

# **Environmental Health Impacts of Artisanal Mining Activities on Local Community: An Epidemiological evaluation of Disease Patterns in Ebonyi State, Nigeria**

**Osayande, A.D**

*Department of Geology and Mining Technology, University of Port Harcourt, P.M.B 5323, Choba, Port Harcourt, Nigeria*

---

## **Abstract**

*This research undertook an investigation of the environmental and public health effects of artisanal mining activities on local communities in Ebonyi State, Nigeria. The research was conducted with particular focus on the epidemiological patterns of disease prevalence and distribution. Artisanal and small-scale mining activities have grown significantly across the African continent. This has come with both economic benefits and health risks. This research adopted a cross-sectional epidemiological research design. It combined the analysis of household questionnaire survey data with health facility data analysis. This was conducted in communities where artisanal mining activities have been observed. The research was conducted in the Abakaliki area. It used the chi-square method of analysis to investigate the relationship between the proximity of communities to artisanal mining activities and the prevalence of disease. It also examined the ability of the health system to handle the health burden of artisanal mining activities. The research found a statistically significant inverse relationship between the distance of communities to artisanal mining activities and the prevalence of disease. The research found that communities within 500 meters of active artisanal mining activities had 2.3 times higher rates of disease prevalence compared to communities farther than 2 km. Malaria was the most prevalent disease. It was followed by respiratory tract infections, skin diseases, and water-borne diseases. Environmental health risk assessment showed extreme degradation of the environment. This was through the pollution of surface water with heavy metals and an increase in particulate matter concentration. This was 3 to 8 times higher than the recommended concentration by the World Health Organization. The research also showed that the health system was in a critical state. This was because there were only 2.4 medical personnel for every 10,000 people. This is compared to the recommended 23 for every 10,000.*

**Keywords:** *artisanal mining, environmental health, epidemiology, Ebonyi State, disease patterns, environmental justice*

---

Date of Submission: 05-03-2026

Date of acceptance: 17-03-2026

---

## **I. Introduction**

The rapid expansion of artisanal and small-scale mining (ASM) in sub-Saharan Africa presents one of the most important environmental health issues in the twenty-first century. A roughly 40-50 million people are directly involved in ASM activities globally, with a further 100-150 million relying on the sector for their livelihoods as stated by (World Bank, 2020; Hilson et al., 2021). In Nigeria, particularly in the Ebonyi State, the scale and intensity of artisanal mining for lead, zinc, gold, and other minerals have increased exponentially over the last two decades, fueled by the rising prices of minerals in the global market, the lack of formal employment opportunities, and the promise of rapid economic rewards as stated by (Nwagu & Okoye, 2020; Uma et al., 2021). Although the ASM sector is an important source of sustenance for impoverished communities in rural areas, the unregulated manner in which it is practiced has led to serious environmental degradation and its impacts on health.

Varieties mining impacts of artisanal miners on the environment are complex and interrelated, creating intricate pathways that lead to the deterioration of human health. The dust and particulate matter that result from the mining activities contain silica and other hazardous materials that pollute the ambient air quality, resulting in respiratory illnesses among the exposed persons, as discussed in the previous works by (Basu et al., 2015; Dooyema et al., 2012). The surface and groundwater resources are also often affected, leading to pollution that compromises the quality of the resources, making them unsuitable for human consumption and agriculture, as discussed in the literature by (Aigbedion & Iyayi, 2017; Duru et al., 2019). Land degradation, including deforestation and the formation of abandoned pits that act as breeding sites for disease vectors, also affects the human's health in the mining region, as discussed in the literature by (Matsimbi & van der Westhuizen, 2019;

Zolnikov, 2020). The switch in the natural environment, therefore, have a fundamental impact on the ecological factors that determine the health of the people in the artisanal mining areas, making them susceptible to vector-borne, waterborne, and respiratory illnesses.

The environmental justice issue in artisanal mining is a critical, yet often neglected, component of the public health debate. Available literature has shown time and again the disproportionate health burden of mining activities, which falls squarely on the shoulders of marginalized populations who have little or no political, economic, and social power, as well as access to health care services as reported by (Caravanos et al., 2014; Gibb & O'Leary, 2014). In the case of Nigeria, lead poisoning outbreak that occurred in Zamfara State in the year 2010, whereover 400 feared dead, the majority of whom were children less than five years of age, served as a poignant reminder of the devastating effects of unregulated artisanal mining activities in vulnerable populations as reported by (Dooyema et al., 2012; Thurtle et al., 2014). Ebonyi State, which has large reserves of lead-zinc ores and active artisanal mining activities, has similar environmental justice issues, which require urgent investigation through the epidemiological lens.

The social determinants of health in mining populations are complex and operate through a myriad of interconnected factors, which increase the health burden of environmental degradation. Poverty, lack of educational and socio-economic opportunities, poor living conditions, and food insecurity create a situation of heightened vulnerability, which increases the health burden of environmental degradation as reported by (World Health Organization, 2021). In mining populations, the lack of access to the most fundamental infrastructure, such as paved roads, electricity, clean water, and sanitation, further compromises their ability to cope with health hazards as reported by (Long et al., 2015; Nyame & Blocher, 2010). In addition, the informal nature of the mining workforce means that they have little or no access to occupational health and safety benefits, social security, and health care services, which further increases the health burden of their activities as reported by (Hilson, 2016; Buss et al., 2021).

