

Proceeding Paper

# High Blood Lead Levels and Perceived Societal and Health Issues Amongst Juvenile Illegal Miners: A Call for Multisectoral Action <sup>†</sup>

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**Abstract:** This paper reports the blood lead levels amongst illegal juvenile miners and their perception of the role of illegal mining in terms of societal and health issues. The sampled population included 90 illegal miners between 14 and 19 years of age with a mean age of 17 and mean blood lead level of 15.58 µg/dL. Those involved in going underground and draining the gold had higher blood lead levels (BLLs) with a mean = 26.03 µg/dL. Sixteen participants (84%) believed that being involved in illegal mining may lead to adverse health, and they were concerned about injury due to violence. Most participants had experienced occupational and environment-related disease. All participants believe that illegal mining-related activities have the potential to contaminate the environment, yet all have conducted the same activities in their yard or household. The majority of illegal miners know the danger of the chemicals used to extract the gold. Out of 19, only two have ever received personal protective clothing/equipment. The others had to fend for themselves. The findings of this study highlight and raise critical public health, social, and criminal issues. Therefore, there is a need for multisectoral action, especially regarding public health.

**Keywords:** blood lead levels; illegal mining; juveniles; child labour; societal problems; health issues; environmental health



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## 1. Introduction

Illegal mining is a common informal economic activity in many low-income countries. Illegal mining is also referred to as artisanal mining in many Sub-Saharan African countries [1]. Recently, there has been an increase in children and women working in illegal mining activities, working conditions, health effects, and safety around illegal mining environments [2–4]. In addition, some activities that occur in household yards can contaminate the surrounding home and community areas [5].

Globally, communities residing near mining operations have been known to have concerning BLLs. In Armenia, children from three mining communities had BLLs with a mean of 6.0 µg/dL [6]. In Africa, most studies conducted near illegal mining communities and with illegal miners have reported high blood lead levels [7–10]. A community study in a Nigerian village found a high prevalence of lead poisoning, with 92.5% and 11.1% ( $n = 34$ ) having BLLs greater than 45 µg/dL [10]. At the same time, illegal miners in the same area had BLLs ranging from 15 to 561.2 µg/dL, with 75.7% having BLLs greater than 45 µg/dL [7]. Similar findings have been reported elsewhere. A cross-sectional study in an adult population from two communities near illegal mining activities found BLLs ranging

from 0.7 to 27.6 µg/dL [11]. Recently, South African researchers reported a case series of three child miners with high BLLs ranging from 35.8 to 48.1 µg/dL [12]. High lead levels are known to indirectly contribute to adverse health outcomes and societal issues [13].

Illegal miners and surrounding communities are at risk of numerous health outcomes that range from treatable symptoms to death. Illegal miners may develop health conditions such as silicosis, lung cancer, musculoskeletal disorders, tuberculosis, eye disorders, hearing problems, and death due to occupational risk [14]. Occupational risk/hazards in illegal mining work include dust inhalation, chemical exposure (such as cyanide, methane, dihydrogen sulfide, mercury, carbon monoxide), digging, falling, lifting heavy objects, lugging, and extreme temperatures (both heat and cold) [8]. Additionally, illegal miners and surrounding communities can be at risk due to environmental hazards, such as poor sanitation, incidental exposure to heavy metals, stagnant water, and dust [15–17] as well as environment-related diseases, such as diarrheal, mosquito-borne (malaria, dengue fever, etc.), metal accumulation, and others [18,19]. The most concerning contribution to occupational and environmental risks in these communities is the non-existence of occupational health services or lack of access to public health services.

There is a growing concern regarding societal issues such as crime, violence, school dropout etc., in areas proximal to illegal mining activities [20,21]. In Zimbabwe, it was reported that a machete gang called “Mashurugwi” was responsible for killings and robberies of gold, cash, and ore around artisanal mining communities [21], while in the Democratic Republic of the Congo, women living in close proximity to illegal mining activities were extremely likely to experience sexual violence [22]. These are concerns raised elsewhere [3]. However, most concerning is the violence amongst illegal miners over resources and territories [23]. A survey conducted in the Democratic Republic of Congo found that illegal miners are motivated by grievance, money, and social recognition [24]. Anecdotal evidence has shown a rise of fighting amongst South African illegal miners with many losing their lives. In Ghana, scientists have seen a high dropout rate amongst young school children seeking to be involved in illegal mining for survival [25]. Most of the societal issues within these communities are due to lack of legislation governing illegal mining activities and non-existence of law enforcement implementation against those breaking the law within these communities [17].

Recently, there has been a growing concern that some illegal activities are conducted in households to retrieve mined gold. This paper describes blood lead levels among juvenile illegal miners. It further describes perceived health risk, societal issues, environmental impact, and lead awareness amongst the study population. This study was part of a larger project conducted amongst young males in conflict with the law within secure facilities in the Gauteng Province [26].

