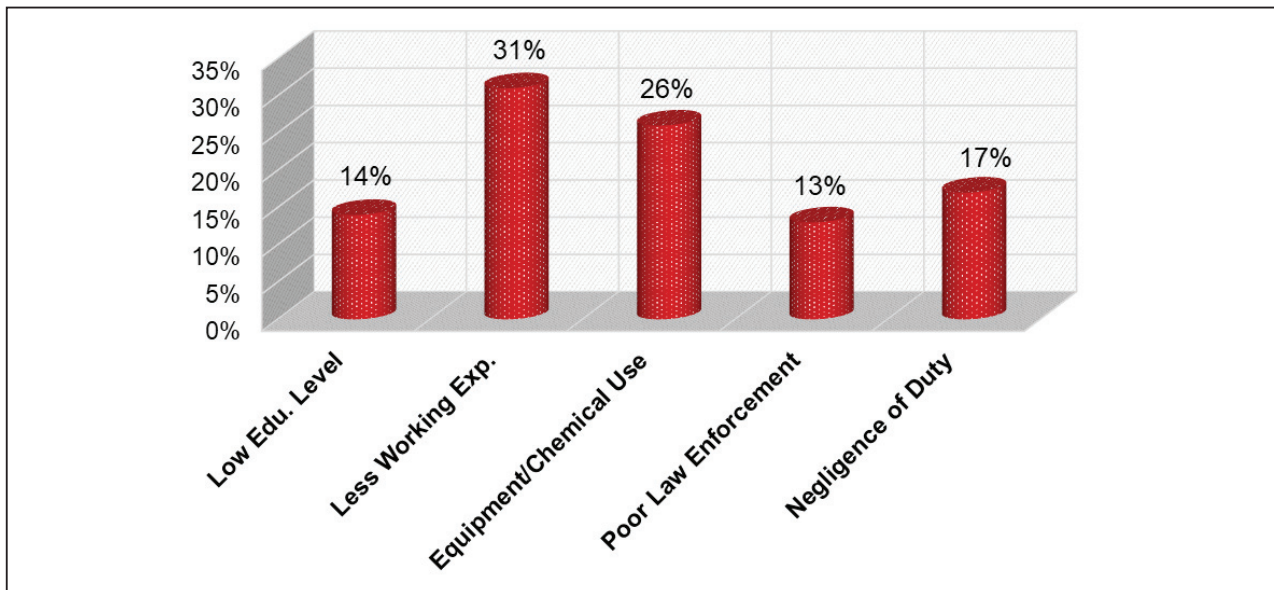
Notes. Data regarding availability of features based on observation and interviews.

¹Occupational health and safety



Note. Regions of Ghana are shown on the left, and a map of the Ashanti Region on the right. Obuasi Municipality is indicated with an arrow.³⁶

Figure 1: Map of Ghana Showing Study Area



Notes. Edu. = educational; exp. = experience

Figure 2: Most Common and Significant Factors Influencing Exposure to Occupational Health Hazards Associated with Mining based on Workers' Views