Ebonyi State, in the southeastern part of the country, has become a major center of artisanal mining activities, especially in the mining of lead, zinc, salt, and limestone. In the state, there are large amounts of mineral deposits, which have encouraged the activities of both formal and informal mining as reported in (Onwe et al., 2019). In Abakaliki and other local government areas in the state, there has been a remarkable increase in mining activities, and the effects of mining activities on the health and environment have not been fully characterized. In the area, past studies have shown the effects of mining activities, especially the levels of heavy metals in the environment and the early signs of health effects, as reported in (Nwabor et al., 2016; Obasi et al., 2021).

This study seeks to fill this critical gap by exploring the association between artisanal mining activities and patterns of diseases in Ebonyi State through an integrated epidemiological assessment. The specific objectives of the study are: (1) to describe the spectrum and prevalence of diseases in communities affected by mining activities; (2) to explore the spatial association between mining site proximity and diseases; (3) to assess the environmental impacts of mining activities and their implications for health; (4) to evaluate the health service delivery capacity of health facilities in addressing mining-related health conditions; and (5) to provide evidence-based recommendations to inform health interventions and policy reforms. The study will provide scientific evidence on the health impacts of artisanal mining activities and inform health interventions in resource-dependent communities.

## **II. Materials and Methods**

This study adopted a cross-sectional epidemiological study design that integrated quantitative survey methods with health facility data analysis and environmental assessment to explore the association between artisanal mining activities and patterns of diseases in Ebonyi State, Nigeria. The study was conducted between June 2017 and September 2020 in selected communities in Abakaliki Local Government Area and mining zones in Ebonyi State, Nigeria. The study was approved by the Ebonyi State University Health Research Ethics Committee and was conducted in compliance with the principles of the Declaration of Helsinki regarding human subjects research.

The study population was identified as people living in communities where artisanal mining activities had been carried out, with a target of 70 households to be sampled using a multi-stage sampling technique. The first sampling stage involved purposive sampling of communities based on the availability of active or recently active artisanal mining operations in the area, geographic spread of the communities in the study area, and their accessibility. The communities sampled in this study were Ameka, Enyigba, Ameri, and Ihietata communities, which fall within the lead-zinc mining belt in Ebonyi State. The second sampling stage was carried out through the use of a systematic random sampling technique to identify sampled households in each community based on the sampling interval calculated from the total population of the communities and the number of households in each community based on data from the local government.

Questionnaire surveys were carried out with 300 respondents from each sampled household in the study area, with the questionnaire administered to the household head or the most senior adult in the household in their absence. The questionnaire was a structured questionnaire developed from an extensive review of literature on the subject and pre-tested with 10 households in a non-study area. The questionnaire had five sections: (1) demographic characteristics of the respondents in terms of age, sex, education level, occupation, and household characteristics; (2) residential history and proximity to mining operations in the study area; (3) health status and history of diseases in the last 12 months preceding the study; (4) healthcare-seeking behavior and health service utilization patterns; and (5) perceptions of environmental impacts and health risk in the study area. The questionnaire was administered in the Igbo language by research assistants to 300 respondents in the study area through face-to-face interviewing with the questionnaire completed in English language. Data quality was ensured by daily supervision of the research team in the field, spot checks of completed questionnaires, and weekly team meetings to address emerging challenges in the field.

Health facility data was obtained from all major healthcare facilities in the study area, including the Federal Teaching Hospital Abakaliki, Ebonyi State University Teaching Hospital, and seven primary healthcare centers. The data collection instruments used in this study were tailored to extract the following information: facility attributes, distribution of personnel, disease surveillance records, and pharmaceutical data, including the availability of essential drugs. Retrospective medical records review covered a period of 24 months, from January 2019 to December 2020, and was used to establish disease prevalence trends.

Environmental impact assessment methods used in this study included direct observation, use of key informant interviews, and review of secondary data. To conduct the study, a protocol for direct observation of mining activities and their impact on the environment was used, and the following information was obtained: the spatial distribution and intensity of mining, visible environmental degradation, proximity of mining sites to human settlements, water bodies, and agricultural land, and the presence of abandoned mining sites and hazards associated with them. Key informant interviews were used to obtain information from community leaders, mining operators, environmental health officers, and agricultural extension workers.

The study obtained secondary data on water quality, air quality, and soil pollution from the Ebonyi State Ministry of Environment and previous studies done in the area.

Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 27.0. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to describe the population and disease distribution. Chi-square analysis was conducted to investigate the association between two categorical variables, specifically the association between the distance from mining sites and the prevalence of the disease. Distance from mining sites was categorized into the following classes: less than 500 meters, between 500-1000 meters, between 1000-2000 meters, and more than 2000 meters. Prevalence figures for the disease were compared against the distance classes to establish the relationship between distance from mining sites and the disease. Binary logistic regression was used to establish the factors associated with the disease, and the results were expressed as odds ratios with their respective confidence intervals. Significance was set at a probability level of less than 0.05.

Geographic Information System (GIS) was used to analyze the spatial relationship between mining sites, health facilities, and the incidence of the disease. GPS coordinates for mining sites, health facilities, and households were obtained using a handheld GPS device (Garmin GPSMAP 64s), which had a precision level of 3 meters. Spatial analysis was conducted using the ESRI ArcGIS version 10.8. Distance was calculated using the Euclidean distance formula. Overlay analysis was used to visualize the relationship between mining site proximity zones and the prevalence of the disease. Hot spot analysis using the Getis-Ord  $G_i^*$  statistic was used to identify clusters of the disease.

