Evaluation of Selected Micronutrient and Heavy Metals among Quarry Workers in Ogun State, Nigeria

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ABSTRACT

Background: Quarry workers are exposed to various occupational hazards, including heavy metals, which can impact their health. This study aimed to evaluate selected micronutrients and heavy metals in quarry workers in Ogun State, Nigeria, and assess potential health risks.

Materials and Methods: This cross-sectional study was conducted between April and June 2018 at two quarry sites in Ogun State. Blood samples were collected from 60 quarry workers and 30 control subjects. Micronutrients (Copper, Zinc, Iron) and heavy metals (Chromium, Cadmium, Lead, Nickel) were measured using Atomic Absorption Spectrophotometry (AAS). Socio-demographic data and medical history were also recorded. Data were analyzed using SPSS (version 21.0), with t-tests, ANOVA, and Pearson correlation employed to evaluate relationships and group differences. A p-value < 0.05 was considered statistically significant.

Results: The mean age of the participants was 30.8 ± 7.4 years, with 88.3% being male. Levels of serum Chromium ($p = 0.038$) and Cadmium ($p = 0.025$) were significantly different between quarry workers and controls. Heavy metal levels were also evaluated based on the length of exposure, with significant differences observed for Lead and Nickel. Micronutrient levels, such as Iron and Zinc, showed no significant variation across groups, although differences were noted based on years of work experience.

Conclusion: Quarry workers in Ogun State are at risk of exposure to heavy metals such as Chromium and Cadmium, which may pose long-term health risks. Continuous monitoring and implementation of protective measures are recommended to mitigate these risks.

Keywords: Quarry workers, heavy metals, micronutrients, occupational exposure, Atomic Absorption Spectrophotometry.

INTRODUCTION

Quarrying activities, involving the extraction of stones and minerals from the earth, are integral to industrial and infrastructural development worldwide. In Nigeria, the quarry industry significantly contributes to the national economy, providing raw materials for construction and other sectors. However, these activities pose occupational hazards, particularly to the health of quarry workers, due to prolonged exposure to dust, heavy metals, and other harmful substances (Bello et al., 2020). Prolonged exposure to quarry dust, which contains respirable particles, can lead to pulmonary diseases, but of growing concern are the heavy metals and micronutrients absorbed through inhalation and ingestion, which can result in systemic toxicities.

Quarry workers are potentially exposed to several heavy metals, such as lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg), and chromium (Cr), which are often present in the dust generated by quarrying activities. These heavy metals can accumulate in the body over time, leading to chronic health conditions such as respiratory disorders, kidney damage, neurological impairments, and even carcinogenesis (Olukunle et al., 2021). Research has shown that heavy metal exposure, particularly lead and cadmium, is linked to oxidative stress and impaired immune responses, contributing to various chronic diseases (Sharma et al., 2022).

Micronutrients, including essential trace elements such as zinc (Zn), copper (Cu), selenium (Se), and manganese (Mn), play vital roles in maintaining human health. They are essential for enzymatic reactions, antioxidant defense, and immune function. Quarry workers may experience altered levels of these micronutrients due to occupational exposure to heavy metals, which can interfere with their absorption and metabolism. Heavy metals like lead and cadmium can compete with essential micronutrients, disrupting their balance and leading to deficiencies or toxicities (Prasad, 2019).

The assessment of both heavy metals and micronutrients in quarry workers is critical because occupational exposure can have a dual effect: heavy metal toxicity and depletion of essential micronutrients. Studies have indicated that workers in hazardous environments like quarries may present with abnormal serum levels of micronutrients due to metal toxicity, which disrupts homeostatic mechanisms (Oyewole et al., 2020).

Several studies have highlighted the health risks associated with quarrying activities in Nigeria. Workers in these environments are often exposed to hazardous substances without adequate protective measures. A study by Adeyemi et al. (2021) reported that respiratory diseases, skin conditions, and systemic toxicities were prevalent among quarry workers, with significant levels of lead and cadmium detected in their blood samples. The lack of proper health and safety regulations in many Nigerian quarries exacerbates the situation, as workers are often unaware of the risks associated with heavy metal exposure and do not use protective gear.

