



Assessment of Occupational Hazards and Health Risks Among Workers in Kaidi Quarry Industry, Ohosu, Ovia North-East, Edo State, Nigeria

Giegbefumwen, M. K., Oposola, O. A., Adiama, B. Y., Jimoh, K. B., Afolabi, O. S.*, Sulaimon, O. D. & Adaramoye, T. S.

Faculty of Allied Health Sciences, Department of Environmental Health Science, Kwara State University, Malete, Nigeria

*Corresponding author: samson08060@gmail.com, +2348147498586

Abstract

Background: The quarry industry is a demanding and hazardous workplace that threatens the health and safety of its workforce through chemical exposures, physical strain, and ergonomic challenges. Workers in this sector face multiple occupational risks that place their wellbeing in jeopardy. **Objectives:** This study investigated occupational hazards and health risks among workers at Kaidi Quarry Industry, Ohosu, Ovia North-East, Edo State, Nigeria, to provide evidence for improving workplace health and safety standards. **Methodology:** A descriptive cross-sectional survey design was adopted. Data were obtained from 101 workers using structured questionnaires administered through stratified random sampling. Both descriptive statistics (frequencies and percentages) and inferential statistics (chi-square tests) were employed for data analysis using SPSS version 26. **Results:** Findings revealed high exposure levels to occupational hazards: 87.1% were exposed to dust, 75.2% to loud noise, and 62.4% to extreme heat. Reported health issues included respiratory symptoms (68.3%), skin irritation (55.4%), and musculoskeletal disorders (47.5%). Only 48.5% consistently used personal protective equipment (PPE), while 61.4% viewed existing safety measures as inadequate. Chi-square analysis revealed significant associations between job role and hazard exposure ($p = 0.041$), between employment duration and respiratory issues ($p = 0.038$), and between hazard exposure and health risks ($\chi^2 = 19.58$, $p = 0.0097$). PPE availability showed significant impact on worker health outcomes ($\chi^2 = 21.48$, $p = 0.0107$). **Conclusion/Recommendations:** Kaidi quarry workers face widespread exposure to occupational hazards with serious health consequences, while existing safety measures remain inadequate. The study recommends stronger regulatory enforcement, improved health education programs, mandatory use of personal protective equipment, enhanced workplace safety infrastructure, regular role-specific training, routine health surveillance for high-risk workers, and collaboration with regulatory bodies like NESREA to ensure compliance and improve workplace conditions.

Keywords: Kaidi, Quarry, industry, Safety, risks, occupational health, workers, production

Introduction

Occupational activities often expose workers to various forms of risk that may result in injuries or diseases (Lohe & Ghosh, 2022). Previous research has documented different categories of workplace hazards among several professions, including sanitation workers (Oza *et al.*, 2022), meat industry employees (van

Holland *et al.*, 2015), and migrant labourers in Europe (Diego-Cordero *et al.*, 2021). One of the high-risk occupations is quarrying. A quarry is an open excavation site where stones are extracted from rock formations for use in construction, agriculture, and other industrial processes (Alley *et al.*, 2019; Wilfried & Whiteman, 2021). The work requires drilling,

blasting, crushing, and transporting materials, which expose workers to dust, noise, vibration, and mechanical injuries.

Quarry workers are exposed to a range of occupational hazards that include chemical, physical, and ergonomic risks (Alley *et al.*, 2019). Among these, dust generated during quarrying and stone processing is a major health concern. Stone dust contains fine particulates such as silica and heavy metals, which, when inhaled over time, can lead to chronic respiratory conditions including bronchitis, silicosis, and obstructive pulmonary disease (Sunny *et al.*, 2022; Janakiraman *et al.*, 2024). Studies conducted in different African countries have shown a high prevalence of respiratory symptoms among quarry workers, largely due to poor dust control measures and weak enforcement of occupational safety regulations (Poudel *et al.*, 2021; Dagnew *et al.*, 2021; Ubongabasi & Atulomah, 2023).

In addition to chemical exposures, quarry workers face physical hazards such as excessive noise and vibration from heavy machinery. Noise levels in many quarry and cement sites have been found to exceed international safety limits, resulting in hearing impairment and stress-related disorders (Zhao *et al.*, 2021; Thai *et al.*, 2021; Ahmad, 2023). More so, the physically demanding nature of quarry work, combined with repetitive manual tasks and poor ergonomic conditions, contributes to musculoskeletal injuries and long-term physical strain (Emmanuel *et al.*, 2022).