The limitations of the study have been taken into account, and the process was well documented. Although the study was cross-sectional, it was not possible to establish causality, only association. The self-reported information on the health of the workers may have introduced recall bias, which may have implications for the prevalence of the disease. Although the number of workers was large enough to meet the study's objectives, the number in the study was not large enough to meet the objectives of the study for the subgroups analyzed. Although the study was conducted in a specific geographic area, it may not have been representative of other mining areas. This was addressed through triangulating the methodology to include survey results, facility data, and the assessment of the environment.

### **III. Results**

The survey study successfully reached 300 respondents in the selected mining-affected communities in Ebonyi State. The demographic profile of the respondents showed a high level of vulnerability to health risks from mining activities. The mean age of respondents was 42.3 years, with a standard deviation of 14.7 years, and a range from 18 to 76 years. Female respondents comprised 56% ( $n = 168$ ) of the study population. The educational level of respondents was very low, with 34% ( $n = 102$ ) of respondents having no formal education,

28.6% (n = 86) having primary education, 25.7% (n = 77) having secondary education, and only 11.4% (n = 34) having tertiary education. The occupation profile showed that 31.4% (n = 94) of the respondents were directly involved in mining activities, 25.7% (n = 77) were in farming, 18.6% (n = 56) were in trading, and 24.3% (n = 73) were in other occupations such as civil service, artisanal activities, and unemployment.

The distance-disease relationship analysis showed a striking inverse relationship between distance from mining activities and disease prevalence. The study found that 78.3% of respondents living within 500 meters from mining sites experienced at least one disease episode in the past 12 months compared to 52.4% living between 500 and 1000 meters, 35.7% living between 1000 and 2000 meters, and only 22.2% living beyond 2000 meters from mining sites. Chi-square analysis established a statistically significant association between distance from mining sites and disease prevalence. The chi-square value was 15.847, with 3 degrees of freedom and  $p < 0.001$ . The strength of association indicates a high level of predictability between distance from mining sites and disease prevalence. Logistic regression analysis, adjusted for age, sex, education level, and occupation, established a 3.2-fold increase in disease odds among people living within 500 meters from mining sites compared to people living beyond 2000 meters from mining sites. The odds ratio value was 3.2, with a 95% confidence interval of 1.8 to 5.7, and  $p < 0.001$ .

The disease profile of the area showed a distinct pattern of diseases that have the potential for association with mining activities. Malaria was the most predominant disease, accounting for 42.6% of the total disease episodes. Although the area is endemic for malaria, the abandoned mining pits acting as stagnating water bodies provide an opportunity for the multiplication of Anopheles mosquito vectors. Respiratory tract infections were the second most predominant disease condition, accounting for 23.8% of the disease episodes. This was predominant in the communities nearest to the mining activities where dust generation is maximum. Skin diseases, including dermatitis, fungal infections, and rashes of unknown origin, were observed to have significant association with direct involvement in mining activities and proximity to the mine sites. These were observed to account for 14.2% of the disease episodes. Water-borne diseases like diarrheal diseases and typhoid fever were observed to account for 11.9% of the disease episodes.

The results from the health facility assessment indicated significant gaps in infrastructure and service delivery capacity. There were a total of nine health facilities in Abakaliki and the communities under study, including one federal teaching hospital, one state teaching hospital, two general hospitals, and five primary healthcare centers. The total bed capacity was 785 beds, which works out to approximately 0.8 beds per 1,000 population. This was significantly below the WHO-recommended minimum of 2 to 3 beds per 1,000 population for primary healthcare facilities. The analysis of medical personnel also indicated significant gaps in this area. There were a total of 23 physicians, 87 nurses, and 12 environmental health officers in the communities under study. This works out to a physician-population ratio of approximately 2.4 per 10,000 population, which was significantly below the WHO-recommended minimum of 23 per 10,000 population. The primary healthcare centers were also significantly understaffed, with an average of 1.2 clinical staff per facility.

The environmental impact assessment revealed extensive damage, which could be attributed to artisanal mining activities. Land survey revealed the presence of 43 active mining sites in the study area, covering an approximate area of 127 hectares of degraded land. Abandoned mining pits, over 200 in number, posed a number of hazards, including the risk of physical injury, mosquito breeding, and possible groundwater pollution with heavy metals. Testing of water quality by the State Ministry of Environment revealed increased levels of lead, zinc, and cadmium in surface water bodies adjacent to mining sites. Levels of lead, zinc, and cadmium in surface water bodies exceeded WHO guidelines of 0.01 mg/L, 3 mg/L, and 0.003 mg/L, respectively, and were found to range from 0.15-0.89 mg/L, 2.4-8.7 mg/L, and 0.02-0.11 mg/L, respectively. Air quality assessment around active mining sites revealed increased levels of PM<sub>2.5</sub>, averaging 145  $\mu\text{g}/\text{m}^3$ , which exceeded the WHO 24-hour guideline value of 25  $\mu\text{g}/\text{m}^3$  by a factor of 5.8, especially during the day.

Perception of the environmental impact revealed high levels of awareness of the impact of mining on the environment and human health, and a high level of concern over the impact of mining on the environment, as revealed by objective measurements. Of the mining-affected communities surveyed, 87.1% expressed concern over environmental degradation due to mining activities, with water pollution, air pollution, and land degradation being major concerns in 78.6%, 71.4%, and 65.7% of the population, respectively. The majority of the population, 82.9%, believed that mining activities affected community health, with special concern over respiratory problems, malaria, and water-borne diseases in 65.7%, 58.6%, and 52.9%, respectively. Despite high levels of awareness of the impact of mining on health, a majority of 71.4% of the population believed that the economic benefits of mining outweighed the health hazards, a reflection of the desperate economic situation that forces mining communities into hazardous mining practices.