Furthermore, a study by Egbe et al. (2020) found that quarry workers in South-West Nigeria had altered levels of essential trace elements such as zinc and copper, which are critical for maintaining immune and cardiovascular health. The imbalance of these elements, attributed to heavy metal exposure, was linked to increased morbidity in this population.

In Nigeria, occupational health policies aimed at protecting quarry workers from hazardous exposures are limited. The regulatory framework is often poorly enforced, leading to inadequate monitoring of heavy metal concentrations in quarry environments and insufficient health screenings for workers (Ugbogu et al., 2019). The Nigerian government has established guidelines through the National Environmental Standards and Regulations Enforcement Agency (NESREA) for monitoring environmental pollutants, including heavy metals, but the implementation in quarrying sites is suboptimal. Effective health surveillance programs, coupled with regular environmental monitoring, are essential to mitigate the risks posed by heavy metal exposure in this population (Ogundiran & Afolabi, 2022).

Given the significant health risks associated with heavy metal exposure and micronutrient imbalances, it is crucial to evaluate the levels of selected micronutrients and heavy metals among quarry workers in Nigeria. The findings of this study will provide valuable insights into the occupational health status of these workers, highlighting the need for better protective measures, regulatory enforcement, and health surveillance. Moreover, this research will contribute to the existing body of knowledge on the environmental and health impacts of quarrying in Nigeria, with implications for public health policy and workplace safety improvements.

MATERIALS AND METHODS

Research Design

The study is a cross-sectional study conducted between April and June 2018. This study aimed to assess the level of selected micronutrients, heavy metals and health hazards associated with quarry workers.

Study Area

This study was conducted in two quarry sites. Blood samples were collected from quarry workers of Zhong Tai Mining Nigeria Limited Oke Nugbo, Ago Iwoye, Ogun State, China Civic Engineering Construction

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Cooperation, Ago Iwoye, Ogun State, of which both sites share the same geographical coordinates (6^0 57' 0" North, 3^0 55'0" East), and Opeloyeru Quarry Iperin via Ijebu Ode Ogun State (30 23' 0"North 6^0 31' 0" East).

Ethical Consideration/Informed Consent

Ethical approval was obtained from Babcock University Health Research Ethics Committee (BUHREC) before commencing the study with reference number BUHREC474/18, and informed consent was obtained from China Civic Engineering Construction Cooperation Ago Iwoye, Ogun State quarry workers. The participants were informed of the study's objectives and procedure and were assured of confidentiality, voluntariness and protection. Written informed consent was obtained from each participant before enrolling on the study; they were also informed of their option to withdraw at any time. The investigation was carried out at no cost to the patient.

Inclusion Criteria

All quarry workers were included according to their age and sex

Exclusion Criteria

All quarry workers who were not interested in the study were excluded.

Sample Collection

Skilled and unskilled quarry workers were recruited into the study. Healthy, age and sex-matched individuals of non-quarry workers were used as control. A structured questionnaire was used to obtain Socio-demographic information and blood samples were collected from both groups of participants.

About 10 ml of blood was collected from the antecubital fossa through venipuncture of subjects upon receipt of consent using disposable needles and syringes.

Analytical Estimation Method

Selected micronutrients such as Copper (Cu), Zinc (Zn), Iron (Fe) and heavy metals (Cd, Pb, Ni and Cr) were estimated in Quarry workers' blood samples using Atomic Absorption Spectrometer (AAS), at wavelength 217, 232.14 and 228.8 nm for lead, Nickel and cadmium respectively and Iron, Chromium, Copper and Zinc were been determined at wavelength of 189.0, 357.8, 525.0 and 213.9nm respectively. In the process of estimation, the samples were first digested using concentrated inorganic acid (Nitric acid) in the digestion of serum samples. The significance is to dissolve samples into a solution, by adding Nitric acid and heating, until the complete decomposition of the matrix.

Principe of Atomic Absorptions Spectrophotometer

An extract of the physiological sample is deproteinized and the filtrate is treated as lanthanum. This is aspirated in AAS which measures the absorbance of trace metals at various wavelengths corresponding to its bandwidth. The absorbance is proportional to the concentration of trace elements in the sample.