Globally, evidence indicates that quarrying remains one of the most hazardous occupations. In Spain, Sanmiquel *et al.* (2021) reported approximately 13,150 injuries per 100,000 quarry workers. In Nigeria, more than 60% of employees in the solid mineral industry have experienced one or more work-related hazards (Kareem *et al.*, 2022). Similar conditions have been documented across the European Union (2019), the United States

(Shkembi *et al.*, 2022), China (Li *et al.*, 2022), Ghana (Joe-Asare *et al.*, 2023), and Brazil (Ismail *et al.*, 2021).

In Nigeria the situation is critical as occupational mortality remains high and the quarry industry continues to contribute to many preventable illnesses and injuries (Bobola *et al.*, 2020). Local studies have shown that workers in quarry industries experience impaired lung function, heavy metal toxicity, and elevated oxidative stress, which are associated with long-term risks of organ damage and cancer (Omgie *et al.*, 2019; Ugbaja *et al.*, 2020; Yahaya *et al.*, 2024). The physical environment intensifies the danger, as excessive heat, unsafe machinery, and inadequate safety training have been linked to high rates of workplace accidents and injuries (Fresenbet *et al.*, 2022; Putro *et al.*, 2024).

This study focuses on Kaidi quarry Industry, Ohosu, Ovia North-East, Edo State, where a large workforce is exposed daily to dust, noise, heat, and physical strain. The research examines the prevalence of work-related illnesses, including respiratory and musculoskeletal disorders, and considers how these are influenced by factors like educational background and years of service.

Materials and methods

Study Area

The study was conducted at Kaidi Quarry in Ohosu, Ovia North-East LGA, Edo State, Nigeria. As one of the region's largest quarrying operations, Kaidi Quarry employs a sizable workforce across production, quality control, maintenance, laboratory, health/safety, and administration departments. Workers are routinely exposed to occupational hazards, including dust, noise, heat, vibration, and heavy machinery, making the site suitable for examining workplace risks and related health outcomes.

Study Design

A descriptive cross-sectional survey design was adopted for this study. This approach allowed for the assessment of occupational hazards, health risks, and safety practices among quarry workers at a specific point in time.

Sample Size Determination and Sampling Technique

The study population consisted of 140 employees of Kaidi Quarry. Using the Krejcie and Morgan (1970) formula for finite populations, a sample size of 103 was determined. Stratified random sampling was applied to ensure departmental representation, with workers grouped into production, quality control, maintenance, laboratory, health and safety, and administration. Participants were randomly selected from each stratum. A total of 101 workers participated, giving a response rate of 98%.

Data Collection Instrument

Data were collected using a well-structured, pre-tested questionnaire with closed-ended questions. The questionnaire comprised four main sections: socio-demographic characteristics of respondents, types and levels of occupational hazard exposure (chemical, physical, ergonomic, and psychosocial), prevalence of work-related health issues, and workers' perceptions of existing safety measures and policies. The instrument was validated by experts in occupational health and pretested among workers in a similar quarry facility to ensure clarity and reliability.

Data Collection Procedure

Ethical approval was obtained from the Department of Environmental Health Science, Kwara State University, Malete. Permission was also secured from the management of Kaidi Quarry before commencing data collection. Written informed consent was

obtained from all participants after explaining the purpose, procedures, voluntary nature, and confidentiality of the study.

Statistical Analysis

Data were cleaned, coded, and analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics including frequencies and percentages were used to summarize socio-demographic characteristics, occupational hazard exposures, and health outcomes. Inferential statistics, specifically chi-square tests, were employed to examine associations between socio-demographic variables and hazard exposure, as well as between hazard exposure and health risks.

Results

Socio-demographic information of respondents

Table 1 showed the workforce profile. Most employees were aged 35–44 (38.6%) and 45–54 (28.7%), with few under 25 years (5.0%). The workforce was male-dominated (60.4%), while women accounted for 35.6% and 4.0% did not disclose their gender. Most respondents were married (82.2%). Education levels were relatively high. Over half of the respondents held HND or BSc degrees (54.5%), 31.7% had OND/NCE, 6.9% held postgraduate degrees, and few had secondary (5.9%) or primary (1.0%) education. Job roles were mainly in production (37.0%), maintenance and administration (19.0% each), laboratory services (14.0%), and health and safety (11.0%). More than 80% had worked for at least seven years, with 43.6% having over 11 years of experience. Most respondents were full-time employees (74.0%), while 22.0% were contract staff and 4.0% were casual workers. Rotational shifts were the most common (60.0%), followed by day (36.0%) and night shifts (4.0%).