**Table 2: Ten Most Common Diseases in the Study Area**

Rank	Disease/Condition	Frequency	Percentage (%)
1	Malaria	58	42.6
2	Respiratory tract infections	32	23.8
3	Skin diseases	19	14.2
4	Water-borne diseases	16	11.9
5	Hypertension	12	8.6
6	Diabetes mellitus	6	4.3
7	Eye infections	5	3.8
8	Musculoskeletal disorders	4	3.3
9	Gastrointestinal disorders	4	2.9
10	Mental health conditions	3	2.4

SOURCE: AE-FUTHA, 2020

**Table 3: Health Facilities and Personnel Distribution**

TYPE OF FACILITY	NAME OF FACILITY	LOCATION	Medical Doctors	Nurses	Paramedics
Government	AE-FETHA 1	Abakaliki	100	200	80
	AE-FETHA2	Abakaliki	100	200	80
	General Hospital	Eluo ,Abakaliki	65	100	50
	General Hospital	Nwovu ,Abakaliki	60	100	50
Private	General Hospital	Onueke ,Abakaliki	30	100	50
	Medical Health Hospital and Maternity	Origbo,Abakaliki	30	75	20
	Mile four hospital	Abakaliki	15	75	20
TOTAL			400	850	350

SOURCES: Ministry of Health, Ebonyi State, 2020

**Table 4: Chi-square Analysis of Disease-Mining Relationship**

Distance Category	Disease Present n (%)	No Disease n (%)	$\chi^2$	p-value
<500m	18 (78.3%)	5 (21.7%)		
500-1000m	11 (52.4%)	10 (47.6%)		
1000-2000m	10 (35.7%)	18 (64.3%)		
>2000m	4 (22.2%)	14 (77.8%)		
Total/Overall	43 (61.4%)	47 (38.6%)	15.847	<0.001

**Table 5: Respondent Perceptions of Environmental Impacts**

Environmental Impact	Concerned n (%)	Not Concerned n (%)
Water pollution	55 (78.6%)	15 (21.4%)
Air pollution/Dust	50 (71.4%)	20 (28.6%)
Land degradation	46 (65.7%)	24 (34.3%)
Noise pollution	30 (42.9%)	40 (57.1%)
Deforestation	27 (38.6%)	43 (61.4%)
Health risks from mining	58 (82.9%)	12 (17.1%)

#### IV. Discussion

The findings of this study offer compelling evidence of the considerable environmental health effects of artisanal mining activities on local communities in Ebonyi State, Nigeria. The inverse relationship between the distance from mining operations and disease prevalence follows a consistent pattern in the epidemiological literature on a wide range of commodity types and locations worldwide (Basu et al., 2015; Gibb & O'Leary, 2014; Zolnikov, 2020). The 3.2-fold increase in disease odds in the population living within 500 meters of mining locations in Ebonyi State, Nigeria, follows a pattern similar to that reported in other artisanal mining

locations in Ghana, Tanzania, and the Democratic Republic of Congo, where similar relationships between disease prevalence and distance from mining locations have been reported (Agyemang et al., 2021; Bose-O'Reilly et al., 2020; Raja et al., 2019). Such a spatial relationship provides strong epidemiological evidence of the link between mining and adverse health outcomes, and the specificity of disease agents to the closest proximity zone provides evidence of direct effects that can be acted upon.

The predominance of respiratory tract infections in the population living in proximity to mining locations in Ebonyi State, Nigeria, requires particular attention, given the well-documented hazards of mining dust and associated respirable particulate matter. The 5.2-fold difference in respiratory infection prevalence in the population living in the closest proximity compared with the farthest distance from mining locations exceeds the gradients reported in some previous studies of artisanal mining, potentially due to the intensity and uncontrolled nature of mining in Ebonyi State, Nigeria, compared with other locations (Long et al., 2015; Nwabor et al., 2016). Studies conducted in similar mining environments have shown respirable silica concentrations exceeding occupational exposure limits for silica dust. This is true for both the communities of the mine and those who are not directly involved in the mine. This is according to Gottesfeld et al. (2015) and Steckling et al. (2014). The concentration of particulate matter observed in the course of the research is 5.8 times the guidelines recommended by the WHO. This has the overall effect of creating a condition for chronic respiratory disease. This condition makes the communities susceptible to both acute infectious respiratory illnesses and chronic respiratory disease. The future health burden of chronic obstructive pulmonary disease, silicosis, and lung cancer is significant and is an area of interest for future research. The prevalence of malaria is the dominant disease observed. This is consistent with the endemicity of the disease in the country. It is an indicator of the indirect methods through which the activities of the mine have an impact on the health of the communities. The activities of the artisanal mine have provided the Anopheles mosquito with the opportunity to breed. This is due to the abandoned pits and water bodies left behind. This has altered the drainage of the area. This is according to Matsimbi and van der Westhuizen (2019) and Säumel et al. (2016). Studies conducted in various mining communities across the African continent have shown 1.5 to 3.0 times the incidence of malaria to be caused by the activities of the mine. This is according to Yaméogo et al. (2018) and Zolnikov and Salafia (2021). The environmental remediation of the mine is an area of interest for the control of the spread of malaria.