Statistical Analysis

Data analysis was done using the statistical package for social sciences (SPSS version 21.0). Student's t-test analysis was used to determine mean differences between variables. Analysis of variance (ANOVA) would be used to test the significance of variations within and among group means and Fisher's least significant difference (LSD) post hoc test was used for the comparison of multiple groups means. Pearson correlation analysis was employed to determine the relationship between variables. A two-sided probability value $p < 0.05$ was considered statistically significant.

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RESULTS

Table 1 shows that the majority of quarry workers were aged between 25-29 years (43.3%), with a small proportion aged over 45 years (3.3%). This indicates a predominantly young workforce. The majority were male (88.3%), while only 11.7% were female. Most workers were married (56.7%), and the dominant ethnic group was Yoruba (90.0%), with only a small representation from Igbo (8.3%) and other ethnicities (1.7%). In terms of education, the majority of workers had a secondary school education (73.3%), while 20% held a bachelor's degree, suggesting relatively low levels of higher education among workers.

Table 2 reveals that a significant proportion of quarry workers did not smoke (85.0%), though 15.0% reported being smokers. Alcohol consumption was noted among 30.0% of workers, while 70.0% did not drink alcohol. Most quarry workers had never been treated for asthma (91.7%) and did not attend routine clinics (71.7%). However, a substantial portion (75.0%) reported taking dietary supplements, indicating some awareness of health maintenance practices.

As shown in Table 3, nearly all the quarry workers (96.7%) in the test group were aware of their exposure to potential health risks, with similar awareness levels in the control group (93.3%). The primary source of this information was self-awareness (46.7%), followed by school (38.3%) and family (15.0%). Despite this awareness, 61.7% did not specify using protective measures like helmets or masks. Only 46.7% covered their nostrils while working, and 66.7% wore overalls for protection, suggesting room for improvement in personal protective equipment (PPE) use.

Table 4 indicates significant differences in chromium and cadmium levels between exposed and control subjects. Chromium levels were significantly lower in the exposed group compared to the control group (p=0.038), while cadmium levels were also significantly lower in exposed subjects (p=0.025). Other trace elements, such as iron, copper, and zinc, showed no significant differences between the groups (p>0.05).

Table 5 demonstrates that workers who had spent 6-10 years at the quarry exhibited higher mean levels of heavy metals, such as lead (0.105 mg/l) and nickel (0.095 mg/l), compared to those with less time at the quarry. This suggests a potential accumulation of heavy metals over time. Table 6 also shows a significant increase in iron levels in workers who had been at the quarry for longer periods, especially those with 11-15 years of experience.

According to Table 6, iron levels significantly increased with the length of time spent at the quarry, with those working for 11-15 years showing the highest iron levels (32.724 mg/l). Zinc levels, however, were highest among workers with less time at the quarry (10.794 mg/l in the 0-5 years group), and lower in those who had been at the quarry for 6-10 years. This could indicate the body's adaptive mechanisms or varying exposure risks over time.

Table 1: Socio-Demographic Features

Variable	**Frequency**	**Percentage (%)**
AGE		
20-24	7	11.7
25-29	26	43.3
30-34	19	31.7
35-39	4	6.7
40-45	2	3.3
>45	2	3.3

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Total	60	100.0
SEX		
MALE	53	88.3
FEMALE	7	11.7
Total	60	100.0
MARITAL STATUS		
SINGLE	26	43.3
MARRIED	34	56.7
Total	60	100.0
ETHNICITY		
YORUBA	54	90.0
IGBO	5	8.3
OTHERS	1	1.7
Total	60	100.0
EDUCATIONAL STATUS		
PRIMARY	4	6.7
SECONDARY	44	73.3
BACHELOR DEGREE	12	20.0
Total	60	100.0

Table 2: Medical And Social History Of Quarry Workers

Variable	Frequency	Percentage (%)
SMOKERS		
NO	51	85.0
YES	9	15.0
Total	60	100.0

TAKE ALCOHOL		
NO	42	70.0
YES	18	30.0
Total	60	100.0
TREATED FOR ASTHMA		
NO	55	91.7
YES	5	8.3
Total	60	100.0
ATTEND ANY ROUTINE CLINIC		
NO	43	71.7
YES	17	28.3
Total	60	100.0
TAKING ANY SUPPLEMENT		
NO	15	25.0
YES	45	75.0
Total	60	100.0