Table 1: Socio-demographic characteristics of workers

| Variable | Sub Variable | Frequency (Percentage %) |
|---------------------------|-------------------|--------------------------|
| Age | <25 | 5 (5.0) |
| | 25-34 | 15 (14.9) |
| | 35-44 | 39 (38.6) |
| | 45-54 | 29 (28.7) |
| | 55+ | 13 (12.9) |
| Sex | Male | 61 (60.4) |
| | Female | 36 (35.6) |
| | Prefer not to say | 4 (4.0) |
| Marital Status | Single | 17 (16.8) |
| | Married | 83 (82.2) |
| | Divorced | 1 (1.0) |
| Educational Qualification | Primary | 1 (1.0) |
| | Secondary | 6 (5.9) |
| | OND/NCE | 32 (31.7) |
| | HND/BSc | 55 (54.5) |
| | MSc/PhD | 7 (6.9) |
| Job Role | Production | 37 (37.0) |
| | Maintenance | 19 (19.0) |
| | Admin | 19 (19.0) |
| | Laboratory | 14 (14.0) |
| | Health/Safety | 11 (11.0) |
| Years of Experience | <1 | 2 (2.0) |
| | 1-3 | 2 (2.0) |
| | 4-6 | 14 (13.9) |
| | 7-10 | 39 (38.6) |
| | 11+ | 44 (43.6) |
| Employment Type | Full-time | 74 (74.0) |
| | Contract | 22 (22.0) |
| | Casual | 4 (4.0) |
| Working Shift | Day | 36 (36.0) |
| | Night | 4 (4.0) |
| | Rotational | 60 (60.0) |
| State of Residence | EDO | 101 (100.0) |

Major occupational hazards

Figures 1 to 3 presented data on the major occupational hazards faced by workers in the cement manufacturing industry, categorized into chemical, physical, and ergonomic hazards. For chemical hazards, the majority of workers (87.4%) were highly exposed, while

9.2% were moderately exposed and only 3.5% were not exposed. For physical hazards, 84.4% of workers were highly exposed, 11.9% were moderately exposed, and 3.7% were not exposed. Ergonomic hazards showed a similar pattern, with 85.9% of workers being highly

exposed, 12.4% moderately exposed, and just 1.7% not exposed.

Prevalence of work-related health issues among workers

Table 2 revealed a high prevalence of work-related health issues among Kaidi quarry workers. A large proportion of respondents (93.1%) reported visiting the hospital due to work-related illnesses, and the same percentage confirmed that these incidents were reported to management. Regarding specific health symptoms, 90.1% of workers reported experiencing a persistent cough, while 84.2% reported eye irritation. Skin irritation or rashes were reported by 89.1% of respondents, and 93.1% indicated experiencing hearing difficulties. In addition, 90.1% of workers reported chronic fatigue, and 92.1% experienced musculoskeletal pain. Difficulty breathing was also reported by 93.1% of respondents. Finally, 92.1% indicated that they had been diagnosed with a work-related illness.

Effectiveness of existing occupational safety measures and policies

Table 3 showed workers' perceptions of occupational safety measures and policies at Kaidi Quarry. Most workers (77.2%) reported receiving no safety training upon joining, and 76.2% indicated that personal protective equipment was unavailable or inadequate. About 70% noted poor visibility of health and safety signs, and more than 60% were unaware of emergency response plans. Regarding management practices, 73.3% stated that safety policies were not enforced, incidents were rarely recorded, and health and safety were not

taken seriously. Over half of the respondents reported that their well-being was undervalued (56.4%) and that they were not encouraged to report unsafe conditions (57.4%). Nearly two-thirds (64.4%) indicated that supervisors ignored health concerns, and 68.3% felt excluded from safety-related decision-making.

Effectiveness of existing occupational safety measures and policies in protecting Kaidi Quarry Industry workers

Figure 4 showed workers' perceptions of occupational safety measures. Most respondents rated personal protective equipment availability (76.2%), safety training (77.2%), policy enforcement (73.3%), and safety signage (70.3%) as ineffective. Emergency response plans (62.4%), incident documentation (66.3%), supervisor response to health concerns (64.4%), and worker involvement in safety decisions (68.3%) were also largely perceived as ineffective. Workplace values on safety (56.4%) and encouragement to report unsafe conditions (57.4%) received slightly lower ineffective ratings.