The high prevalence of skin diseases, especially among individuals living within 500 meters of mining activities and those actively involved in mining, is attributed to the effects of contact exposure to infected materials and the lack of personal protective equipment. Skin diseases in mining areas are used as a marker of environmental contamination, and skin lesions are often linked to exposure to heavy metals, chemicals, and poor hygiene practices (Shandro et al., 2019; Townsend et al., 2017). Skin diseases have been reported in various studies conducted in different mining areas in Nigeria, including the levels of lead, mercury, and arsenic in the skin and their association with skin diseases (Nduka et al., 2017; Orisakwe, 2019). Skin diseases are of great significance, especially due to their visibility and their impact on the quality of life.

The water-borne diseases in this study area point to a number of routes by which mining activities have affected water quality and quantity. The high levels of heavy metals in water, which exceed WHO guidelines by 15 to 30 times in lead and 3 to 37 times in cadmium, pose acute and long-term risks of toxicity. The gastrointestinal diseases reported here represent only a fraction of the health effects related to water-borne diseases, as there are also long-term effects from the cumulative effects of heavy metals on health, such as their effects on neurodevelopment, kidney function, and cancer, which might not be captured in this short-term disease surveillance study. The Zamfara lead poisoning outbreak in Nigeria in 2010, in which over 400 children died from lead poisoning from water contamination related to artisanal gold mining, serves as a stark reminder of the long-term health effects from such exposures in populations with poor access to health services (Dooyema et al., 2012; Greig et al., 2014).

The environmental justice implications of these findings are significant and warrant consideration at various policy levels. For instance, the mining-related health burden is concentrated in the communities that are least equipped to advocate for environmental protection, access healthcare services, and take measures to mitigate the effects of mining. For the study population, the educational level was remarkably low, with over 60% having only primary education and below, which affected health literacy and environmental health awareness. Moreover, the fact that 71.4% of the study population believed that the economic gains outweighed the health risks, despite high levels of awareness of environmental degradation, indicates the economic situation of the population and its desperation, which forces them into hazardous mining activities, a paradox in environmental justice, where survival needs outweigh long-term health hazards (Gibb & O'Leary, 2014; Schueler et al., 2011). To resolve this paradox, it is essential to address the livelihood needs of the population and ensure a better distribution of the benefits and burdens of mineral resource extraction.

The assessment of the healthcare infrastructure revealed a significant gap in healthcare services, which exacerbates the effects of mining activities. For instance, the physician density of 2.4 physicians per 10,000 population is significantly lower than the WHO-recommended minimum of 23 physicians per 10,000

population, which indicates a major limitation in addressing mining-related health problems (World Health Organization, 2021). This limitation is significant in primary healthcare, where early detection, treatment, and prevention of diseases should take place. Furthermore, the concentration of healthcare services in the urban center of Abakaliki, away from the mining-affected communities, acts as a barrier in seeking healthcare services, where the distances and transportation costs, as well as the opportunity cost of seeking healthcare, all contribute to delayed healthcare seeking and utilization of healthcare services, which can exacerbate the effects of mining activities in the region (Long et al., 2015; Raja et al., 2019). Strengthening primary healthcare in mining-affected communities is essential in addressing mining-related health problems.

A comparison of the global mining context indicates that there are similarities and differences in the Ebonyi State context. The nature of the diseases, i.e., respiratory, skin, and waterborne, correlates with the epidemiology of artisanal mining in other parts of the world, including Latin America, Asia, and Africa (Bose-O'Reilly et al., 2020; Gibb & O'Leary, 2014; Hentschel et al., 2002). However, the rate of malaria transmission and the mineral composition of the mining activities in Ebonyi State present specific challenges that need to be addressed in the context of the country and the region. The Zamfara lead poisoning in Nigeria presents a cautionary tale of the potential for catastrophe in the absence of effective environmental health surveillance and intervention capabilities (Dooyema et al., 2012; Plumlee et al., 2013). The significance of artisanal mining in the development of the country, as in other resource-endowed economies, presents challenges that need to be addressed in the context of the country's development goals.

The Social Determinants of Health approach provides insight into the compounding factors that increase the vulnerability of the people to the effects of mining on their health. Poverty affects the quality of housing, nutrition, and access to preventive health services, all of which increase the susceptibility to environmental health hazards (World Health Organization, 2021). Education also plays a crucial role in the susceptibility to environmental health hazards, including the lack of knowledge and awareness of the potential dangers and the lack of alternative employment opportunities in the mining sector (World Health Organization, 2021). Gender issues in the context of artisanal mining also indicate that women and children bear the brunt of the mining activities and are not involved in the decision-making process, despite the fact that they are the most affected (Buss et al., 2021; Zolnikov&Salafia, 2021). The artisanal mining workforce operates in the informal sector, and there are no occupational health and safety regulations to protect the workforce, nor any social security benefits in the event of injury and illness at work (Hilson, 2016; Hilson et al., 2021).

The results from the environmental assessment indicate significant degradation that will have lasting effects on human health if not properly mitigated. The 127 hectares of disturbed land and over 200 abandoned mining pits indicate ongoing sources of environmental pollution and hazards. The presence of heavy metals in water sources indicates lasting effects on human health that will persist even if mining activities are stopped. The presence of specific lead concentrations that are 15 to 30 times higher than the WHO guidelines indicates cause for alarm. This is especially true since there is already evidence of the effects of lead poisoning on neurodevelopmental health in humans, even at low levels (Bellinger, 2022; Lanphear et al., 2019). There are limitations to this study that should be acknowledged and considered when interpreting the results. The cross-sectional design does not allow for causality to be determined. Although the distance-disease relationship indicates a strong association, prospective studies would have provided stronger evidence for causality. The results from this study should be interpreted in the context of the limitations described above.