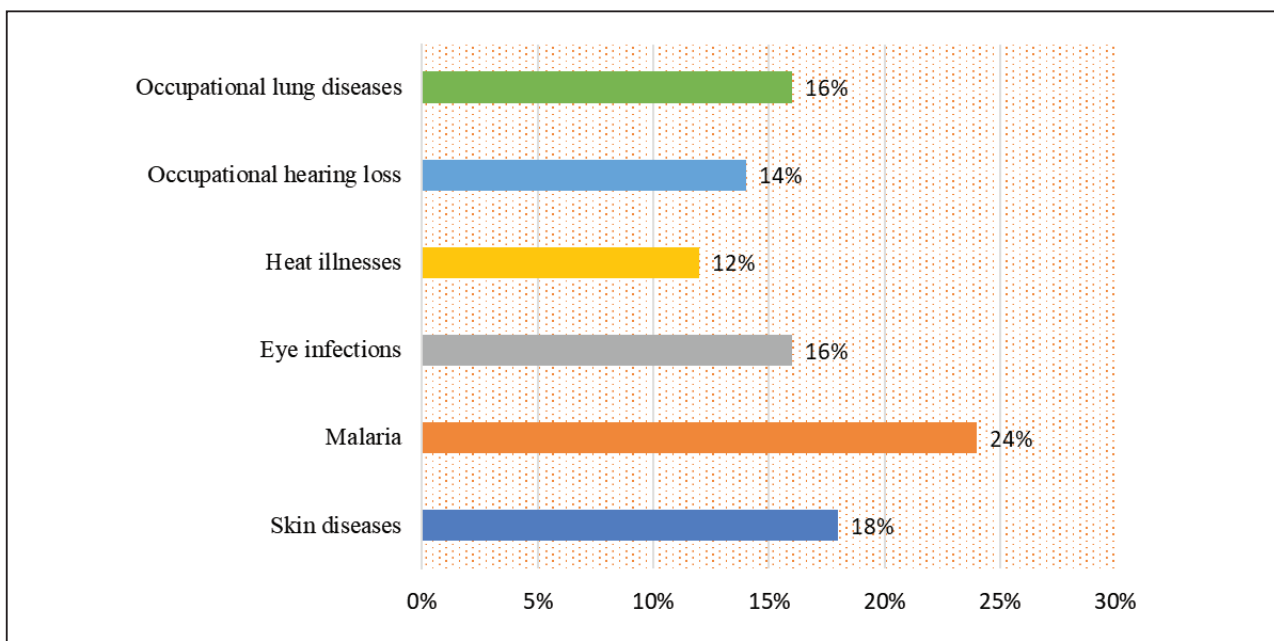


Figure 3: The Most Common and Significant Occupational Health Problems Workers Reported

Discussion

Small-scale gold mining in Ghana has attracted much attention due to the increased rates of morbidity and mortality and environmental destruction associated with it. Small-scale mining has more occupational health hazards than regulated mining.³⁹ The present study included active, injured, and retired workers in gold mines from both rural and urban areas of the Obuasi Municipality.

We compared the most common and significant work-related health problems among the active and injured workers by considering the following explanatory variables: duration of work, place of work (surface or underground), exposure to solar heat, physical fitness, distance covered to work daily, and eating habits. Our survey indicated that eye infections, skin diseases, and occupational hearing loss (OHL) were the most common and significant health problems among active

workers. For injured workers, malaria, OHL, heat illnesses, and skin diseases were the most common and significant health problems.

Jennings (2003) found that the poor maintenance of mining equipment leads to mining-related accidents and injuries and that the equipment used by gold miners is designed with limited safety features, leading to increased mining-related injuries among equipment operators.⁴⁰ Furthermore, Michelo et al. (2009) identified rock falls as one of the most common causes of fatalities in gold mines. Given this, a comprehensive safety campaign associated with public health programs has the potential to reduce the most significant health and safety risks for gold miners.⁴¹ This study suggests that workers are provided with PPE suitable for the type and level of risk they experience. If it becomes difficult to control risk at the mining site, PPE must be provided and maintained as reasonably necessary without cost to workers. The PPE should comply with the standards set by mining authorities and considering ergonomic principles. Further findings of the present study are discussed in subsequent sections.

OHSR in Mining

We found low implementation of workplace safety measure among small-scale miners in the Obuasi Municipality. Low educational levels and limited work experience contributed to miners' inability to understand and comply with safety regulations. Additionally, the results of this study suggest that small-scale mining companies should identify and report unsafe acts, unsafe working conditions, and failure to adhere to existing health and safety policies at mines, and also focus on making recommendations to address health and safety problems to ensure the safety of workers.⁴² We could not establish whether the workers who participated in this study were aware of and understood the regulations published by the Ghana Chamber of Mines and the Inspectorate Division of the Mineral Commission because the respondents did not comment on the activities of these two bodies when verbally asked.