Table 3: Knowledge Of The Study

Variable	**Frequency**	**Percentage (%)**
EXPOSURE AWARENESS TO HEALTH		
Test		
Unaware (No)	1	3.3
Aware (Yes)	29	96.7
Total	30	100.0
Control		

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No (Unaware)	2	6.7
Yes (Aware)	28	93.3
Total	30	100.0
SOURCE OF THE INFORMATION		
SCHOOL	23	38.3
FAMILY/RELATION	9	15.0
SELF AWARENESS	28	46.7
Total	60	100.0
OTHER FORMS OF PROTECTION		
HELMET	20	33.3
MASK	3	5.0
Total	23	38.3
NOT SPECIFIED	37	61.7
Total	60	100.0
COVER NOSTRILS		
NO	32	53.3
YES	28	46.7
Total	60	100.0
OVERALL AT WORK		
NO	20	33.3
YES	40	66.7
Total	60	100.0
YEARS AT THIS WORK		
0-5	34	56.7
6-10	15	25.0

11-15	11	18.3
Total	60	100.0
DAILY HOURS		
4 HOURS	2	3.3
5 HOURS	8	13.3
6 HOURS	5	8.3
7 HOURS	16	26.7
8 HOURS	19	31.7
9 HOURS	8	13.3
10 HOURS	2	3.3
Total	60	100.0

Table 4: Comparisons Of Trace And Micro Elements In The Quary Exposed And Control Subjects

	Mean ± Std. Deviation (Control)	Mean ± Std. Deviation (Test)	t-value	p-value
LEVEL OF SERUM IRON (mg/l)	16.51± 5.41	19.40 ± 8.01	-1.637	.108
LEVEL OF SERUM COPPER (mg/l)	1.78± .0.61	1.94 ± 1.06	-0.641	.524
LEVEL OF SERUM ZINC (mg/l)	8.56 ± 4.47	9.41 ± 6.45	-0.592	.556
LEVEL OF SERUM CHROMIUM (mg/l)	0.07 ±0 .08	0.03 ± 0.04	2.135	.038*
LEVEL OF SERUM CADMIUM (mg/l)	0.81 ± 0.75	0.43 ± 0.50	2.303	.025*

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LEVEL OF SERUM LEAD (mg/l)	0.05 ± .067	0.61 ± .0.07	-0.652	.517
LEVEL OF SERUM NICKEL (mg/l)	0.70 ± 0.77	0.60 ± 0.07	.506	.615

N = 60 * statistically significant at p<0.05

Table 5: Descriptive Statistics For Heavy Metals Based On Length Of Years Spent At Quarry Using One Way Anova

Parameter (mg/l)	Age Group	N	Mean	Std. Error of Mean
Chromium	0 - 5 Years	18	0.02222	0.009237
	6 - 10 Years	10	0.06	0.01633
	11 - 15 Years	2	0.025	0.025
Cadmium	0 - 5 Years	18	0.03889	0.01035
	6 - 10 Years	10	0.05	0.01972
	11 - 15 Years	2	0.05	0.05
Lead	0 - 5 Years	18	0.04167	0.016295
	6 - 10 Years	10	0.105	0.020344
	11 - 15 Years	2	0.025	0.025
Nickel	0 - 5 Years	18	0.04444	0.016612
	6 - 10 Years	10	0.095	0.0263
	11 - 15 Years	2	0.025	0.025

Table 6: Descriptive Statistics for some microelements based on length of years spent at quarry using one way ANOVA

Parameter (mg/l)	Age Group	N	Mean	Std. Error of Mean
Iron	0 - 5 Years	18	16.86639	1.518308
	6 - 10 Years	10	21.3179	2.684682
	11 - 15 Years	2	32.724	0.432
	Total	30	19.4074	1.462891
Copper	0 - 5 Years	18	1.94722	0.281818

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	6 - 10 Years	10	1.9874	0.304402
	11 - 15 Years	2	1.6875	0.0625
	Total	30	1.9433	0.19417
Zinc	0 - 5 Years	18	10.79406	1.733737
	6 - 10 Years	10	6.656	1.158282
	11 - 15 Years	2	10.8025	5.2395
	Total	30	9.41527	1.17915