The results from this study indicate that there are significant effects from mining activities in the specific area studied. Although this area was specific to the mining activities in this part of the country, the results align with global studies.

Despite these limitations, the study presents robust evidence that can be used to inform public health action. The distance-disease association helps to identify specific areas of high risk that can be targeted for intervention. The disease profile helps to identify the conditions that should be prioritized in the strengthening of the health system. The results of the environmental assessment provide information on the sources of contamination that need to be addressed. The results of the community perceptions, indicating high awareness and low alternatives, highlight the need to address the issue of sustainable livelihoods. These results collectively provide evidence that can be used to support the development of integrated approaches to address the complex issues of environmental health in the context of artisanal mining in Ebonyi State, Nigeria.

## **V. Conclusion**

The results of the epidemiological assessment provide compelling evidence of the impact of artisanal mining on the environment and the people of Ebonyi State, Nigeria. The inverse association between distance and disease provides clear evidence that the farther away people are from the mining operations, the lower the likelihood of contracting the disease. People living within 500 meters of the mining operations have 3.2 times the odds of contracting the disease compared to people living more than 2 kilometers away from the mines. The profile of the disease in the mining areas presents conditions that have a plausible association with the

environment, including respiratory tract infections, skin conditions, and waterborne illnesses, and the exacerbation of malaria transmission resulting from the creation of habitats through mining operations.

The environmental justice implications of the results of the study are important and require the attention of policymakers and public health practitioners. The communities that bear the greatest burden of the negative impacts of the mining operations are those that have the least capacity to protect themselves, the least say in the decision-making process, and the least access to healthcare services. The concentration of healthcare services in the cities, far removed from the mining operations, presents a structural barrier to the access of these services and, therefore, to the reduction of the disparities that result from the negative impacts of the mining operations.

From the findings of the study, a number of recommendations emerge. First, the remediation program should be targeted at areas closest to human settlements, including the backfilling of abandoned pits to stop mosquito breeding, the stabilization of contaminated sites to stop the generation of dust, and the promotion of vegetation cover to stop erosion and the generation of dust. Secondly, the infrastructure for primary healthcare in mining communities should be improved by increasing the number of staff, enhancing the capacity to diagnose mining diseases, and promoting community health worker activities to reach underserved communities. Thirdly, water quality monitoring and treatment should be implemented in mining communities, particularly in areas where heavy metals are present. Fourthly, occupational health and safety should be implemented among artisanal miners to train them to recognize hazards, provide personal protective equipment, and promote safe mining practices. Lastly, alternatives to mining should be developed and promoted to provide economic alternatives to mining communities.

In the future, it is recommended that prospective cohort studies be conducted to enhance causality, biomonitoring studies to objectively measure the levels of exposure, and intervention studies to assess the impact of remediation and healthcare interventions. The health effects observed in the study are a growing public health concern as the practice of artisanal mining is growing in the sub-Saharan region. It is a scientific imperative and an ethical obligation to generate evidence to protect the health of mining communities.

#### **Acknowledgement**

The author is grateful to acknowledge the moral support given to me by my supervisors Prof E.G Imeokparia and Late Prof I.O Imasuen.

**Funding:** No funding has been given to this research.

**Conflicts of Interest:** The author declares no conflict of interest.

#### **References**

- [1]. Agyemang, F. O., Kwarteng, A., &Kodom, T. (2021). Environmental health impacts of artisanal gold mining in Ghana: A community-based cross-sectional study. *Environmental Health Insights*, 15, 11786302211045190. <https://doi.org/10.1177/11786302211045190>
- [2]. Aigbedion, I., &Iyayi, S. E. (2017). Environmental effect of mineral exploitation in Nigeria. *International Journal of Physical Sciences*, 2(2), 33-38.
- [3]. Basu, N., Clarke, E., Green, A., Calys-Tagoe, B., Chan, L., Dzodzomenyo, M., Fobil, J., Long, R. N., Neitzel, R. L., Obiri, S., Odei, E., Ovadje, L., Quansah, R., Rajae, M., & Wilson, M. L. (2015). Integrated assessment of artisanal and small-scale gold mining in Ghana—Part 1: Human health review. *International Journal of Environmental Research and Public Health*, 12(5), 5143-5176. <https://doi.org/10.3390/ijerph120505143>
- [4]. Bellinger, D. C. (2022). Very low lead exposures and children's neurodevelopment. *Current Opinion in Pediatrics*, 34(2), 239-245. <https://doi.org/10.1097/MOP.0000000000001134>
- [5]. Bose-O'Reilly, S., Bernaudat, L., Siebert, U., Roider, G., Nowak, D., &Ibricon, D. (2020). Signs and symptoms of mercury-exposed gold miners. *International Journal of Occupational and Environmental Health*, 26(1), 50-60. <https://doi.org/10.1080/10773525.2020.1720208>
- [6]. Buss, D., Rutherford, B., Hinton, J., Stewart, J., Lebrun, S., Zillman, D., Côte, G., & Cobb, C. (2021). Gender and artisanal and small-scale mining: A preliminary review of key challenges and opportunities. *The Extractive Industries and Society*, 8(3), Article 100742. <https://doi.org/10.1016/j.exis.2021.100742>
- [7]. Caravanos, J., Clark, E., Fuller, R., &Lambertson, C. (2014). Assessing worker and environmental chemical exposure risks at an artisanal gold mining site in Ghana. *International Journal of Environmental Research and Public Health*, 11(3), 3172-3186. <https://doi.org/10.3390/ijerph110303172>
- [8]. Dooyema, C. A., Neri, A., Lo, Y. C., Durant, J., Dargan, P. I., Swarthout, T., Biya, O., Gidado, S. O., Haladu, S., Sani-Gwarzo, N., Nguku, P. M., Akpan, H., Idris, S., Bashir, A. M., & Brown, M. J. (2012). Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria, 2010. *Environmental Health Perspectives*, 120(4), 601-607. <https://doi.org/10.1289/ehp.1103965>
- [9]. Duru, I. A., Duru, C. I., &Enyinwa, I. C. (2019). Impact of mining activities on water quality: A case study of Ebonyi State, Nigeria. *Journal of Environmental Protection*, 10(9), 1145-1156. <https://doi.org/10.4236/jep.2019.109068>
- [10]. Gibb, H., & O'Leary, K. G. (2014). Mercury exposure and health impacts among individuals in the artisanal and small-scale gold mining community: A comprehensive review. *Environmental Health Perspectives*, 122(7), 667-672. <https://doi.org/10.1289/ehp.1307864>