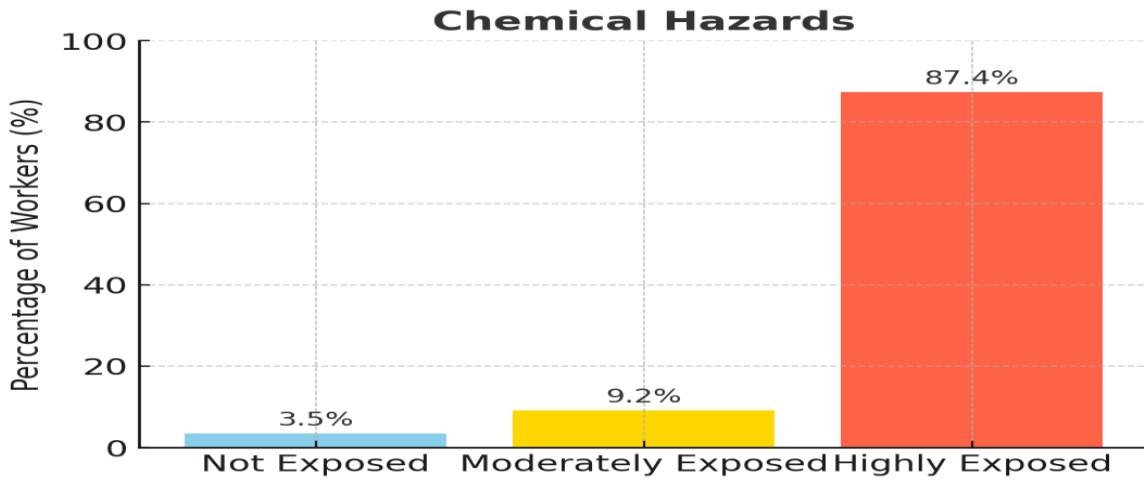


Figure 1: Level of chemical hazards experiences by workers

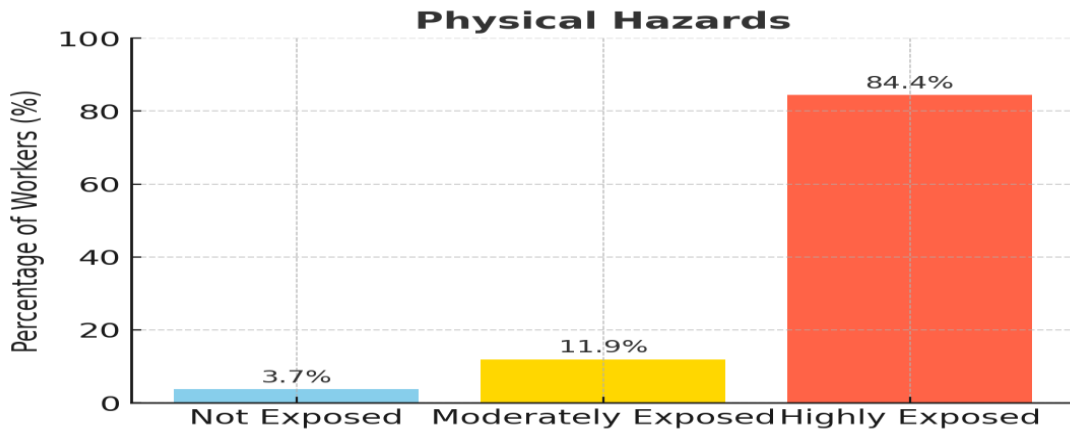


Figure 2: Level of physical hazards experiences by workers

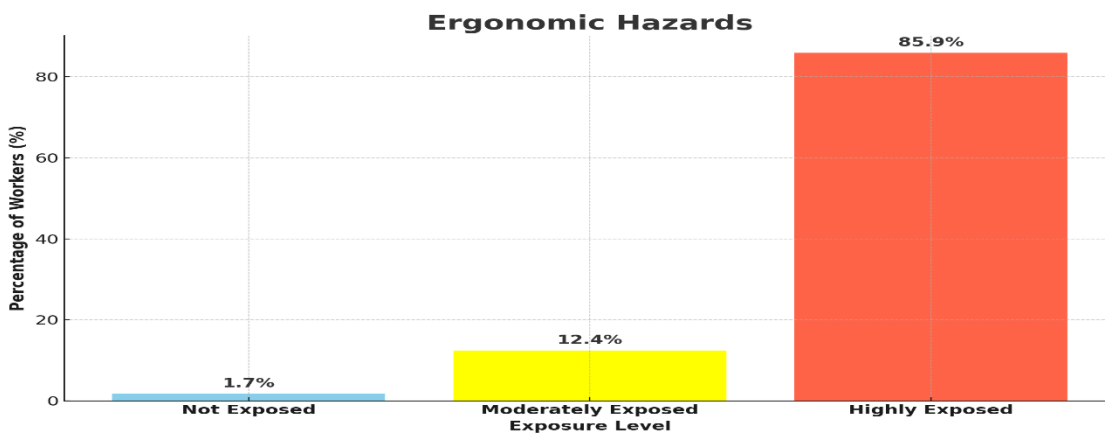


Figure 3: level of ergonomic hazards experiences by workers

Table 2: Experience of work-related health issues among workers

| Health Condition/Symptom | Yes (Frequency and %) | No (Frequency and %) |
|--|-----------------------|----------------------|
| Visited hospital due to work-related illness | 94 (93.1) | 7 (6.9) |
| Incident reported to management | 94 (93.1) | 7 (6.9) |
| Persistent cough | 91 (90.1) | 10 (9.9) |
| Eye irritation | 85 (84.2) | 16 (15.8) |
| Skin irritation/rash | 90 (89.1) | 11 (10.9) |
| Hearing difficulties | 94 (93.1) | 7 (6.9) |
| Chronic fatigue | 91 (90.1) | 10 (9.9) |
| Musculoskeletal pain | 93 (92.1) | 8 (7.9) |
| Difficulty breathing | 94 (93.1) | 7 (6.9) |
| Diagnosed work-related illness | 93 (92.1) | 8 (7.9) |

Table 3: Workers' perception of the effectiveness of 's occupational safety measures and policies

| Variable | Strongly Disagree (%) | Disagree (%) | Neutral (%) | Agree (%) | Strongly Agree (%) |