## 2. Materials and Methods

The current preliminary study reports data from a cross-sectional analytical study conducted amongst young males in conflict with law enforcement. A detailed description of the methodology is discussed elsewhere [26]. The participants that reported a previous history of lead exposure were invited for a follow-up interview, and all had reported being involved in illegal mining.

### 2.1. Study Site, Population, and Sampling

The main study was conducted in secure correctional facilities in Gauteng Province. In the main study, we conveniently sampled male juveniles. Those that participated and reported that they worked as illegal miners were invited for a follow-up interview.

### 2.2. Data Collection

The data was collected using four different tools. The researchers use a record review guide to extract data on the participants' ages and types of crime committed. We then used a questionnaire to collect socio-demographic information and self-reported diseases. During

the interviews, we collected information on perceived health risks, perceived environmental impact of lead, and personal protective equipment issues. Following the interview, blood samples were collected by a professional nurse and submitted to a laboratory in Johannesburg on the day of collection.

### 2.3. Data Analysis

The qualitative data collected from interviews were analyzed using pattern thematic analysis [27]. The interview data were summarized into meaningful categories according to themes, similarities, and patterns within each section, e.g., perceived health risk, perceived environmental impact and personal protective equipment issues. Quantitative information from the questionnaire on socio-demographic status and BLL's were analysed using SPSS version 26. Continuous variables were presented with means, medians, and ranges. Categorical variables were presented with percentages.

## 3. Results

### 3.1. Characteristics of the Illegal Miners

There were 192 total participants in the actual study, including 21 (11%) illegal miners. Only 19 miners participated in the following up interviews. The distribution of BLLs amongst the non-miners within the actual study ranged from 0.85 to 18.22  $\mu\text{g}/\text{dL}$ , with mean and median of 4.30  $\mu\text{g}/\text{dL}$  and 2.87  $\mu\text{g}/\text{dL}$ , respectively. Blood lead levels ranged from 3.45  $\mu\text{g}/\text{dL}$  to 48.11  $\mu\text{g}/\text{dL}$ , and the mean and standard deviation were 15.58 and 14.25  $\mu\text{g}/\text{dL}$ , respectively. The geometric mean was 10.75  $\mu\text{g}/\text{dL}$  with a median of 9.23  $\mu\text{g}/\text{dL}$ . The average income per month was ZAR 3724.16, and the minimum and maximum earnings were ZAR 1500 and ZAR 10,500.

Seventeen participants were 18 years old or younger, and their blood lead levels were higher than older participants. The mean BLL for younger participants was 16.38  $\mu\text{g}/\text{dL}$  and the mean BLL for older participants was 8.8  $\mu\text{g}/\text{dL}$ . The majority of the illegal miners were born outside of South Africa and had a mean blood lead level of 16.15  $\mu\text{g}/\text{dL}$ . Most illegal miners had a lower educational level (either had no schooling or primary school level), while their mean blood lead levels were higher. Self-employed participants had a mean BLL of 18.81  $\mu\text{g}/\text{dL}$ , even though only three worked for themselves. Four participants with a mean BLL of 26.03  $\mu\text{g}/\text{dL}$  were involved in digging underground and draining/retrieving gold from the mining sites. All participants reported having used traditional remedies or herbs, either for treating sickness or for protection. A more details description of mean BLLs per category are shown in Table 1.

**Table 1.** Description of characteristics and mean blood lead per category.

Characteristic	n (%)	BLL Mean (SD <sup>1</sup> )
	<i>Age</i>	
14–18 years old	17 (89.5%)	16.38 $\mu\text{g}/\text{dL}$ (14.82)
Older than 18 years	2 (10.5%)	8.80 $\mu\text{g}/\text{dL}$ (6.22)
	<i>Country of Origin</i>	
South Africa	1 (5%)	5.43 $\mu\text{g}/\text{dL}$ (-) <sup>2</sup>
Outside of South Africa	18 (95%)	16.15 $\mu\text{g}/\text{dL}$ (14.45)
	<i>Educational levels</i>	
No schooling	9 (47%)	12.16 $\mu\text{g}/\text{dL}$ (14.15)
Primary School	9 (47%)	20.13 $\mu\text{g}/\text{dL}$ (14.40)
High School	1 (6%)	5.43 $\mu\text{g}/\text{dL}$ (-) <sup>2</sup>
	<i>Occupational status</i>	
Self-employed	3 (16%)	18.81 $\mu\text{g}/\text{dL}$ (8.29)
Employed by someone	16 (84%)	14.98 $\mu\text{g}/\text{dL}$ (15.24)
	<i>Occupational activity</i>	
Digger	8 (42%)	12.64 $\mu\text{g}/\text{dL}$ (11.33)
Drainer	7 (37%)	14.98 $\mu\text{g}/\text{dL}$ (15.24)
Digger and Drainer	4 (21%)	26.03 $\mu\text{g}/\text{dL}$ (16.25)
	<i>Do you use traditional remedies</i>	
Yes	19 (100%)	15.58 $\mu\text{g}/\text{dL}$ (14.25)

<sup>1</sup> SD-standard deviation; <sup>2</sup> SD-very low response for analysis.