Most participants had low levels of knowledge on OHSR and compliance levels, probably because scant attention has been paid to OHSR in Ghana, despite increased mining-related injuries and diseases. The ILO (2005) also reported that work-related accidents continue to increase in the world, which may be associated with workers' low levels of knowledge about occupational health and safety (OHS).⁴³ We could

also not establish whether workers were aware of Ghana's occupational services policy, which was jointly developed by the Ministries of Manpower, Youth, and Employment; Health; and Lands, Forestry and Mines in 2000. The policy is intended to ensure that better health and safety policies are put in place to protect workers' health and safety in all occupational sectors.²⁹

Our survey revealed that Ghana has not shown a strong commitment and support for enforcing OHSR because of about 70 ILO conventions and recommendations focused on OHSR, Ghana had adopted only nine (ILO Occupational and Safety Conventions)⁴⁴⁻⁵² by 2012 when this study was conducted. Moreover, none of the four core conventions on OHS, conventions^{52, 53-55} have been adopted by Ghana. While the Ghana Labour Act (654 of 2003)²⁹ contains a section on ILO conventions 115 and 161 that highlights OHS for workers, Ghana has not adopted all the recommendations set out in conventions 115 and 161 to ensure complete safety for workers. Ghana's failure to fully adopt the ILO conventions and recommendations may not be the cause of the occupational health hazards and problems in the small-scale mining sector, but it indicates that Ghana has attached less importance to OHSR. This may have also contributed to less knowledge of OHSR among most of the study participants.

Another concern is that even if workers are issued adequate PPE and OHSR are implemented, if workers are not educated on the use of PPE and observing OHSR, they will still be potentially exposed to occupational health hazards and problems in the workplace. Therefore, by fully implementing the ILO recommendations relating to OHSR will be a significant step in controlling health hazards and problems, with the associated health education programs, seminars, and other public programs focusing on OHSR to ensure awareness and prevention of risks.

Our findings on workers' awareness about OHSR suggests that most workers are aware of the presence of regulations. However, the levels of knowledge about the content and the understanding of the regulations were low. This further supports the need for efficient education and training on the content of the regulations to improve compliance levels. The findings of the present study related to regulatory compliance are also at odds with the Ghana Labour Act (2003), which requires employers to ensure that their workers are not exposed to conditions that could lead to work-related injuries and illness.²⁹ We observed that if these

regulations were in operation at the small-scale mine sites, most of the workers interviewed should not have had low levels of knowledge on the regulations.

The Most Common and Significant Factors Influencing Exposure to Health Hazards and Problems Related to Gold Mining

In every country, the primary focus of OHS initiatives has been on chemical, biological, and physical exposures or hazards, diseases, disorders, and injuries related to or affecting work. Psychosocial risks at work remain largely neglected and their causes and consequences still insufficiently understood.²⁵ Though psychological risks are equally important to address, this study was limited in assessing such risks, which necessitates the need for further study.

Several factors influence gold miners' exposure to health hazards in Obuasi Municipality. The findings of the present study suggest that inadequate work experience, negligence, and poor handling of chemicals and equipment may have greatly contributed to exposing miners to occupational health hazards. This could be a result of workers' low levels of knowledge on OHSR coupled with Ghana attaching less importance to the implementation and enforcement of these regulations. A study on the impact assessment of mining activities by Acheampong (2004) reported similar factors of exposure to occupational health hazards in all mining communities in Ghana.⁶² Acheampong's study suggests that exposure to these hazards can be reduced through the enforcement of OHSR and the periodic education of workers on these regulations.

The Most Common and Significant Occupational Health Problems Related to Gold Mining

In 2005, the ILO reported that occupational diseases accounted for 1.7 million annual work-related deaths, outpacing fatal accidents by four to one. This showed a lack of regard for OHSR by employers in general.⁴³ The most common and significant health problems we recorded in the Obuasi Municipality were OLD, OHL, heat-related illness, eye infections, malaria, and skin diseases. Eye infections were more common among active workers, malaria among injured workers, and OLD among pensioners.

