medical sciences forum

MDPI

Proceeding Paper

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

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† Presented at the the 2nd International Electronic Conference on Healthcare, 17 February–3 March 2022. Available online: https://iech2022.sciforum.net/..

Abstract: The paper reports the blood lead levels amongst illegal juveniles miners and their perception of the role of illegal mining on societal and health issues. Ninety illegal miners aged between 14 and 19 years with the mean age of 17. The blood lead mean was 15.58 µg/dL in the sampled population. Those involved in going underground and draining the gold had higher blood lead levels (BLLs) with a mean=26.03 µg/dL. Sixteen (84%) participants believed that being involved in illegal mining may lead to adverse health, and they were concerned about injury due to violence. Most participants had experience occupational and environmental-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 the illegal miners know the danger of the chemicals used to get the gold. Out of 19, only two have ever received personal protective clothing/equipment. The others had to fend for themselves. The study findings highlight and raise critical public health, social and criminal issues. Therefore, there is a need for multisectoral action, especially public health.

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

Citation: Mbonane, T.P.; Mathee, A.; Swart, A. and Naicker, N. High Blood Lead Levels and Perceived Societal and Health Is-sues Amongst Juvenile Illegal Miners: A Call for Multisectoral Action. *Med. Sci. Forum* **2021**, *1*, x. https://doi.org/10.3390/xxxxx

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 child and women labour in illegal mining activities. These developments have raised concerns about unsafe working conditions, health effects and safety around illegal mining environments [2–4]. In addition, some activities occur in household yards that can contaminate the surrounding home and community areas [5].

Globally, communities residing near mining have been known to have concerning BLLs. In Armenia, children from three mining communities had BLLs mean 6.0 µg/dL [6]. In African 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 prevalence of lead poisoning to be high at 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 - 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 μg/dL to 27.6μg/dL [11]. Recently, South African researchers reported a case series of 3 child miners with high BLLs ranging from 35.8 – 48.1μg/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; numerous health outcomes 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 the illegal mining work include dust inhalation, chemical (such as cyanide, methane, dihydrogen sulfide, mercury, carbon monoxide) exposure, digging, falling, lifting heavy objects, lugging, extreme temperatures (both heat and cold) [8].While illegal miners and surrounding communities can be at risk due to environmental related hazards such as poor sanitation, heavy metals incidental exposure, stagnant water and dust [15–17]. Environmental related diseases such as diarrheal, mosquito-borne (malaria, dengue fever, etc), metal accumulation and others [18,19]. The major concern contribution to occupational and environmental risk in these communities is the non-existence occupational health services or lack of access to public health services.

There is a growing concern of societal issues such as crime, violence, school dropout etc., in areas proximity 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]. Anecdote evidence has shown a rise of fighting amongst South Africa, illegal miners with many losing their lives. In Ghana, scientist have seen a dropout out amongst young school children, in order to be involved in illegal mining for survival [25]. Most of the societal issue 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 mining activities are conducted in households to retrieve the gold. This paper describes the 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. 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 wasconducted in secure correctional facilities in Gauteng Province. In the main study, we conveniently sampled male juvenilles. 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' age, and type 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. Followig the interview blood samples were collected by a professional nurse and submitted to the laboratory in Johannesburg on the day of collection.

2.3. Data Analysis

The qualitative data collected using 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. . Quantitaive information from the questionnaire on socio-demographic status and BLL's were analysed using SPSS version 26. Continuos variables were preseted with means, medians and ranges. Categorical variables were presented with perecentages.

3. Results

3.1. Characteristics of the illegal miners

The total participants in the actual study were 192 and 21 (11%) were illegal miners. and only 19 miners participated in the following up interviews. The BLLs distribution amongst the non-miners within the actual study ranged from 0.85-18.22 μg/dL with mean and median of 4.30 μg/dL and 2.87 μg/dL respectively. Blood lead levels ranged 3.45 μg/dL to 48.11 μg/dL, while the mean and standard deviation was 15.58 μg/dL and 14.25 respectively. The geometric mean was 10.75 μg/dL with a median of 9.23 μg/dL. The average income per month was R3 724.16 that the participants earned, whereas the minimum and maximum earnings were R1 500 and R10 500.

Seventeen participants were 18 years old or younger, and their blood lead levels were higher than older participants. The BLLs mean for younger participants was 16.38 μg/dL and 8.8 μg/dL for the older participants. The majority of the illegal miners were born outside South Africa and had a mean blood lead of 16.15 μg/dL. Most illegal miners hada lower educational level (either had no schooling or primary school level), while their blood lead means were higher. Self-employed participants had BLL mean of 18.81 μg/dL, even though only three worked for themselves. Four participants with BLL mean of 26.03 μg/dL were involved in digging underground and draining/retrieving gold from the dirty. All participants reported having used traditional remedies or herbs either for treating sickness or protection.