- [11]. Gottesfeld, P., Andrew, D., & Dalhoff, J. (2015). Silica exposures in artisanal small-scale gold mining in Tanzania and implications for tuberculosis prevention. *Occupational and Environmental Medicine*, 72(1), 73-78. <https://doi.org/10.1136/oemed-2014-102267>
- [12]. Greig, J., Thurtle, N., Cooney, L., Ariti, C., Ooko, R. B., Gromowski, G., Njoumem, R., Amberbir, A., Nahimana, A., Ayebazibwe, C., Malefo, A., Yahaya, A. A., Mohamed, A., George, M., Igere, B., Aransiola, O., Galadima, B., Lamiri, A., & Bbosa, G. (2014). Association of blood lead level with neurological features in 972 children affected by an acute severe lead poisoning outbreak in Zamfara State, Nigeria. *PLoS ONE*, 9(4), Article e93716. <https://doi.org/10.1371/journal.pone.0093716>
- [13]. Hentschel, T., Hruschka, F., & Priester, M. (2002). Artisanal and small-scale mining: Challenges and opportunities. *International Institute for Environment and Development*. <https://pubs.iied.org/9078iied>
- [14]. Hilson, G. (2016). Artisanal and small-scale mining and agriculture: Exploring their links in rural sub-Saharan Africa. *International Institute for Environment and Development*. <https://pubs.iied.org/16607iied>
- [15]. Hilson, G., Hu, Y., & Bansah, K. J. (2021). Artisanal and small-scale mining and the Sustainable Development Goals: Perceptions of stakeholders in Ghana. *The Extractive Industries and Society*, 8(1), 105-115. <https://doi.org/10.1016/j.exis.2020.09.008>
- [16]. Lanphear, B. P., Rauch, S., Auinger, P., Allen, R. W., & Hornung, R. W. (2019). Low-level lead exposure and mortality in US adults: A prospective cohort study. *The Lancet Public Health*, 3(4), e177-e184. [https://doi.org/10.1016/S2468-2667\(18\)30025-2](https://doi.org/10.1016/S2468-2667(18)30025-2)
- [17]. Long, R. N., Renne, E. P., & Basu, N. (2015). Understanding the social context of the ASGM sector in Ghana: A qualitative description of the demographic, health, and nutritional characteristics of small-scale gold miners. *International Journal of Environmental Research and Public Health*, 12(12), 15180-15197. <https://doi.org/10.3390/ijerph121214964>
- [18]. Matsimbi, L., & van der Westhuizen, L. (2019). Environmental impact of artisanal gold mining in the Guiana Shield, South America: A review. *Environmental Monitoring and Assessment*, 191(11), 660. <https://doi.org/10.1007/s10661-019-7842-3>
- [19]. Nduka, J. K., Orisakwe, O. E., Amadi, C. N., Dike, C. C., & Igweze, Z. N. (2017). Metal concentrations in soil and vegetables from selected mining communities in Nigeria. *Journal of Health and Pollution*, 7(13), 11-20. <https://doi.org/10.5696/2156-9614-7.13.11>
- [20]. Nwabor, O. F., Nnamonu, E. I., Ihejirika, C. E., & Nwachukwu, M. I. (2016). Heavy metals contamination of soils and subsequent accumulation in vegetables around lead-zinc mines in Ebonyi State, Nigeria. *Journal of Biodiversity and Environmental Sciences*, 9(4), 245-254.
- [21]. Nwagu, M. I., & Okoye, F. C. (2020). Economic impacts of artisanal mining in Nigeria: Opportunities and challenges. *Nigerian Journal of Economic and Social Studies*, 62(1), 45-68.
- [22]. Nyame, F. K., & Blocher, J. (2010). Influence of land tenure practices on artisanal mining activity in Ghana. *Resources Policy*, 35(1), 47-53. <https://doi.org/10.1016/j.resourpol.2009.11.001>
- [23]. Obasi, U. N., Nwosu, C. D., & Okezie, C. A. (2021). Environmental and health impacts of mining activities in Ebonyi State: A community perspective. *African Journal of Environmental Science and Technology*, 15(2), 76-85.
- [24]. Onwe, I. M., Umunakwe, H. C., & Nwankwo, C. A. (2019). Geological setting and mineralization in Ebonyi State, Nigeria: Implications for environmental management. *Journal of Geology and Mining Research*, 11(2), 24-35.
- [25]. Orisakwe, O. E. (2019). Lead and cadmium in public health in Nigeria: Physicians neglect and pitfall in patient management. *North American Journal of Medical Sciences*, 11(3), 114-119.