Malaria and skin diseases were prevalent among workers. Although malaria is an environmental problem, its high prevalence in the Obuasi Municipality may be attributed to gold mining, as the mines create pool

of stagnant water in which mosquito larvae thrive. A study on disease and mortality among miners reported similar findings that malaria and skin infections have the highest prevalence of all diseases in the Obuasi Municipality.⁶³ Another study on the impact of mining activities carried out in Obuasi and Bibiani also reported that malaria was the most prevalent among all mining health-related problems.⁶² Similarly, a study conducted at the AGC Hospital found that 76% of the population living in Obuasi (Obuasi Center for Disease Control, 2001) carried the malaria parasite, while a survey conducted at the Municipal Health Centre put the proportion at 75%.⁶⁴

Moreover, our analysis indicated that skin diseases were the second most common disease type. The high prevalence of skin diseases may be the consequence of the contamination of water through mining operations and the improper disposal of waste products. Our survey established that chemicals used in small-scale mining (cyanide, sulfur dioxide, and mercury) were allowed to run into water after being used for gold processing. This contaminates the water, making it unsafe for use. We established, based on our observations, that uninformed residents who rely on such bodies of water as their only source of water use the contaminated water for their household activities, resulting in the development of various skin diseases and other related infections.

Our observations also indicated that some residents may have developed cancer and other diseases of the internal organs as a result of the use of contaminated water. However, we could not carry out a detailed analysis to assess the relationship between cancer cases and the use of contaminated water. According to a study conducted in Buyat Bay, Indonesia, health problems such as skin diseases, headaches, and unusual swelling have been associated with gold mining operations.⁶⁵ Our survey indicated that chemicals used in laboratories and in the explosives used during mining operations cause health problems, particularly affecting the eyes and skin, and that fumes from smelters affect the air quality, which in turn causes respiratory health problems.

We attempted to determine how heat may influence the health of miners. A common and significant health problem for miners that we observed was the development of illnesses related to exposure to heat. Miners are exposed to almost constant heat, including solar heat. We found that workers experienced heat-

related health problems, possibly because they spent hours working in the sun and were exposed to heat during the smelting or processing of gold dust. A further study on heat-related illness would be a significant step in combating this health problem.

Health Effects of Mining Activities Based on Workers' Knowledge

According to our survey, miners working in private mines are much more likely than formal workers to be exposed to poor working environments, low health and safety standards, and environmental hazards, and to suffer poor health and injuries. The workers we interviewed have low knowledge of the occupational health hazards they face and of how to avoid them. The lack of importance attached to OHSR in the informal sector would make it impossible for OHS authorities to monitor and investigate working conditions, even if the authorities in Ghana were to fully implement and enforce OHSR.

Most workers (72%) acknowledged that mining has significant negative effects on health—considerably increasing morbidity and mortality. In the Obuasi Municipality, the Ghana Health Service reported in 2009 that most residents had experienced at least one mining-related health problem between 2005 and 2009. The findings of the present study also align with a study on the environmental effects of mining, which likewise reported that most residents in areas where mining takes place are affected by mining-related health effects.⁶² Consequently, there is a need to implement efficient policies and health interventions to control the health effects associated with gold mining to help improve the health of the workers.

Accidents Related to Gold Mining

We observed that common mining accidents, injuries, diseases, and disasters that occur at gold mines inform the need to implement and enforce OHSR in Ghana. Mining operations accidents include physical, biological, mechanical, chemical, and psychosocial injuries.²⁰ Exposure to accidents among the respondents was high, with most accidents occurring among workers between the ages of 31 and 35 years. Most accidents were caused by poor law enforcement, incorrect handling of equipment or chemicals, and exposure to solar heat. This indicates that miners involved in small-scale mining employ poor techniques that expose workers to health hazards.²⁷ Furthermore, the workers do not understand preventive and control measures because they have not been enforced. This,

coupled with a lack of knowledge about OHSR, may have contributed to the high levels of mining-related accidents among the workers.