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

Characteristic	n (%)	BLL mean (SD[1])
	Age	
14-18 years old	17 (89.5%)	16.38 μg/dL (14.82)
Older than 18 years old	2 (10.5%)	8.80 μg/dL (6.22)
	Country of Origin	
South Africa	1(5%)	5.43 μg/dL (-)[2]
Outside of South Africa	18 (95%)	16.15 μg/dL (14.45)
	Educational levels	
No schooling	9 (47%)	12.16 μg/dL (14.15)
Primary School	9 (47%)	20.13 μg/dL (14.40)
High School	1 (6%)	5.43 μg/dL (-)[2]
	Occupational status	
Self-employed	3 (16%)	18.81 μg/dL (8.29)
Employed by someone	16 (84%)	14.98 μg/dL (15.24)

Occupational activity		
Digger	8 (42%)	12.64 μg/dL (11.33)
Drainer	7 (37%)	14.98 μg/dL (15.24)
Digger & Drainer	4 (21%)	26.03 μg/dL (16.25)
Do you use traditional remedies		
Yes	19 (100%)	15.58 μg/dL (14.25)

[1] SD-standard deviation; [2] SD-very low response for analysis.

3.2. Health outcomes

The incidence of self-reported diseases was chest pain (67%), shortness of breath (89%), frequent tiredness (84%), abdominal pain (79%), weakness joints and muscle pain (79%), convulsions (53%), diarrhoea (60%), constipation (95%), hearing problem (47%), eye problem (47%) and sexually transmitted disease (42%).

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

Diseases	N	%
Chest pain	12	67%
Shortness breath	17	89%
Frequent tiredness	16	84%
Abdominal pain	15	79%
Weakness joints and muscle pain	17	89%
Convulsions	10	53%
Diarrhoea	10	53%
Constipation	19	95%
Hearing problem	9	47%
Eye problem	9	47%
Sexually transmitted disease	8	42%

3.3.Perceived health and social risk 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 when they are going down the mine shaft as there are no proper lightning and structure to go down to the shafts. One indicated that he got injured when blasting explosives; however, these are hardly used because they sometimes alert law enforcement, making the shafts unstable and expensive. Five (26%) miners indicated diseases as a major outcome. They suspected it was due to the food not being kept in good conditions, lack of ablution facilities, and clean air (proper ventilation).

3.3. 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. They use old cloth/es to make a mask and old safety boots in most instances.

3.4. Perceived impact of illegal mining on the environment

All the participants believed that the areas where they have mined gold would collapse in 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 it when they have

mined the gold. Furthermore, they needed more water to retrieve and filter the gold from the dirty from mining sites.

3.5. Lead and other Heavy Metals Awareness

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 Sulphur and Nitrate. 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 diseases. 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 2. Description of characteristics and blood lead mean per category.

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

4. Discussion

According to our knowledge, this short communication is the first study to report blood lead levels and perceive impacts of illegal mining amongst illegal juvenile miners in the Sothern African region. Most studies that have been conducted amongst communities living near illegal mining activities, especially gold, without looking at the impact of such activities (7,10,28–31). This paper highlights numerous health and anti-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 BLLs mean was 15.58 μg/dL, with the lowest and highest levels being 3.45 μg/dL and 48.11 μg/dL, respectively. While the BLLs mean 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. For example, illegal minors younger than 18 years and those working for someone had BLLs mean 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 develop anti-social behaviour [13,32]. In South Africa, no study has been conducted on the abovementioned 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 suffering from respiratory problems, diarrheal, 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 the secure facilities.

Child labour is a major problem in sub-Saharan African poverty-stricken regions [33]. According to International Labour Organisations, in 2016, it was estimated that 152 million children are in child labour, and 72 million are Africans aged 5-17 years old [34]. The number of African children involved in hazardous work was more concerning, 31.5 million children. 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]. Consequetly, 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 a high school level. 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 South Africa, and 84% worked for someone. This information supported the anecdote 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 character 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 incidence that has 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 the criminal justice and mineral resources sector. This approach will not address environmental and health injustice 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 study findings highlight the need for a multisectoral and holistic approach to illegal mining. A collaborated efforts from National Departments of Health, Employment and Labour, Mineral Resources and Energy, Justice, Home Affairs, Small Business Development, Trade and Industry, Police and other provincial and local government institutions. Numerous institutional reports have recommended legalizing 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 impact of illegal mining on communities nearby and those directly involved in mining. At the same time, immediate implementation of health care services is required immediately, 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 the nineteen illegal miners had never received. Elsewhere, similar issues have been raised about poor access to support services in the sector.

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

5. Conclusion

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 for sustainable and safe livelihoods.

Author Contributions: "Conceptualization, TPM, NN, A.M and AS.; methodology, TPM; validation, NN, A.M and AS, formal analysis, TPM; investigation, TPM; writing—original draft preparation, TPM; writing—review and editing, NN, A.M and AS.; supervision, NN, A.M and AS; project administration, TPM; funding acquisition, TPM All authors have read and agreed to the published version of the manuscript."

Funding: This research was funded by National Research Foundation (NRF).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the UNIVERSITY OF JOHANNESBURG, Faculty of Health Science's Research Ethics Committee (REC-241112-035 approved on the 27th of June 2018).

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.

Acknowledgements: We acknowledge the participants' willingness to be part of the actual study and share their experiences. All the role players that made the study possible.

Conflicts of Interest: The authors declare no conflict of interest.

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