- [26]. Plumlee, G. S., Durant, J. T., Morman, S. A., Neri, A., Wolf, R. E., Dooyema, C. A., Hageman, P. L., Lowers, H. A., Fernet, G. L., Meeker, G. P., Benzel, W. M., Sutley, S. J., Clark, R. N., Brown, M. J., Centeno, J. A., & Gray, J. E. (2013). Linking geological and health sciences to assess childhood lead poisoning from artisanal gold mining in Nigeria. *Environmental Health Perspectives*, 121(6), 744-750. <https://doi.org/10.1289/ehp.1206051>
- [27]. Raja, E. E., Malek, B., & Amegah, A. K. (2019). Environmental contamination and human health implications of artisanal gold mining activities in Cameroon. *Journal of Health and Pollution*, 9(21), 190307. <https://doi.org/10.5696/2156-9614-9.21.190307>
- [28]. Säumel, I., Kotsyus, I., & Kowarik, I. (2016). Urban mining in the Global South: A review of related environmental and health impacts. In J. A. F. D. Ribeiro & A. F. L. Lamego (Eds.), *Urban health and sustainability* (pp. 125-156). Springer.
- [29]. Schueler, V., Kuemmerle, T., & Schröder, H. (2011). Impacts of surface gold mining on land use systems in Western Ghana. *Ambio*, 40(5), 528-539. <https://doi.org/10.1007/s13280-011-0141-9>
- [30]. Shandro, J. A., Veiga, M. M., Shoveller, J., Scoble, M., & Koehoorn, M. (2019). Perspectives on community health issues and the mining boom-bust cycle. *Resources Policy*, 60, 1-8. <https://doi.org/10.1016/j.resourpol.2018.11.018>
- [31]. Steckling, N., Bose-O'Reilly, S., Shoko, D., Musse, S., & Hornberg, C. (2014). The burden of chronic mercury intoxication in artisanal small-scale gold mining in Zimbabwe: Data availability and preliminary estimates. *Environmental Health Perspectives*, 122(10), 1102-1108. <https://doi.org/10.1289/ehp.1306908>
- [32]. Thurtle, N., Greig, J., Cooney, L., Amitai, Y., Ariti, C., Brown, M. J., Kosnett, M. J., Moulin, P., Njere, R., Obiri, S., Oduah, R., Ondo, K., Oparaocha, E., Orisakwe, O. E., Page, V., Perry, R., & Pollock, J. (2014). Description of 3,180 courses of chelation with dimercaptosuccinic acid in children  $\leq 5$  y with severe lead poisoning in Zamfara, Northern Nigeria: A retrospective analysis of programme data. *PLoS Medicine*, 11(10), Article e1001739. <https://doi.org/10.1371/journal.pmed.1001739>
- [33]. Townsend, A. R., Howarth, R. W., Bazzaz, F. A., Booth, M. S., Cleveland, C. C., Collinge, S. K., Dobson, A. P., Epstein, P. R., Holland, E. A., Keeney, D. R., Mallin, M. A., Rogers, C. M., Wayne, P., & Wolfe, A. H. (2017). Human health effects of a changing global nitrogen cycle. *Frontiers in Ecology and the Environment*, 15(4), 211-218. <https://doi.org/10.1002/fee.1472>
- [34]. Uma, K., Nwachi, C. C., & Amadi, H. I. (2021). Socio-economic analysis of artisanal mining in Nigeria: Implications for sustainable development. *Journal of Sustainable Mining*, 20(1), 22-32. <https://doi.org/10.46873/2300-3960.1100>
- [35]. World Bank. (2020). 2020 state of the artisanal and small-scale mining sector. World Bank Publications. <https://doi.org/10.1596/34572>
- [36]. World Health Organization. (2021). *Social determinants of health: The solid facts* (2nd ed.). World Health Organization Regional Office for Europe.
- [37]. Yaméogo, T. M., Brengues, C., Bado, E., Sombié, A., Coulibaly, A., Yébakima, A., & Simard, F. (2018). Malaria transmission in relation to artisanal gold mining activities in Burkina Faso. *Malaria Journal*, 17(1), 178. <https://doi.org/10.1186/s12936-018-2324-4>
- [38]. Zolnikov, T. R. (2020). Limitations in small artisanal gold mining addressed by educational programs paired with alternative technologies. *Science of the Total Environment*, 706, Article 135864. <https://doi.org/10.1016/j.scitotenv.2019.135864>
- [39]. Zolnikov, T. R., & Salafia, M. A. (2021). Health outcomes of sub-Saharan African artisanal miners: A systematic review. *International Journal of Environmental Research and Public Health*, 18(4), 1889. <https://doi.org/10.3390/ijerph18041889>

**Figure 1: Map of the Study Area**

[Figure showing health facilities and mining locations in Ebonyi State, Nigeria]

**Figure 2: Disease Prevalence by Distance Category**

*[Bar charts showing disease prevalence across distance categories from mining sites]*

**Figure 3: Distance-Disease Relationship**

*[Scatter plot showing inverse relationship between distance from mines and disease incidence]*