|--|-----------------------|--------------|-------------|-----------|--------------------|
| Safety practices and policy compliance | | | | | |
| Received safety training during on boarding | 4 (4.0) | 78 (77.2) | 7 (6.9) | 11 (10.9) | 1 (1.0) |
| PPE is always available and in good condition | 4 (4.0) | 77 (76.2) | 9 (8.9) | 10 (9.9) | 1 (1.0) |
| Health and safety signage is visible | 5 (5.0) | 71 (70.3) | 16 (15.8) | 8 (7.9) | 1 (1.0) |
| Emergency response plan known to all staff | 5 (5.0) | 63 (62.4) | 29 (28.7) | 3 (3.0) | 1 (1.0) |
| Management enforces safety policies strictly | 4 (4.0) | 74 (73.3) | 18 (17.8) | 4 (4.0) | 1 (1.0) |
| Incidents are documented and investigated | 5 (5.0) | 67 (66.3) | 23 (22.8) | 5 (5.0) | 1 (1.0) |
| Organizational safety culture and perceptions | | | | | |
| values workers' health and safety | 12 (11.9) | 57 (56.4) | 26 (25.7) | 5 (5.0) | 1 (1.0) |
| Workers are encouraged to report unsafe conditions | 11 (10.9) | 58 (57.4) | 25 (24.8) | 6 (5.9) | 1 (1.0) |
| Supervisors take health concerns seriously | 13 (12.9) | 65 (64.4) | 17 (16.8) | 6 (5.9) | 0 (0.0) |
| Workers involved in safety decisions | 12 (11.9) | 69 (68.3) | 14 (13.9) | 6 (5.9) | 0 (0.0) |