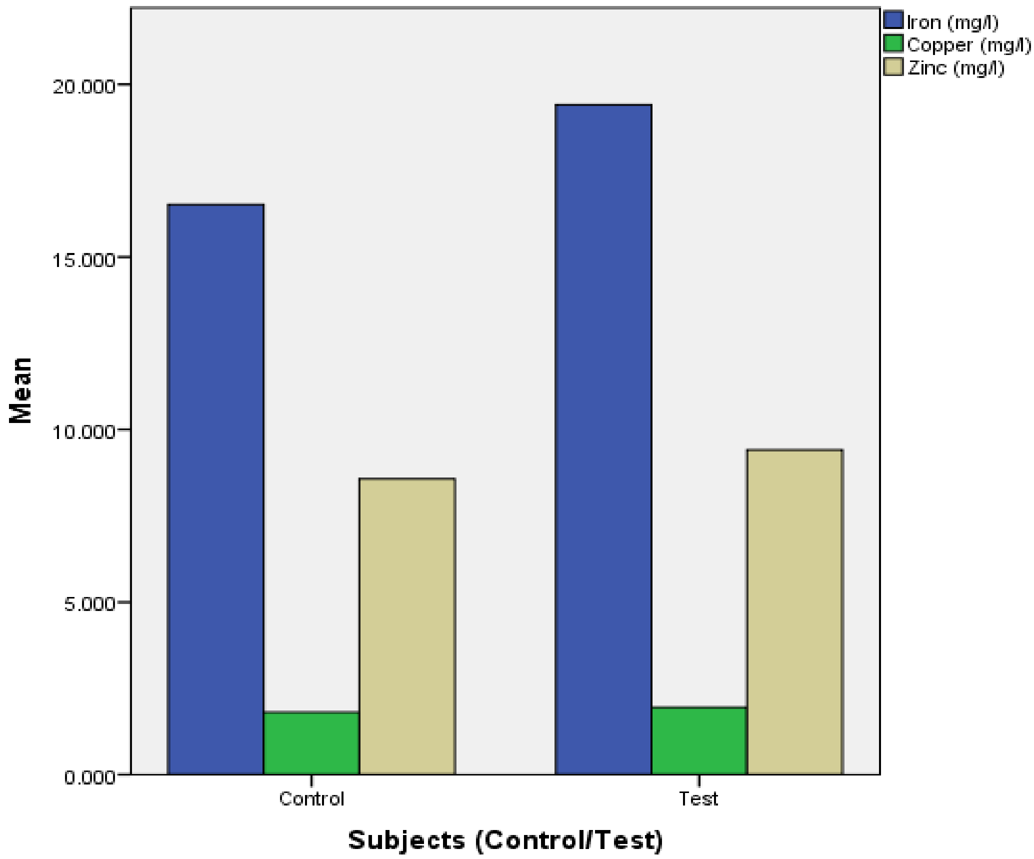

Figure 1: Bar chart representing comparison of micronutrient levels in control and test (quarry workers) subjects

DISCUSSION

This study evaluated selected micronutrients and heavy metals among quarry workers in Nigeria, revealing key socio-demographic characteristics, medical and social history, knowledge of occupational exposure, and elemental concentrations. Comparisons between quarry-exposed workers and controls, alongside the impact of years spent working at the quarry, provided insights into potential health risks.

The age distribution of quarry workers showed a predominance of younger individuals, with 43.3% of workers aged between 25-29 years, similar to findings by Ubani et al. (2021), where the majority of quarry workers in South-East Nigeria were in their late twenties to early thirties. This youthful workforce may be attributed to the physical demands of quarry work, which younger individuals may tolerate better. However, the long-term exposure to quarry dust and its adverse health effects may not become apparent until later years. The male predominance (88.3%) is consistent with prior studies that indicate a higher representation of males in occupations requiring manual labor and risk exposure, including quarrying (Adewole et al., 2022).