Workers' Approach to Addressing Health Problems Related to Mining

Our survey indicated that several public health and primary health care programs exist that gold miners can use to address health problems. However, these programs are relatively new, and study participants noted that they are expensive. We established that few miners currently use the programs. Hence, addressing the mining-related health problems in Obuasi Municipality requires a cost-effective program that is available to most of the population. This situation needs further investigation to determine why miners do not use the existing programs. Participants in the present study identified financial constraints and the long distance to primary health care centers as barriers to using primary health care resources.

The miners we interviewed generally had a poor approach to addressing their health problems. Some miners were willing to be screened and to undergo treatment should they test positive for any symptom through screening, provided treatment is free and screening centers were within walking distance to avoid transportation costs. Other miners felt reluctant to undergo further treatment after testing positive for a health problem, which they attributed to financial constraints. This lack of medical care may have increased the severity of the health problems among the workers. Our survey suggests that most small-scale miners relied on cheap medical services, which also led to worsening health conditions. We can assume that the lack of knowledge about OHSR among the miners may also be a contributory factor for the poor approach to addressing health problems.

We further assessed the willingness of the workers to offer support to others. Some workers were ready to offer support to those affected by mining-related diseases and in dire financial straits. Further, several workers requested self-screening from the nearest health care authorities, while others reported being reluctant to be screened for fear of testing positive for any mining-related health problem. Only a small number of workers had sought treatment by qualified health professionals for symptoms of health problems caused by mining. The fear of being screened, financial constraints, the long distances to the screening centers and health facilities, and little knowledge of OHSR may

explain the poor approach to addressing occupational health problems. The stigmatization of those who test positive for and show symptoms of mining-related health problems—though this was not the main subject of discussion—also played a major role in the feared of being screened.

Strengths and Limitations of the Study

This study has revealed a general impression of workers' knowledge of occupational health hazards as a potential cause of mortality and morbidity that needs to be addressed to promote health. The study also served as a platform for further studies to be carried out on gold mining.

Nevertheless, the study had several limitations. First, it lacked a validated questionnaire, although the questionnaire used was designed to be user-friendly and reliable. Second, scant studies have been published on small-scale gold mining in Ghana, which made it difficult to find literature to compare with our findings. Third, we lack objective findings because the small sample size selected for the study cannot be used to generalize the prevailing occupational health hazards and problems among the entire population of small-scale mine workers in Ghana. Furthermore, the questionnaire was not pretested to obtain a general impression of workers before conducting the study due to the small, randomly selected sample and limited time to conduct the study.

Conclusions

The results of the present study suggest high levels of occupational health hazards and problems in small-scale gold mines. The most common and significant causal factors of health hazards and problems are inadequate work experience, negligence, and poor handling of chemicals and equipment. OLD, OHL, heat-related illness, eye infections, malaria, and skin

diseases were found to be the most common and significant health problems in the study population. Education on safety and mining regulations were almost nonexistent among the miners who participated in the study. Implementing a comprehensive safety program with an associated public health program could limit the most significant risks related to health hazards and problems in small-scale gold mines. We further recommend the use of PPE, and we encourage the adoption of a primary health care approach in addressing occupational health problems associated with small-scale mining.

Acknowledgment

My heartfelt appreciation to Berndt Stenberg (Professor and MD), Umeå University, Sweden for his support, motivation, and scientific guidance in the entire project. Also, thanks to Nawi Ng (Professor), Kjerstin Dahlblom (Ph.D.), and Yulia Blomstedt (Ph.D.) (Department of Public Health and Clinical Medicine, Umea University) for their additional scientific guidance in the preparation of the manuscript. I would like to acknowledge the respondents of the Obuasi Municipality, Ghana who took part in the study and for making data available. Many thanks to Dr. Ernest Buanya-Mensah (Ridge Hospital, Accra-Ghana) for your data collection assistance. To Jenas Nyarko, my deepest gratitude for your care, support, and excellent proofreading assistance. It was a great comfort and relief for you to be there for me. Finally, many thanks to the Department of Public Health and Clinical Medicine, Faculty of Medicine, Umeå University, Sweden, and the Swedish Government for the support and opportunity to study in Sweden. I am very grateful.

Conflicts of interest

The authors declared that they have no potential conflict of interest in this study.

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