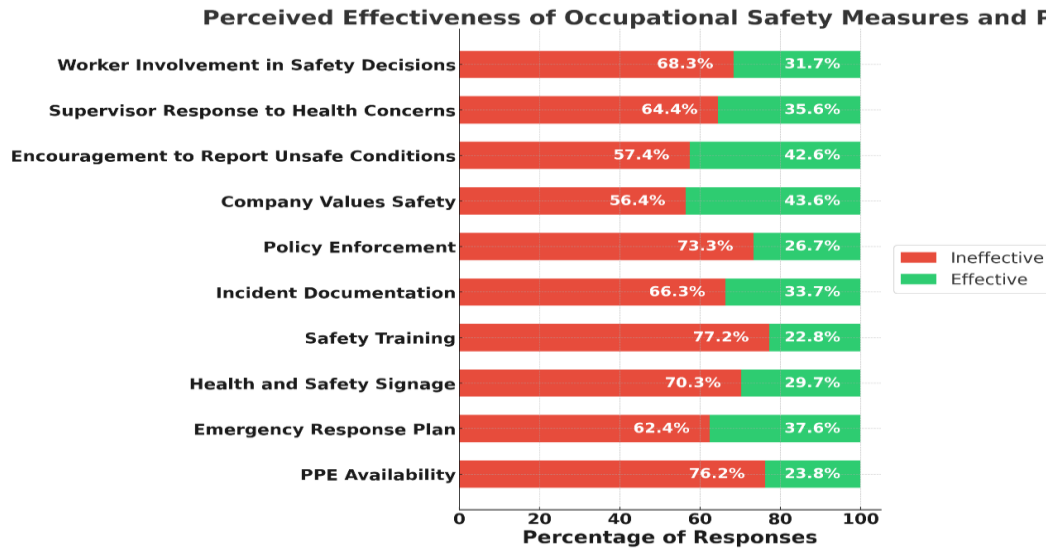


Figure 4: Perceived effectiveness of occupational safety measures and policies

Workers’ recommended strategies to improve occupational health and safety practices

Table 4 showed workers’ perceptions of occupational safety measures. Most respondents rated the availability of personal protective equipment (76.2%), safety training (77.2%), enforcement of safety policies (73.3%), and safety signage (70.3%) as ineffective. Emergency response plans (62.4%), incident documentation (66.3%), supervisors’ responses to health concerns (64.4%), and worker involvement in safety-related decision-making (68.3%) were also largely perceived as ineffective. Workplace safety values (56.4%) and encouragement to report unsafe conditions (57.4%) received comparatively lower ratings of ineffectiveness.

Hypotheses Testing

Hypothesis One: There is no significant relationship between exposure to occupational hazards and the prevalence of work-related hazards among Kaidi quarry workers

Table 5 showed the relationship between workers’ exposure to chemical, physical, ergonomic, and psychosocial hazards and the

occurrence of work-related health problems. Most exposed workers reported high levels of health issues, while few unexposed workers did. A chi-square test confirmed this association ($\chi^2 = 19.58, p = 0.0097$), indicating that exposure to these hazards significantly increased the likelihood of work-related health problems.

Hypothesis Two: Existing occupational safety measures and policies in quarry industry in Nigeria do not significantly impact the reduction of work-related health risks among factory workers.

Table 6 showed workers’ perceptions of safety measures and policies in the quarry industry. Most workers indicated that key safety practices, including training, access to personal protective equipment (PPE), and enforcement of safety rules, were ineffective. For instance, more than 76% reported that PPE was not consistently available or was in poor condition. A statistical test conducted on PPE availability showed a significant effect on workers’ health outcomes. Since the p-value (0.0107) was less than 0.05, this indicated a strong association between adequate safety gear and reduced health problems. These findings demonstrated

that effective safety measures, particularly in protecting workers from occupational proper PPE provision, played an important role illnesses and injuries.

Table 4: perception of serious hazards and recommended strategies to improve occupational health and safety practices

| Variable | Sub Variable | Frequency (Percentage %) | |
|--------------------------------|---------------------------|--------------------------|-------------|
| Most serious hazard | Eye irritation | 3 (3.0) | |
| | Eye irritation and damage | 6 (6.0) | |
| | Health stress | 1 (1.0) | |
| | Hearing loss | 20 (19.8) | |
| | Heat stress | 24 (23.8) | |
| | Musculoskeletal disorders | 5 (5.0) | |
| | Respiratory diseases | 21 (20.8) | |
| | Skin disorders | 21 (20.8) | |
| | Recommended changes | Dust extraction machine | 2 (2.) |
| Dust extraction | | 2 (2.0) | |
| Dust extraction machine | | 8 (7.9) | |
| Dust masks | | 1 (1.0) | |
| Enforce work rotation | | 3 (3.0) | |
| Gloves and protective clothing | | 9 (8.9) | |
| Hearing loss | | 10 (9.9) | |
| Heat stress | | 12 (11.9) | |
| Job rotation | | 8 (7.9) | |
| Noise insulation | | 10 (9.9) | |
| Protective clothing | | 3 (3.0) | |
| Regular health surveillance | | 5 (5.0) | |
| Respirator | | 1 (1.0) | |
| Respirators | | 1 (1.0) | |
| Respirators and dusk masks | | 5 (5.0) | |
| Respiratory diseases | | 9 (8.9) | |
| Respiratory diseases | | 1 (1.0) | |
| Skin disorders | | 10 (9.9) | |
| Use of protective clothing | | 1 (1.0) | |
| Refused task due to safety? | | No | 101 (100.0) |