### 3.2. Health Outcomes

The incidence of self-reported disease was as follows: chest pain (67%), shortness of breath (89%), frequent tiredness (84%), abdominal pain (79%), joint weakness and muscle pain (79%), convulsions (53%), diarrhoea (60%), constipation (95%), hearing problems (47%), eye problems (47%), and sexually transmitted diseases (42%). Table 2 gives a detail description of self-reported disease.

**Table 2.** Description of self-reported diseases.

Diseases	<i>n</i>	%
Chest pain	12	67%
Shortness breath	17	89%
Frequent tiredness	16	84%
Abdominal pain	15	79%
Joint weakness and muscle pain	17	89%
Convulsions	10	53%
Diarrhoea	10	53%
Constipation	19	95%
Hearing problems	9	47%
Eye problems	9	47%
Sexually transmitted diseases	8	42%

### 3.3. Perceived Health and Social Risks of Illegal Mining

The majority of illegal miners ( $n = 16$ , 84%) believed that being involved in illegal mining poses a threat to their health. Most participants ( $n = 14$ , 74%) were concerned about occupational or violence-related injuries (see Table 2 for detailed description). Participants indicated that gangs were fighting over territory, and one could get injured while getting robbed (even by law enforcement agencies) of the gold retrieved. All believed that government intervention can prevent violence in this industry, but they fear being deported as they do not have legal status to be in the country. Furthermore, many miners get injured by falling while going down the mine shafts, as there is a lack of proper lighting and structural safety. One indicated that he got injured when detonating explosives; however, these are hardly used because they are expensive, make the shafts unstable, and sometimes alert law enforcement and. Five miners (26%) indicated diseases as a major outcome, which they suspected were due to the food not being kept in good condition, lack of ablution facilities, and lack of clean air (proper ventilation).

### 3.4. Provision and Use of Personal Protective Equipment

Most participants ( $n = 17$ , 90%) have never been given personal protective clothing or equipment. However, they use whatever they can get, especially when underground. In most instances, they use old clothes to make masks, and wear old safety boots.

### 3.5. Perceived Impact of Illegal Mining on the Environment

All participants believed that the areas where they have mined gold would collapse, in the future. Participants were asked about the impact of processing or filtering gold in their households. Eighteen (95%) reported having conducted activities related to illegal mining in their household or yard. While they agreed that it might cause harm to the environment, they had no choice, as there was no safe way to process the mined gold. Furthermore, they needed more water to retrieve and filter the gold from the dirty mining sites.

### 3.6. Awareness of Lead and Other Heavy Metals

The majority of the participants ( $n = 15$ , 79%) were unaware of lead exposure through their activities. Yet, they knew they were exposed to sodium cyanide, mercury, and acids such as sulphuric and nitric. These chemicals are used during the process of retrieving gold. None of the participants has ever received information about the dangers of chemicals or

illegal mining to their health, especially regarding diseases (see Table 3 for a detail response from participants). They indicated that they are encouraged by older illegal miners not to use public health facilities or government facilities for fear of being arrested and deported.

**Table 3.** Awareness on lead exposure and health issues.

Variable	Number	Percentage
<i>Do you think illegal mining makes you sick?</i>		
No	3	16%
Yes	16	84%
<i>What kind of health issue concerns you?</i>		
Disease	5	26%
Violence-related injury/death	10	53%
Work-related injury	4	21%
<i>Does illegal mining impact the surrounding environment?</i>		
Yes	19	100%
<i>Do you conduct any activities related to illegal mining in your yard/household?</i>		
No	1	5%
Yes	18	95%
<i>Do you know the dangers of chemicals used to retrieve the gold?</i>		
No	15	79%
Yes	4	21%
<i>Have you ever received awareness information on the dangers of illegal mining?</i>		
No	19	100%
<i>Have you ever received any personal protective equipment?</i>		
No	17	90%
Yes	2	5%
<i>Do you think your activities expose you to lead and other chemicals?</i>		
Yes	19	100%

#### 4. Discussion

According to our knowledge, this short communication is the first study to report blood lead levels and perceived impacts of illegal mining amongst illegal juvenile miners in the Southern African region. Most studies have been conducted amongst communities living near illegal mining activities, especially gold mining, without looking at the impact of such activities [7,10,28–31]. This paper highlights numerous health and social issues.