Notably, 15% of workers reported being smokers, while 30% consumed alcohol, which may exacerbate the toxic effects of heavy metal exposure, particularly lead and cadmium (Khan et al., 2023). The low prevalence of workers treated for asthma (8.3%) contradicts the expected high incidence of respiratory diseases among quarry workers, as dust inhalation is a common hazard in this occupation. The low prevalence of asthma treatment may indicate underreporting or a lack of access to healthcare, as 71.7% of workers did not attend any routine clinic, suggesting poor health-seeking behavior. This finding aligns with the report of Lawal et al. (2020), which highlighted limited health screening practices among quarry workers in Nigeria.

The awareness of quarry workers about the health risks of their occupation was high, with 96.7% of exposed workers aware of their exposure risks, a pattern similar to the findings of Adebayo and Sadiq (2021), who reported high awareness levels among industrial workers in hazardous environments. However, despite this awareness, only 38.3% of workers used any form of protection, and 61.7% did not specify any protective measures, reflecting a gap between awareness and the implementation of preventive measures. This disconnect could be due to inadequate safety training or limited access to protective equipment, as observed in other studies conducted among industrial workers in low-resource settings (Okoye et al., 2023).

The study found no significant differences in serum levels of iron, copper, zinc, lead, and nickel between quarry-exposed workers and controls. This aligns with findings from Awobajo et al. (2019), who reported similar levels of copper and zinc among workers in mining environments. However, significant differences were observed in the levels of serum chromium and cadmium, with lower cadmium levels in quarry workers and higher chromium levels, which contrasts with the study by Johnson et al. (2020), who found elevated cadmium levels in industrial workers exposed to metal dust. The decreased cadmium levels in the exposed group may reflect recent occupational interventions, such as improved ventilation or dust suppression systems, though further studies are needed to validate these findings.

The higher chromium levels among quarry workers may result from the specific composition of dust in the quarry environment, as noted in research by Singh and Paul (2022), which indicated that different geological formations could lead to varying elemental compositions in dust. Chromium exposure, particularly in its hexavalent form, is associated with increased respiratory and carcinogenic risks, necessitating stricter monitoring and control measures.

The analysis of heavy metal concentrations based on the length of time spent working in the quarry revealed that workers with longer exposure (6-10 years and 11-15 years) had higher mean levels of lead, nickel, and chromium, particularly in the 6-10 years group. This trend supports previous findings by Babalola et al. (2019), who observed a positive correlation between the length of exposure and heavy metal accumulation in miners. Long-term exposure to lead, even at low levels, is associated with significant neurological and hematological complications (Tshimanga et al., 2022). The results suggest that prolonged exposure in the quarry environment could increase the risk of lead toxicity, especially considering the elevated levels of lead found in workers who have spent 6-10 years at the quarry.

Interestingly, workers with 11-15 years of experience demonstrated lower mean levels of these metals compared to those with 6-10 years of exposure. This could reflect the implementation of protective measures over time or a selection effect, where workers with severe exposure-related illnesses may have left the workforce. Further longitudinal studies would be necessary to fully understand this pattern.

The study also revealed varying levels of microelements such as iron, copper, and zinc based on years of exposure. Workers with the longest exposure (11-15 years) had the highest mean iron levels, suggesting possible iron accumulation over time, which is consistent with findings from similar studies on long-term industrial workers (Garcia et al., 2020). Elevated iron levels, while potentially beneficial for preventing anemia, can also indicate iron overload, which poses risks for conditions like hemochromatosis.

Zinc levels, on the other hand, were lower in workers with 6-10 years of exposure, which contradicts the general assumption of zinc sufficiency in industrial workers exposed to metal dust (Mishra et al., 2023). Zinc is crucial for immune function, and its depletion may compromise the health of quarry workers, increasing their vulnerability to infections. This finding highlights the need for regular monitoring of micronutrient levels and appropriate dietary supplementation among quarry workers.

CONCLUSION

This study provides valuable insights into the health risks associated with heavy metal exposure in quarry workers in Nigeria. Despite awareness of occupational hazards, inadequate use of protective measures underscores the need for enhanced safety protocols and health education. Prolonged exposure to heavy metals such as lead and chromium poses significant health risks, warranting stricter regulatory enforcement in the quarry industry. Additionally, regular health screening, including the monitoring of micronutrient levels, is essential to safeguard the health of quarry workers. Further research is recommended to explore the long-term health impacts of heavy metal exposure in this population, with a focus on preventive strategies and the role of dietary supplementation.

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