Table 5: Chi square test of association between exposure to occupational hazards and the prevalence of work-related hazard

| Hazard Type | High Exposure | Moderate Exposure | Total | χ^2 | p-value |
|-------------|------------------------------|--------------------------------|-------|----------|---------|
| Chemical | 7 (Exposed), 2 (Not Exposed) | 80 (Exposed), 12 (Not Exposed) | 101 | 19.58 | 0.0097 |
| Physical | 7, 2 | 75, 17 | 101 | | |

| | | | |
|--------------|------|--------|-----|
| Ergonomic | 7, 2 | 77, 15 | 101 |
| Psychosocial | 9, 0 | 76, 16 | 101 |

Table 7: Perceived effectiveness of existing occupational safety measures and policies

| Safety Dimension | Ineffective (%) | Effective (%) | D. F | Chi Squared value | p-values |
|---|-----------------|---------------|------|-------------------|----------|
| PPE Availability | 76.20 | 23.80 | 9 | 21.484 | 0.010 |
| Emergency Response Plan | 62.40 | 37.60 | | 1 | 7 |
| Health and Safety Signage | 70.30 | 29.70 | | | |
| Safety Training | 77.20 | 22.80 | | | |
| Incident Documentation | 66.30 | 33.70 | | | |
| Policy Enforcement | 73.30 | 26.70 | | | |
| Values Safety | 56.40 | 43.60 | | | |
| Encouragement to Report Unsafe Conditions | 57.40 | 42.60 | | | |
| Supervisor Response to Health Concerns | 64.40 | 35.60 | | | |
| Worker Involvement in Safety Decisions | 68.30 | 31.70 | | | |

Discussion

The study found that Kaidi quarry workers are highly exposed to chemical, physical, ergonomic, and psychosocial hazards, resulting in respiratory, musculoskeletal, and stress-related illnesses. Dust, heat, and long working hours were major concerns; this study showed that Kaidi quarry workers are highly exposed to multiple occupational hazards, particularly chemical, physical, ergonomic, and psychosocial risks. A majority (87.4%) reported exposure to dust, fumes, and solvents, confirming evidence that silica and alkaline compounds in dust cause respiratory illnesses, skin burns, and eye infections (Poudel *et al.*, 2021; AlMousa *et al.*, 2022). Physical hazards were also widespread, with 84.4% exposed to excessive noise, heat, and falling objects, conditions known to cause hearing loss, heat stress, and chronic fatigue (Thai *et al.*, 2021;

Miao *et al.*, 2023). Ergonomic risks affected 85.9% of workers, who performed repetitive, strenuous tasks linked to musculoskeletal disorders (Emmanuel *et al.*, 2022). Another important finding was that 85.4% reported psychosocial pressures such as stress, long hours, and burnout, which reduce motivation for preventive behaviours (Nasir *et al.*, 2021; Ikegami *et al.*, 2023). The statistical association between hazard exposure and health symptoms in this study (Chi-square = 19.58, p = 0.0097) strongly supports the claim that workplace conditions directly contribute to illness. These findings echo those of Shanshal and Al-Qazaz (2022), who showed elevated oxidative stress among cement workers due to exposure to both dust and heat. Moreover, the Health Belief Model helps explain the high prevalence of symptoms despite workers’ awareness of risks. Many workers may believe they are susceptible and that the risks are

serious, but without supportive workplace policies, protective equipment, or effective interventions, they may feel helpless to act.

Statistical analysis confirmed a significant link between the availability of safety measures and reduced health issues, particularly in relation to PPE availability (Chi-square = 21.4841, $p = 0.0107$). This supports research by Zahra *et al.* (2024), who found that access to protective equipment and safety training leads to a marked reduction in workplace injuries and illnesses. Furthermore, demographic factors such as job role ($p = 0.044$) and years of experience ($p = 0.041$) were significantly associated with hazard exposure, showing that frontline and long-serving workers are more vulnerable; this study found that workers were aware of occupational hazards and suggested practical measures such as dust extraction, noise insulation, PPE provision, and job rotation. The main deficiency identified was inadequate training (77%) and lack of empowerment, as none of the respondents had ever refused unsafe tasks. Although engineering controls and PPE are proven strategies for reducing occupational risks (Ciobanu *et al.*, 2021; Zahra *et al.*, 2024), their effectiveness is limited without proper knowledge, usage, and hands-on training (Pandeya *et al.*, 2021). Similar conditions have been reported in other heavy industries where workers face pressure and fear of reprisal (Ikegami *et al.*, 2023).

Conclusion and Recommendations

This study on occupational hazards and health risks among Kaidi Quarry workers, using questionnaires and an observational checklist, found that workers are regularly exposed to dust, noise, heat, and poor ergonomics, resulting in respiratory problems, musculoskeletal pain, and fatigue. Safety policies exist but awareness, training, and enforcement were inadequate, and workers' education and experience influenced their

ability to recognize and manage risks. Based on the findings of this study, the following recommendations are proposed:

❖ *Mandatory regular role-specific safety training:* Comprehensive safety training programs should be provided to all workers during onboarding and at regular intervals throughout employment.