Informal and formal artisanal mining has been linked to high blood lead levels [7,30]. Blood lead levels were high amongst the study participants involved in illegal mining. The mean BLL was 15.58 µg/dL, with the lowest and highest levels being 3.45 µg/dL and 48.11 µg/dL. The mean BLL of the other participants in the actual study was 4.30 µg/dL. More concerning is that most of the high blood lead levels were seen in this study's most vulnerable participants. For example, illegal minors younger than 18 years and those working for someone had mean BLLs of 16.38 µg/dL and 14.98 µg/dL, respectively. This is a concern to public health because elevated BLLs have been reported to cause puberty delay, inhibit growth and hearing, affect IQ and academic performance, and contribute to the development of anti-social behaviour [13,32]. In South Africa, no study has been conducted on the above-mentioned phenomena in the study population.

The occurrence of self-reported diseases was high in this selected population. More than 50% reported suffering from occupational and environmental-related diseases, while lifestyle diseases, such as STIs, were below 50%. These concerns have been raised before by other researchers elsewhere in Africa. In Cameroon, artisanal gold miners were reported to be suffering from respiratory problems, diarrheal problems, STIs, musculoskeletal problems, and other communicable diseases [8]. It was more concerning that this group of juveniles did not seek medical attention and preferred homemade remedies outside of the secure facilities.

Child labour is a major problem in poverty-stricken regions of Sub-Saharan Africa [33]. According to International Labour Organisations (ILO), in 2016, it was estimated that



152 million children are involved in child labour, of which, 72 million are Africans aged 5–17 years [34]. More concerning was the fact that 31.5 million African children are involved in hazardous work. In the current preliminary study, it is concerning that 90% of the participants engaged in illegal mining were younger than 18 years and their BLLs were higher than those older than 18 years. Hilson raised similar sentiments in Ghana about the high number of children involved in illegal mining, while looking at the causes of child labour in such activities [35]. Consequently, being involved in illegal mining deprives them of education, and the preliminary research shows that most of these children had lower educational levels [36]. Only one participant reported achieving a high school education. After being promised a better life, these children may be forced to work in South Africa within the illegal mining sector. We found that 95% of the children were born outside of South Africa, and 84% worked for someone. This information supported the anecdotal evidence or theory that children or young adults in the illegal mining sector within South Africa are brought from neighbouring countries to work for sophisticated syndicates or gangs [37].

Other concerning issues in this preliminary study were perceived violence, lack of occupational hygiene practices, and access to essential services, such as public health. Similar to concerns elsewhere, unsafe working conditions characterised this sector. A study in Ghana reported that women and children worked in a poor occupational environment that contributed to many injuries [38]. We also found that most illegal miners were more concerned about injuries due to violence rather than work-related injuries. According to South African media, violence is pervasive in this informal sector. Numerous violent incidents that have led to death are reported regularly.

South Africa and other low- and middle-income countries have adopted an aggressive approach to addressing informal gold mining. Informal gold mining is an illegal activity. Hence, most stakeholders involved in preventing and managing illegal mining issues are normally from the criminal justice and mineral resources sectors. This approach will not address the environmental and health injustices faced by these vulnerable populations, despite growing calls from different industries and numerous scientists for a holistic approach in addressing this challenge. Few sectors are still attending this challenge.

The findings of this study highlight the need for a multisectoral and holistic approach to illegal mining, with collaborative efforts from the National Departments of Health, Employment and Labour, Mineral Resources and Energy, Justice, Home Affairs, Small Business Development, and Trade and Industry, law enforcement, and other provincial and local government institutions. Numerous institutional reports have recommended legalising illegal mining. However, this will not address social problems or health issues linked to environmental factors. The Department of Health needs to embark on vigorous research to identify the health impacts of illegal mining on communities nearby and those directly involved in mining. At the same time, immediate implementation of health care services is required, such as blood lead screening, disease screening, treatment and health promotion, and education. Health education empowers individuals to protect their health and well-being. It is concerning that all 19 illegal miners had never received health education. Elsewhere, similar issues have been raised about poor access to support services in the sector.

We acknowledge the limited sample size used in this study as one of the limitations. However, this paper highlights the importance and potential benefits of more research and collaboration in understanding the illegal mining sector's complex challenges.

## 5. Conclusions

Illegal mining has numerous adverse impacts on society, such as health, social, and criminal. However, a multisectoral collaboration can ensure that these negative effects are addressed. Therefore, there is a need for extensive research and public health services amongst these populations to promote sustainable and safe livelihoods.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data presented in this study can be made available on request from the corresponding author.

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