❖ *Consistent supply and monitoring of quality PPE:* High-quality personal protective equipment, including respirators, hearing protection, heat-resistant clothing, safety goggles, gloves, and protective footwear, should be consistently provided to all workers free of charge.

❖ *Implementation of engineering and administrative controls:* Engineering controls such as dust extraction systems, enclosed crushing operations, noise insulation, improved ventilation, and mechanization of heavy lifting tasks should be installed.

❖ *Establishment of routine health surveillance programs:* Regular medical examinations and health monitoring should be conducted for all workers, particularly those in high-risk roles.

❖ *Strengthening of organizational safety culture:* Management must demonstrate visible commitment to worker health and safety through allocation of adequate resources, enforcement of safety policies, encouragement of hazard reporting without fear of reprisal, involvement of workers in safety decision-making, and recognition of safe work practices.

❖ *Collaboration with regulatory bodies:* Partnership with regulatory agencies such as the National Environmental Standards and Regulations Enforcement Agency (NESREA), Federal Ministry of Labour and Employment, and occupational health professional bodies should be established to ensure compliance with national and international occupational health and safety standards. Regular workplace inspections and audits should be conducted.

❖ *Provision of adequate welfare facilities:* Clean drinking water, sanitation facilities, rest areas with adequate ventilation and cooling, and first aid facilities should be provided and maintained in good condition.

Research implications of the study

The findings of this study have significant implications for occupational health practice, policy development, and workplace management in Nigeria's quarrying and extractive industries:

❖ *Public health awareness:* The study highlights the urgent need for increased awareness among workers, management, and policymakers about the serious health risks associated with occupational hazards in quarrying operations, particularly respiratory diseases, musculoskeletal disorders, and hearing loss.

❖ *Occupational health service delivery:* The findings emphasize the need for routine health surveillance programs, workplace health promotion initiatives, and accessible occupational health services for quarry workers, which can be integrated into primary health care systems.

❖ *Training and capacity building:* The study emphasizes the critical importance of continuous safety training, education, and capacity building for both workers and management to improve hazard recognition, risk management, and emergency response capabilities.

❖ *Multi-sectoral collaboration:* Effective protection of quarry workers' health requires coordinated efforts among government regulatory agencies, employers, occupational health professionals, trade unions, and civil society organizations.

❖ *Research agenda:* The study identifies gaps in knowledge regarding long-term health outcomes, dose-response relationships between specific exposures and health effects, and effectiveness of various intervention

strategies in the Nigerian quarrying context, pointing to important areas for future research.

Study Limitations

❖ *Cross-sectional design:* The study employed a cross-sectional design, which captures data at a single point in time and therefore cannot establish causal relationships or assess long-term health effects of occupational exposures.

❖ *Single study site:* The research was conducted at only one quarry facility (Kaidi Quarry) in Edo State, which may limit the generalizability of findings to other quarries in Nigeria with different operational characteristics, management practices, and workforce demographics.

❖ *Self-reported data:* Health symptoms and perceptions of safety measures were based on workers' self-reports, which may be subject to recall bias, social desirability bias, or under-reporting due to fear of reprisal.

❖ *Limited objective health measurements:* The study did not include objective clinical assessments such as spirometry for lung function, audiometry for hearing assessment, or biomarker analyses for exposure quantification, which would have provided more robust evidence of health impacts.

❖ *Temporal limitations:* The study did not account for seasonal variations in hazard exposures or health symptoms, which may fluctuate based on weather conditions, production cycles, and workload variations.

❖ *Limited hazard assessment:* The study relied on workers' perceptions of hazard exposure rather than direct environmental monitoring of dust levels, noise intensity, heat stress indices, or ergonomic assessments, which would have provided quantitative exposure data.

Ethical Approval

Ethical approval for this study was obtained from the Department of Environmental Health

Science, Faculty of Allied Health Sciences, Kwara State University, Malete, Nigeria. Permission to conduct the research was also secured from the management of Kaidi Quarry Industry, Ohosu, Ovia North-East, Edo State.

Informed Consent

Written informed consent was obtained from all participants prior to data collection. The purpose, procedures, voluntary nature, potential risks and benefits, and confidentiality measures of the study were clearly explained to all participants. Workers were informed of their right to withdraw from the study at any time without consequences.

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